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**Financial Deregulation, Banking Efficiency and Productivity
Growth: Empirical Evidence from Bangladesh**

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Iftekhhar Ahmed Robin

Perth, 30 June 2015

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To

My

Mother

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List of Acronyms

BB	Bangladesh Bank
BBS	Bangladesh Bureau of Statistics
BSEC	Bangladesh Security and Exchange Commission
CEO	Chief Executive Officer
CIB	Credit Information Bureau
DEA	Data Envelopment Analysis
DFI	Development Financial Institution
FCB	Foreign Commercial Bank
FSRP	Financial Sector Reform Program
GDP	Gross Domestic Product
GNI	Gross National Income
GNP	Gross National Product
GOB	Government of Bangladesh
HHI	Herfindahl-Hirschman Index
ICT	Information and Communication Technology
IDA	International Development Association
IFS	International Financial Statistics
IMF	International Monetary Fund
LDC	Least Developed Country
MFI	Micro Finance Institution
NBFI	Non-Bank Financial Institution
NIM	Net Interest Margin
NPL	Non-Performing Loan
PCB	Private Commercial Bank

ROA	Return on Asset
ROE	Return on Equity
RWA	Risk-weighted Asset
SCB	State-owned Commercial Bank
TFP	Total Factor Productivity
USA	United States of America
USAID	United States Agency for International Development
WDI	World Development Indicators
WTO	World Trade Organization

Abstract

The financial systems in world economies have experienced remarkable changes over the years due to increased global integration, deregulation and technological advancement. Like many other developing countries, the financial sector, predominantly the banking sector in Bangladesh has undergone a series of legal, policy and institutional reforms during the past three decades. There are numerous empirical studies investigating the impact of financial reforms on banking performance for different country perspectives; however, the results are inconclusive. The mixed evidence intuitively implies that the relationship between financial reform and banking performance remains an empirical issue.

Smith (1998) suggests that improved efficiency and performance of financial systems can be implemented through deregulatory policies. Financial reforms may modify the business environment where banks operate through liberalization of interest rates and capital flows, elimination of directed credit and introduction of market-based government securities. Reform policies may also increase competition by allowing new banks in the market, bringing changes in management and ownership (e.g., privatization) and adopting prudential regulations and supervision (Patti and Hardy, 2005). Therefore, examining the effects of financial reforms on bank performance is crucial.

To the best knowledge of the author, the efficiency and productivity of the banking sector in Bangladesh in the context of financial liberalization has not been studied specifically. Hence, this thesis attempts to fill up the gap in the empirical literature on Bangladesh banking by investigating the bank performance in terms of efficiency, productivity growth and profitability in the context of financial deregulation implemented during the period 1990-1995.

The thesis provides an empirical analysis by examining the impact of financial reforms on the performance of the 12 major commercial banks (i.e., banks which have both pre- and post-reform operation history) in Bangladesh utilizing a

balanced panel dataset for the period 1983-2012. The sample banks contain 70 percent of the total assets and 56 percent of the total deposits of the banking industry in Bangladesh in 2012 (Bangladesh Bank, 2015). The analysis covers three aspects of banking performance: cost efficiency, total factor productivity (TFP) growth and profitability measures. Employing the one-stage stochastic frontier analysis (SFA), suggested by Battese and Coelli (1995), the thesis addresses the research question whether cost efficiency improves after the financial deregulation. The thesis also computes and decomposes TFP growth by using the Färe-Primont TFP index suggested by O'Donnell (2008, 2011b). In the second step, a panel data regression framework is used to examine the links between the estimated TFP change components and reform period dummy variables controlling for other key determinants of TFP growth. The study further identifies the determinants of profitability measures, such as net interest margin (NIM), return on assets (ROA) and return on equity (ROE) by estimating a panel data regression model.

The thesis finds that bank cost reduces due to financial deregulation. The estimated results reveal that financial liberalization appears to lower the cost frontier but leaves some banks further from it as their adjustment is inadequate. The results also show that the larger banks are more cost efficient than the smaller ones. This implies that scale of operation does matter in gaining efficiency. The study further finds that the banks with political director in the board are less cost efficient than the banks with no political person in the board of directors. The measured TFP change indices indicate that the sample banks have been experiencing positive TFP change after the financial liberalization. The decomposition analysis shows that technological progress is the main driver of the productivity change in the sample banks. On average, the TFP growth is higher in private banks than their public sector counterparts in the post-reform period. The profitability analysis demonstrates that capital strength and asset quality are the main determinants of profitability. The reform initiatives are shown to have positive effect on net interest margin (NIM).

The empirical findings have implications for the development of an efficient and productive banking sector in Bangladesh in the context of financial liberalization. Since not all banks are moving towards the frontier, i.e., best-practice bank, the policy makers may redesign the reform policies considering short-, medium- and long-term targets to strengthen the capacity of the concerned banks in complying the prudential regulations and adopting advanced technology in banking services. In order to utilize the economies of scale, mergers and acquisition would be an appropriate policy strategy for the inefficient banks that have very small scale of operation. The results also suggest that the government should not intervene in appointing directors in the state-owned banks and, also should give autonomy to the central bank to formulate appropriate guidelines for not allowing politically linked persons in the bank board for both public and private sector banks.

Key words: Financial deregulation; banks, efficiency; total factor productivity; panel data model; Bangladesh

JEL: E21, D22, D24, G21

Chapter 1

Introduction

1.1 Context of the study

Twin forces of deregulation and technological advancement have contributed to the progressive process of global financial integration and increased competition in the financial systems in world economies. Since the mid-1970s, many countries have experienced financial reform programs although the motivation varies across the countries. The financial reforms in industrialized developed countries (USA for example) were influenced by contemporary factors, such as restrictive banking regulations, development of the Euro-Dollar market, collapse of the Bretton Woods system of monetary management and adoption of the floating exchange rate system, abolition of capital controls resulting cross-border exchange and trade, technological development and debt-crises leading to a series of financial crisis. However, the context of financial liberalization in developing countries was the prevailing financial repression in the economy. The McKinnon-Shaw (1973) thesis of ‘financial repression’ argues that developing economies are financially repressed, which implies distortion of financial prices including interest rates and foreign exchange rates (Fry, 1995). Thus, financial repression – a combination of interest rate controls and government intervention in the allocation of financial resources, would lead to a loss of efficiency (Sen and Vaidya, 1997).

The developing countries most notably in Latin America (e.g., Argentina, Brazil, Columbia, Mexico, Uruguay and Chile) and in Asia (e.g., Malaysia, Indonesia, South Korea, Thailand, India, Sri Lanka, Philippines and Pakistan) have implemented various financial sector reform programs as part of their development strategies for economic stabilization and growth following the prescription made by various multilateral development agencies, such as the World Bank and the International Monetary Fund (IMF). Likewise, Bangladesh initiated a financial

reform program in the late 1980s, predominantly in the banking sector, with the assistance from the United States Agency for International Development (USAID) and the IMF. However, the recent global financial crisis, particularly the collapse of banks in advanced economies and subsequent steps, such as nationalization and rescue plan for bank recapitalization has stimulated rethinking the process of financial deregulation with a view to boosting up financial institutions and restoring confidence through strengthening regulatory supervision and compliance of prudential regulations.

A combination of the fundamental theorem in welfare economics and the efficient market hypothesis is the basic argument for financial liberalization hypothesis (Chowdhury, 2001). The fundamental theorem suggests that competitive markets lead to Pareto optimal equilibria. The efficient market hypothesis argues that the financial markets use information efficiently. The proponents of financial liberalization, McKinnon (1973) and Shaw (1973), argue for financial reforms leading to significant economic growth through more effective domestic saving mobilization, financial deepening and efficient allocation of financial resources. Levine (1997) also explains the theoretical interrelations between savings, investment, financial markets and economic growth. However, the application of the theories of ‘asymmetric information’ to financial markets suggests that the financial markets are different from other markets (such as commodity markets), with ‘market failures’ are more pervasive in financial markets (Stiglitz and Weiss, 1981).

Smith (1998) suggests that improved efficiency and performance of financial systems can be implemented through deregulatory policies. Financial reforms may modify the business environment where banks operate through liberalization of interest rates and capital flows, elimination of directed credit and introduction of market-based government securities. Reform policies may also increase competition by allowing new banks in the market, bringing changes in management and ownership (e.g., privatization) and adopting new prudential regulations and supervision (Patti and Hardy, 2005). Reform programs may improve allocative

efficiency through removal of regulations and price distortions, reduce cost of financial intermediation through higher operational efficiency and, generate improved banking products and services to ensure dynamic efficiency. Thus, financial resources can be channelled into productive use through efficiency improvement (Chowdhury, 2001).

Empirical evidence on the relationship between financial liberalization and banking performance is inconclusive. For example, U.S. banking efficiency remained relatively unchanged after the deregulation in the early 1980s (Elyasiani and Mehdi, 1995, Bauer et al., 1993). Following a different methodology, Wheelock and Wilson (1999) find that U.S. commercial banks became more technically inefficient between 1984 and 1993 and, a declining productivity trend was associated with small banks compared to large ones. In contrast, Isik and Hassan (2003) find substantial improvement in productivity in Turkish commercial banking after deregulation. Similarly, Kumbhakar and Lozano-Vivas (2005) find that deregulation contributed positively to TFP growth for Spanish savings and commercial banks. According to Berger and Humphrey (1997), the consequences of deregulation may depend on industry conditions prior to the deregulation process as well as the deregulation measures implemented.

There are numerous empirical studies on efficiency and productivity in banking literature. However, there is no comprehensive study on the impact of financial reforms on banking efficiency and productivity in Bangladesh. Therefore, this thesis attempts to fill up the gap in the empirical literature on Bangladesh banking by investigating the banking performance in terms of efficiency, productivity growth and profitability in the context of financial deregulation.

1.2 Rationale for the research

The command economy structure that prevailed in Bangladesh during the period preceding the reforms can be characterized by inefficient allocation of financial

resources, e.g., directed credit to selected sectors including state-owned enterprises at subsidized rates. In fact, very few countries (e.g., Japan and Republic of Korea) successfully used directed credit as a tool for accomplishing their development objectives (Hellmann and Murdock, 1997). In addition, banks often exercised monopoly power in charging high interest rates on lending. As a result, investment in the real sector was discouraged due to high cost of funds. Moreover, government borrowed funds from banks at a lower interest rate to finance its expenditure. The excessive reliance on banks for financing budget deficits crowded out the private sector's access to credit.

Banking in Bangladesh during the pre-reform period 1972-1989 experienced dominance of government ownership and excessive government interference, absence of prudential regulations and inadequate legal support for debt recovery. This was reflected in declining profitability of the banking industry. Since the whole banking sector (excluding foreign bank branches) was under government ownership, banks were used to bailout state-owned enterprises (Salim, 1999).

Unlike private banks, public banks faced a 'soft budget constraint' and, therefore, were not accountable to anyone. The bank lending went to politically motivated projects which were not economically viable. According to the Government statistics, the banking sector was burdened with non-performing loans (NPLs), with a percentage of 30% to 70% of the total loan portfolio at the end of June 1985 (GOB, 1986). In fact, the public banks are historically burdened with NPLs for various reasons. The specific effects of the presence of political directors in the bank board on bank's efficiency and productivity are examined in the empirical chapters.

The banking sector in Bangladesh has experienced a series of legal, policy and institutional reforms since the initiation of the financial liberalization program in the late 1980s. The main objective has been to ensure efficient allocation of financial resources. The measures that have already been taken under the reform process include the introduction of a market determined interest rate, privatization of state-

owned commercial banks, greater freedom for the operation of private sector banks and other financial institutions, and enhanced compliance with prudential regulations. The number of bank branches increased from 4603 in 1983 to 8322 in 2012 (Bangladesh Bank, 2014c). Due to the expansion of the banking institutions, monetization of the economy has increased, e.g., broad money as a percentage of GDP increased from 18% to 69% during the sample period (World Bank, 2014).

The banking sector dominates the financial system of Bangladesh since banks contribute about 74 percent of the total financial intermediation of the economy (Bangladesh Bureau of Statistics, 2013). Although financial reform policies have brought significant changes in the banking environment, still the industry is facing challenges in terms of maintaining required capital adequacy, provisioning against NPLs and compliance with international banking regulations (e.g., Basel accords). In addition, the financial market in Bangladesh suffers from imperfection due to ‘asymmetric information’ and ‘moral hazard’ problem like many other developing countries. Lack of information leads the banks to adverse selection problem and, thus bank finance goes to poor credit worthy customers resulting high volume of NPLs.

The literature suggests that a reasonable period is required for reform initiatives (e.g., regulatory changes) and other macro-financial developments to exert their influence upon banking performance (Isik and Hassan, 2002). Since more than two decades have been passed after the implementation of financial reform programs, it is timely to evaluate how the deregulation policies impact on the banking sector in Bangladesh. This is also vital for the policy makers in Bangladesh to formulate future banking policies in light of the reform evaluation for the development of the sector. Moreover, the issue of efficiency and productivity of banks takes on an added significance because of the increased competition in the financial market after opening up the sector for private sector operation. Therefore, investigating the performance of the banking sector in Bangladesh appears to be a suitable case study in the context of financial liberalization initiated in the late 1980s.

1.3 Research objectives

The thesis aims to examine the impact of financial deregulation on banking performance in Bangladesh in terms of efficiency, productivity and profitability by addressing the following research questions:

Research question 1

The efficiency analysis addresses the research question whether cost efficiency of the commercial banks in Bangladesh improves after financial deregulation. The analysis also examines whether bank-specific and environmental variables have any effect on both the cost function and inefficiency function.

Research question 2

The analysis of productivity addresses the research question whether financial deregulation has any effect on total factor productivity (TFP) change and its various components. The decomposition analysis also investigates the drivers of TFP change components, such as technical change, technical efficiency change and scale-mix efficiency change.

Research question 3

The profitability analysis addresses the research question whether financial deregulation has any impact on profitability measures, such as return on asset (ROA), return on equity (ROE) and net interest margin (NIM) for the sample banks in Bangladesh. The analysis also identifies other determinants of profitability measures.

1.4 Analytical framework and data

The estimation technique of banking efficiency falls into two broad categories: non-parametric and parametric approaches. Farrell (1957) is the pioneer in advocating the

non-parametric measurement of productive efficiency of firms (banks, for example). This approach has the advantage of not imposing *a priori* restrictions on the underlying production or cost structure, although the estimates may suffer from measurement error. On the other hand, the parametric approach of estimating production, cost or profit efficiency presumes a particular specification of production technology and makes specific distributional assumptions for the one-sided error depicting inefficiency (Aigner et al., 1977, Meeusen and Broeck, 1977).

This thesis employs the parametric technique, time-varying one-stage stochastic frontier analysis (SFA), suggested by Battese and Coelli (1995), to estimate the cost efficiency of the sample banks. The SFA allows for measuring the effect of deregulation and other bank-specific and environmental variables on both the cost function and the inefficiency function in one step.

The thesis also uses the Färe-Primont TFP index, suggested by O'Donnell (2008, 2011c) to compute and decompose the total factor productivity (TFP) of the sample banks. The TFP change can be decomposed into two main components: technical change and efficiency change. The components of efficiency change are: technical efficiency change, residual scale efficiency change and mix efficiency change. Alternatively, efficiency change can be expressed as technical efficiency change and scale-mix efficiency change. A panel data regression framework is then employed to examine the links between the estimated TFP change components and reform period dummy variables while controlling for other key determinants of TFP growth.

Finally, the profitability analysis identifies the determinants of profitability measures, such as net interest margin (NIM), return on assets (ROA), and return on equity (ROE), by estimating a panel data regression model that examines the impact of deregulation.

The thesis uses a balanced panel dataset comprising bank level annual data from 12 commercial banks in Bangladesh for the period 1983-2012. Since the focus

of the study is to investigate the impact of financial reform program, the sample includes the banks which have both pre- and post-reform operation history. The bank level data are collected from annual reports and financial statements of individual banks. Further, the aggregate banking data are collected from the Central Bank of Bangladesh (Bangladesh Bank). Finally, the macro data are collected from Bangladesh Bureau of Statistics (BBS), Ministry of Finance, the Government of Bangladesh, Bangladesh Security and Exchange Commission (BSEC), International Financial Statistics (IFS) of the IMF and World Development Indicator (WDI) of the World Bank.

1.5 Significance of the study

This thesis attempts to fill a gap in the banking literature by adding empirical evidence to the existing body of knowledge of efficiency and productivity for Bangladesh banking. Although financial liberalization policies were initiated in the late 1980s, there is no comprehensive study on the efficiency and productivity of the banks in Bangladesh in the context of financial deregulation.

Second, the thesis uses a unique and long balanced panel dataset for a sample period of 30 years including both the pre- and post-reform periods. Thus, the study provides a complete picture of the changes in the banking sector in Bangladesh due to financial reforms.

Third, the thesis applies the Färe-Primont TFP index, suggested by O'Donnell (2008, 2011b), to measure the total factor productivity growth and its components. The index satisfies all required properties (axioms and tests) of the index number theory. The Färe-Primont TFP index can be exhaustively decomposed in an economically meaningful way and, provides an aggregate quantity framework to compute TFP change and its various components. This thesis is the first study that uses the Färe-Primont TFP index to decompose the productivity changes in a banking context.

Finally, the thesis documents an empirical evaluation of the financial reform program on banking efficiency and productivity which will contribute to the policy strategies of the government of Bangladesh. The thesis also provides a benchmark for future research and, therefore, may be of interest to other developing countries which are at similar stage of economic development and have implemented financial reform programs. The findings of this thesis may help policy makers and bankers for understanding the effect of regulatory changes on banking performance. This eventually may lead to redesign of the reform policies in order to accommodate the medium- and long-term challenges.

1.6 Structure and preview

The thesis is organized in eight chapters. The introductory chapter contains the context and rationale of the study, research objectives, methods and significance. Chapter 2 provides an overview of the history of macro financial developments in different policy regimes in Bangladesh since her birth in 1971. The chapter describes the financial structure and the reform policies that have been undertaken during the past three decades as a background for understanding the empirical analysis on banking performance in the context of financial deregulation. The chapter also includes an exploratory analysis of banking performance for both pre- and post-reform periods.

Chapter 3 reviews the theoretical and empirical literature on efficiency and productivity. The chapter begins with a conceptual discussion on the measurement of efficiency and productivity growth. Both parametric and non-parametric frontier techniques are discussed. The empirical evidence focuses on the impact of financial liberalization on banking efficiency and productivity growth, critically analysing the empirical studies from both developed and developing country perspectives. The chapter reviews bank related empirical studies on cost efficiency, total factor productivity (TFP) growth, financial liberalization and efficiency and productivity growth and determinants of efficiency and TFP growth. Finally, a survey of

empirical studies on South Asian and Bangladesh banking is undertaken to explore the gaps in existing literature.

Chapter 4 demonstrates an analytical framework for estimating banking performance in terms of cost efficiency, productivity growth and profitability measures using the sample data. The chapter introduces the origin and recent developments of the frontier methodology: the parametric approach, such as single-stage stochastic frontier analysis (SFA) and panel data SFA framework. The non-parametric approach, data envelopment analysis (DEA) is applied for the measurement of productivity change and its decomposition. The theoretical background of the DEA-based Färe-Primont TFP indices and its computation techniques for estimating the TFP change and its components are reviewed in the chapter. The chapter concludes with explaining the use of panel data regression model in estimating the determinants of TFP change components as well as profitability measures, such as return on assets (ROA), return on equity (ROE) and net interest margin (NIM).

The research contributions of this study are demonstrated in three empirical chapters, Chapter 5 through 7. Chapter 5 investigates the cost efficiency of the sample banks following the one-stage SFA suggested by Battese and Coelli (1995). The estimated single-stage translog cost frontier model allows examining the effect of deregulation and other bank-specific and environmental variables on both the cost and inefficiency function in one step. The chapter discusses different approaches for input and output variable construction used in the estimation. The findings indicate that cost efficiency increases due to financial reform.

Chapter 6 computes and decomposes total factor productivity (TFP) change of by using the Färe-Primont TFP index suggested by O'Donnell (2008, 2011b). The decomposition of TFP change into its components provides the information about the sources of productivity change. The components are: technical change, technical efficiency change, mix efficiency change and scale efficiency change. The findings reveal that the dominant driver of TFP change is technical change. The chapter also

examines the relationship between the estimated TFP change components and reform period dummy variables while controlling for other key determinants of TFP growth by employing a panel data regression framework.

Chapter 7 investigates the determinants of profitability measures, such as net interest margin (NIM), return on assets (ROA), and return on equity (ROE), by estimating a panel data regression model. The chapter includes a discussion of the existing literature on the determinants of the profitability measures and explores how bank-specific characteristics, industry related and macroeconomic factors affect the profitability of the sample banks in Bangladesh. The chapter also focuses on investigating the impact of financial reform policies on profitability.

The concluding chapter (Chapter 8) provides a summary of key findings. The chapter also discusses the policy implications for developing appropriate policy strategies for the banking sector in Bangladesh in order to face the medium- and long-term challenges in the context of financial deregulation. The chapter ends with the limitations of the study and some suggestions for future research.

Chapter 2

Policy regimes and financial sector development in Bangladesh: an overview

2.1 Introduction

A healthy and vibrant economy requires a financial system that ensures efficient financial intermediation, which depends on the financial structure, policies and overall macro financial environment of an economy. The financial sector, predominantly the banking sector in Bangladesh has undergone a series of legal, policy and institutional reforms since the initiation of the financial liberalization program in the late 1980s. The major objectives of the reform initiatives were to improve the overall performance of the financial sector through competition and efficient allocation of financial resources. These in turn were expected to promote investment and growth in the real sector.

Since independence in 1971, Bangladesh has experienced a variety of development approaches in different economic and political regimes. A command economy structure prevailed in the 1970s. This was characterized by administrative price setting practices that lacked flexibility and responsiveness to relative scarcities, with attendant inefficiency in resource allocation. Low administered interest rates on savings in the inflationary environment discouraged financial savings and retarded financial intermediation. By the later 1970s, the negative effect that the command economy regime had on the financial sector was recognized which led to the interest rates rationalization of 1980 with general upward revision, licensing of new private banks and privatization of two state-owned commercial banks in the early 1980s. Although significant, these reforms were seen as piecemeal and ad hoc steps.

After several reviews, the 'Financial Sector Reform Program (FSRP)' was implemented during 1989-1995. The program was supported by technical assistance

from the USAID and the IMF and, a balance of payments assistance loan from the IDA. The program addressed issues on broad fronts, including transition from directed sectoral lending at directed interest rates to unified credit markets with market-based interest rates; transition to indirect tools for monetary management; revision of loan classification and provisioning criteria; revision of legal provisions and procedures for enforcing loan recovery; availability of credit information for loan risk assessment; transition from segmented exchange markets with multiple exchange rates to a unified foreign exchange market with a single market-clearing exchange rate and, upgrading of technology and human resources skills in banks.

This chapter presents a brief sketch of the macro financial development of Bangladesh over the period 1980-2012. The main objective of this chapter is to investigate the performance of the financial sector focusing on the banking sector in the context of financial reforms in the 1980s.

The remainder of the chapter is organized as follows. Section 2.2 describes the macro financial environment of the Bangladesh economy, followed by a discussion on the structure of the financial system and the growth of financial development in Section 2.3. Section 2.4 presents different phases of the financial liberalization process and the policy changes. Section 2.5 provides an overview of the performance of the banking sector achieved so far and, finally, Section 2.6 concludes.

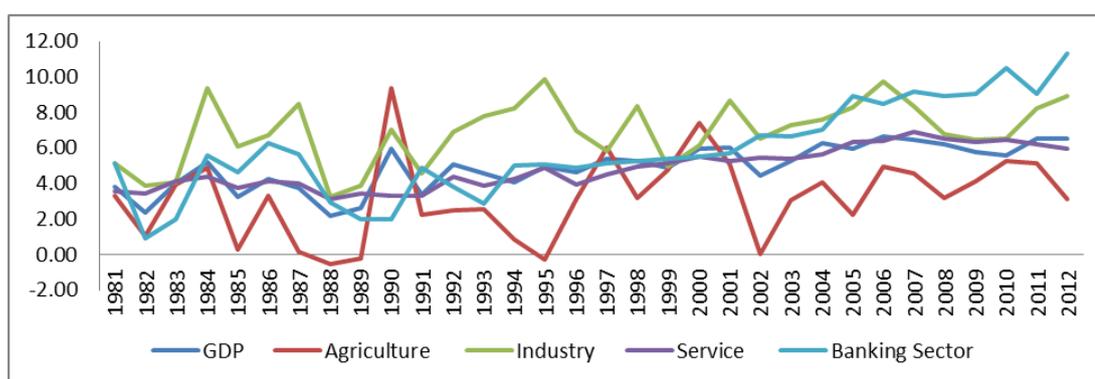
2.2 Macro financial environment

When founded in 1971, Bangladesh had an underdeveloped economy with a narrow undiversified production base. The agricultural sector consisted mainly of subsistence farming while the industrial sector was largely based on agro-based industries, such as jute processing and textile industries. The country's institutions lacked organizational and/or financial strength. During this time, the entire financial sector (excluding the foreign banks) was restructured and nationalized along with

other industrial units. Consequently, about 92 percent of industrial assets came under government control in 1972 (Salim, 1999). However, like many other developing countries, Bangladesh undertook a market-oriented development strategy in the mid-1980s as a part of the ‘Structural Adjustment Program (SAP)’ promoted by the World Bank and the IMF. The reform initiatives comprised fiscal reform, financial deregulation and trade liberalization. The reform policy was implemented to drive the economy with increased openness and private sector participation in different industrial and service sectors including the financial sector.

Bangladesh, with a population of 154.7 million, and per capita GNI (Gross National Income) of USD840 in 2012, has been experiencing a stable macroeconomic condition over the past two decades (World Bank, 2014). The GDP growth rate (at constant price 1995-96) increased from 3.80 percent in 1981 to 6.2 percent in 2012. An indication of the extent of financial deepening is that broad money (M2) as a percentage of GDP increased to 69.7 percent in 2012 compared to 13 percent in 1980, due to increased financial intermediation in the post-reform period (World Bank, 2014). The current account balance improved from -3.8 percent of GDP in 1981 to 0.9 percent in 2011, although the trade balance had been deteriorating over the years (ADB, 2012). The expanded trade deficit has been offset by robust remittance inflows boosting the current account balance to surplus. Figure 2.1 shows the growth of different sectors during the period, 1981-2012.

Figure 2.1: Sectoral growth rate of GDP in Bangladesh, 1981-2012

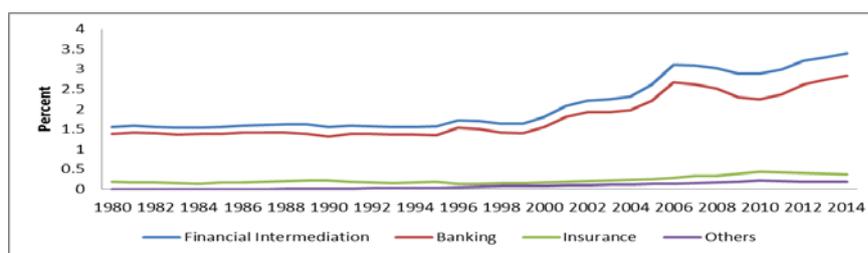


Source: World Development Indicators (World Bank, 2014)

Figure 2.1 shows that the GDP growth rate increased during the period 1981-2012 with some fluctuations. The GDP growth exhibited downward movement in some years as a consequence of the political crisis. In Bangladesh, it has become a common phenomenon that political agitation turns into violence in the year before national elections. Therefore, the GDP growth rate showed a decline in some years as an effect of political unrest in the years preceding the new government assumes power. The new government may require some time to bring the economy back to its usual growth path. For example, the past two governments came into power in 2001 and 2009 after prolonged anti-government movements. Consequently, the GDP growth rate turned down to 4.42 percent in 2002 from 6.04 percent in 2001. Similarly, the GDP growth rate decreased to 5.74 and 5.60 percent respectively in 2009 and 2010 from 6.19 percent in 2008.

Figure 2.1 also demonstrates that all broad economic sectors have contributed to accelerating the growth rate. The industrial sector has been making a larger contribution to economic growth over the years, although the increasing trend was stalled during 2008-2010 due to a severe power shortage in the country and the contagion effect of the global financial crisis. About 70 percent of the incremental growth came from the non-tradable sectors comprising construction, small-scale industry, services and other demand driven activities (Mujeri, 2004). Another reason for the attained growth was the opening up the economy, especially the trade and service sectors in the 1990s through complying with WTO obligations; rationalizing the trade regime by lowering tariff rates, phasing out quantitative restrictions, streamlining import procedures, introducing tax reforms and export promotion measures. The agricultural sector growth fluctuated over the years; even went negative during 1988-1989 due to devastating flood. The growth of financial intermediation has been increasing since the mid-1990s, perhaps as a consequence of financial reforms. The growth of the banking sector increased from 5.16 percent in 1981 to 11.33 percent in 2012 (World Bank, 2014).

Figure 2.2: Share of financial intermediation to GDP, 1980-2014



Source: National Income Accounts, 2000, BBS;
Bangladesh National Accounts Statistics: Sources and Methods, 2014, BBS

In Bangladesh, money market players, e.g., banks, non-bank financial institutions and insurance companies, play major roles in the financial intermediation process, while the capital market occupies a comparatively shallow one. The market capitalization (listed companies) as a percent of GDP was 13.1% in 2012, which is substantially low compared to other neighbouring developing countries. For example, the ratio was 28.7 percent in Sri Lanka, 21.7 percent in Nepal, 19.7 percent in Pakistan and 68.8 percent in India in 2012 (World Bank, 2014). Therefore, the banking sector dominates the financial sector in Bangladesh. Banks contribute about 84 percent of the total financial intermediation in the economy. Figure 2.2 shows the share of financial intermediation in GDP during the pre- and post- reform period, 1981-2012, where banks, insurance companies and other financial intermediaries have contributed.

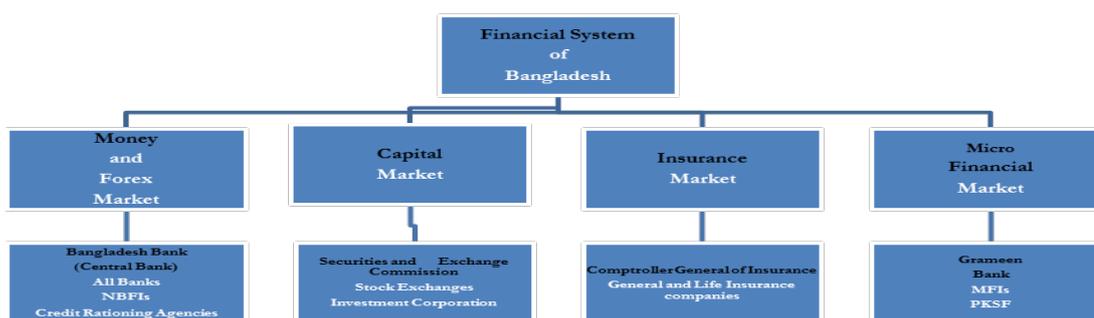
Figure 2.2 reveals that the share of financial intermediation in GDP has been increasing since 1996, perhaps due to government approval for more private banks, insurance companies and non-bank financial institutions to operate in the financial market after the implementation of the financial reform program during 1990-1995. A total of 11 new private sector banks (both domestic and foreign) commenced operations during the period, 1995-96. Another 14 private banks started banking operations during the period, 1999-2001. However, a declining trend in financial intermediation was observed during the period 2007-2010, possibly due to the adverse effect of the global financial crisis. The trend in financial intermediation started to move upward again from 2011. In 2013, another nine private banks got

approval for banking operations in the fourth phase of the expansion of the private sector banking in Bangladesh. However, the share of financial intermediation to GDP is still low, 3.39 percent of GDP in 2014 (BBS, 2014). The intermediation cost (gap between lending and deposit rate) also remains high at 5.32 percent reflecting inefficient financial intermediation (Bangladesh Bank, 2011a). Moreover, a substantial volume of financial transactions does take place in the unorganized money market where the rate of interest is exorbitantly high (Wahid, 1986). Therefore, misallocation of financial resources occurs, which is a significant hindrance to higher investment and economic growth.

2.3 Financial system of Bangladesh

The financial system is complex in structure and function throughout the world. It includes different types of institutions such as banks, insurance companies, stock and bond markets and mutual funds. The main function of the financial system is to mobilize funds and its efficient allocation in order to promote economic growth (Mishkin, 2007). Hence, the financial system is the set of institutional arrangements that facilitates demand, supply and storage of financial assets and instruments and thus enhance savings and investment in the economy. Figure 2.3 presents the major components of financial system in Bangladesh.

Figure 2.3: Financial system of Bangladesh



Source: Financial Sector Review (Bangladesh Bank, 2006)

The financial system of Bangladesh constitutes commercial banks, development banks and financial institutions (FIs), non-schedule banks, microfinance institutions (MFIs), insurance companies, credit rating agencies and stock exchanges. As stated in Section 2.2, the banking sector dominates the financial sector in Bangladesh. The sector comprises four state-owned commercial banks, four government-owned development (specialized) banks dedicated to agriculture, small and cottage industries and housing and industrial lending and, 48 private sector commercial banks, of which nine are foreign commercial banks and eight are Islamic (Islami Shariah based) banks. Out of the 31 non-bank financial institutions, only two have government ownership, and the rest are in the private domain. Apart from this, 650 microfinance institutions including Grameen Bank (the largest microfinance institution in Bangladesh) have been providing microcredit to 24.6 million hard-core poor rural women (MRA, 2014).

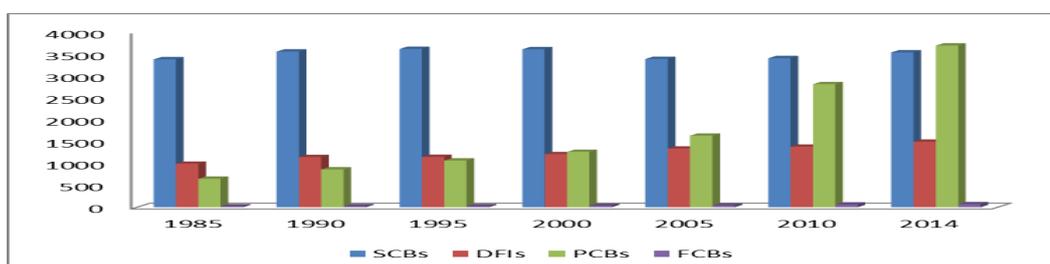
Banks and financial institutions are perceived as partners in the development process in Bangladesh. The Bangladesh Bank performs the usual function of a central bank which, inter alia, includes formulation of monetary and credit policies, issue and management of currency, development of money market, holding of foreign exchange reserves and stabilizing the internal and external value of Taka (Bangladesh currency). Bangladesh Bank also acts as a banker and adviser to the Government and manages the public debt (GOB, 1986). Bangladesh Bank influences the distribution of bank branches across the country in such a way as to help promote a wide dispersal of bank credit, increased flow of credit to rural and other priority sectors and thus ensure balanced economic and financial development across the country.

The state-owned commercial banks have been directed to expand their activities beyond the traditional function of providing credit for trade and commerce, and, to extend loans to priority sectors, agriculture and non-traditional exports, such as small industries, other small borrowers, unemployed youths, less-developed areas, e.g., hilly regions. Both public and private sector banks are required to expand their

rural banking network in order to mobilize savings and facilitate banking services to the door-step of the unbanked people. In the second half of the 1970s, considerable importance was attached to extending banking services to rural areas. However, the distribution of bank branches remains unequal across the country especially for private sector banks; about 61.3 percent of private bank branches are providing banking services to urban territory while 38.7 percent are operating in semi-urban and rural areas (Bangladesh Bank, 2014c). The private sector banks are reluctant to expand their network in rural areas due to the possibility of lower profitability. Foreign banks have no branch in rural areas. All 69 foreign bank branches are located in urban areas particularly in big cities. Only state-owned commercial and development banks have more branches in rural areas. However, Bangladesh Bank has recently directed all commercial banks to open rural branches at an equal proportion to urban branches (1:1) to provide banking services to unbanked rural population with an objective of increased financial inclusion in Bangladesh.

Until 1982, only six state-owned commercial banks and few foreign banks had been operating in Bangladesh. Following government policy on allowing private sector banking operation in the mid-1980s, private sector banks have been entering in the market in several phases. As a result, the total number of bank branches increased from 1299 in 1973 to 8794 in 2014, which is about a seven-fold increase over the past four decades (Bangladesh Bank, 2014a).

Figure 2.4: Bank branch expansion in Bangladesh, 1985-2014



Source: Annual Report(Bangladesh Bank, 2014a); Note: SCBs= State-owned commercial banks; DFIs = Government-owned Development (specialized) banks; PCBs= Domestic private commercial banks; FCBs= Foreign commercial banks

The trend of bank branch expansion of different types of banks is demonstrated in Figure 2.4. The private sector banks (domestic) had rapid branch expansion during the period 1985-2014. As stated in Section 2.2, a good number of private banks were allowed for banking operation in several phases after the implementation of the financial liberalization program in the late 1980s.

2.4 Financial liberalization policies

This section discusses financial liberalization policy initiatives undertaken in the banking sector in Bangladesh since the mid-1980s. As reported in Section 2.2, after the independence in 1971, the government of Bangladesh nationalized almost all key sectors including banking and insurance. The restrictive policies on financial sector include directed sectoral credit, administered interest rate structure and restriction on foreign exchange operations. However, by the mid-1980s centralized control had led to serious deficiencies in the banking system. These included: misallocation and thus inefficient utilization of resources, widespread loan defaults and delinquencies, and poor credit delivery and recovery. This happened due to political influence on credit decision rather than the merit of the project and inadequate monitoring and supervision of the loan portfolios. Similarly, the foreign exchange system also suffered from inefficiencies due to controls and weak management.

Against this backdrop, the government denationalized two state-owned large commercial banks ‘Uttara’ and ‘Pubali’ in 1983 and 1984 respectively, while another state-owned bank ‘Rupali’ was partly privatized. The government also allowed the operation of banks and insurance companies in private sector with the objective of creating competition in the financial sector. However, privatization initiatives did not generate expected results because of rigid economic and banking regulations.

Later a commission on ‘Money, Banking and Credit’ was constituted in 1984 to review and suggest remedial measures to make the banking sector more efficient and competitive. On the basis of the commission’s recommendations and, a review

by the International Development Association (IDA) of the World Bank, 'Financial Sector Reform Program (FSRP)' was launched in 1989. At the same time, macroeconomic stabilization measures were initiated under the 'Enhanced Structural Adjustment Facility (ESAF)' of the International Monetary Fund (IMF).

The thrust of the reform program has been to improve the efficiency and productivity of the financial sector through increased competition, efficient allocation of financial resources and better governance. The reform program focuses on broader areas of development such as greater autonomy of the Central Bank (Bangladesh Bank, BB), enhancement of BB's capacities, strengthening prudential regulations and supervision, restructuring the management and internal processes of the state-owned banks (SCBs) toward privatization, strengthening the legal and judicial processes and improving money and debt markets. These policy measures, however, could not take the economy into the expected level because of inherent structural rigidities in terms of regulations and bureaucratic complexities.

As part of reform measures, indirect monetary policy instruments such as repurchase agreement (repo) and reverse repo were introduced in July 2002 and April 2003 respectively for day-to-day liquidity management in response to temporary and unexpected disturbances in the supply and demand for money. The Bangladesh currency 'Taka' was floated in May 2003 without any disturbance in the foreign exchange market. By and large, financial reform programs emphasize three key areas: enhancement of management capacity, strengthening supervision and banking regulations. A snapshot of different phases of the financial reform program and subsequent outcomes is presented in Appendix 2.2.

2.4.1 Management capacity

Sound management is crucial for overall efficiency of the banking system. This applies as much to the central bank as to the commercial banks and other financial institutions. There are important areas such as corporate governance and risk management of banking institutions, where there is room for significant

improvement in management performance particularly in the financial sector in Bangladesh.

2.4.1.1 Corporate governance

The basic principle of corporate governance can be articulated as fairness, transparency, accountability, and responsibility (Sophastienphong and Kulathunga, 2010). Good corporate governance creates an environment that promotes banking efficiency, mitigates financial risks and, increases the stability and credibility of financial institutions. Corporate governance has become an important issue following the corporate scandals like Enron and Worldcom in 2001 (Spong and Sullivan, 2007).

The corporate governance structure varies from county to country. The BASEL committee recognizes that there are significant differences in legislative and regulatory frameworks across the countries on the functions of the board of directors and senior management in banks and financial institutions.¹ In some cases, the bank board has no executive function while in other cases, the board has broader competence (Gup, 2007).

Research on corporate governance finds a higher level of risk in organizations where managers and directors have higher ownership stakes (Saunders et al., 1990). Shleifer and Vishny (1997) argue that corporate governance is primarily concerned with principal-agency problem between ownership and control. In other words, it deals with the problem arises from the separation of shareholders and management. According to OECD, “Corporate governance involves a set of relationships between a company’s management, its board, its shareholders and other stakeholders.

¹ The BASEL is a committee of Bank of International Settlement (BIS) on banking supervision.

Corporate governance also provides the structure through which the objectives of the company are set, and the means of attaining those objectives and monitoring performance are determined.” (Gup, 2007, p.19).²

The objective of corporate governance is to protect the interests of shareholders, stakeholders and, also satisfy the regulators. Because of the different goals, corporate governance involves different measures, such as effectiveness and efficiency of operations, reliability of financial reporting, compliance with laws and regulations and returns on investment. The corporate governance of banks in developing countries is important for several reasons: first, the banking sector is dominant and thus plays a vital role in economic growth; second, banks are the key sources of finance; third, banks are the main depository institutions for savings and, fourth, bank managers have been enjoying greater freedom in running banking business since the financial deregulation across the world in 1970s (Das and Ghosh, 2004).

The Basel committee on banking supervision defines bank governance structure as including the board of directors, senior management, risk management committee, audit committee, compensation committee and also the supervisory or regulatory authority, e.g., central bank (Andres and Vallelado, 2008). Following the Basel recommendations, Bangladesh Bank has issued necessary guidelines to improve the governance in the banks and other financial institutions. Bangladesh Bank follows a unitary ‘Board’ structure with 13 directors on average. The tenure of the ‘Board’ is three years and, one director can continue maximum up to six years. Besides, no individual or family can hold more than 10 percent of the shares of a

² The OECD is an inter-governmental body that is dedicated to sound practices for economic development.

banking company and, banks must disclose their shareholding structure in the articles of association following the Bank Company Act 1991. Provision has been made for two independent directors in the 'Board', of which at least one shall be from depositors. The other governance issues instructed are: responsibilities of the 'Board'; qualification of bank directors and chief executive officers (CEOs); appointment procedure of CEOs and advisors of banks. The audit committee is required to play an effective role in performing the overall supervision on behalf of the 'Board'; ascertain the compliance of business strategy and policy formulated by the 'Board'; ensure the publication of transparent financial statements, internal control system, financial risk management and the compliance of rules and regulations advised by the regulators (Talukdar, 2007).

In spite of all these regulatory measures, corporate governance has not improved in banks in Bangladesh. The majority of bank shares are owned by a small number of 'sponsor' shareholders who are even family members or relatives or friends with each other. As such, many of the bank directors do not have required academic and professional background. In domestic private banks, the sponsors control or influence on virtually all sorts of banking affairs, such as appointment of CEOs (where Bangladesh Bank gives formal approval only against the 'Board' recommendation), loan approval, procurement decision and salary determination.

In public sector banks, the situation is rather worse since the government uses the banks to execute its political objectives (Reaz and Arun, 2006). The public sector bank boards are constituted with members nominated by the ruling political party, although these banks were corporatized in 1997. Moreover, trade unions in public sector banks, being backed by the ruling political party, force bank management to approve loan applications and other undue privileges; even sometimes they play an important role in appointing CEOs. In regard to financial reporting, irregularities are taking place because of the low quality and lack of integrity of the auditors and/or audit firms (Reaz and Arun, 2006). In many cases, audit firms are linked to the bank owners and, therefore, they prepare audit reports in a way the banks want them to do.

The internal audits however often discover fraudulent activities by executives mostly in public sector banks, but the offenders manage to stall punishment with the help of political or even trade union leaders. As such, sound corporate governance remains a key requirement for ensuring efficiency and productivity of the financial sector in Bangladesh.

2.4.1.2 Risk management

Risk management in banks is essential to identify and analyse risks and manage their consequences. Banks have been facing diversified and complex risks and uncertainty especially in the era of globalization. The Basel committee on bank supervision has advised to develop effective risk management capacity in five core areas. These are credit risk, asset and liability risk, foreign exchange risk, internal control and compliance risk and money laundering risk (Bangladesh Bank, 2012). Another argument is that bankers face generic types of risks, such as credit risk, interest rate risk, foreign exchange risk, liquidity risk, operating risk and capital adequacy risk (Uyemura and Van Deventer, 1993).

Credit risk is by far the most important risk in banking. The effect of significant credit losses causes a loss of liquidity and, also, reduces the true market value of bank assets. Hence, a critical issue is how credit administration and asset-liability management can be coordinated to insure proper returns to shareholders (Uyemura and Van Deventer, 1993). Similarly, many banks are encountering significant exchange rate risk due to involvement in increased international business transactions in the age of globalization.

The key element of a sound risk management system encompasses a risk management structure comprising bank board and senior management, organizational policies, procedures, adequate risk identification, measurement, monitoring, control and management information systems that are in place to support all business operations, internal controls and the performance of comprehensive audits (Bangladesh Bank, 2012).

Since risks can cause systemic threats and jeopardize the stability of the entire financial system, Bangladesh Bank has imposed prudential requirements to assess banks' risk management capacity. An independent risk management unit (RMU) is established in each bank to conduct stress testing for examining the bank's capacity to handle future shocks and deal with all potential risks that might occur at any time. Since banks in Bangladesh have started to follow risk management procedures very recently, the sector is not yet entirely protected from all kinds of possible financial risks.

2.4.1.3 Capital adequacy

The capital adequacy ratio measures the capacity of financial institutions to absorb losses and thus, indicates the financial strength. Two ratios are basically vital for banks: the capital adequacy ratio, which is regulatory capital funds as a percentage of risk-weighted assets; and the leverage ratio, which is total equity as a percentage of total on-balance sheet assets (Sophastienphong and Kulathunga, 2010). The 1988 Basel accord prescribes banks to hold capital at least 8 percent of their risk-weighted assets (RWA) to protect depositors and deposit insurance schemes from the consequences of reckless portfolio management by banks (Thadden, 2004). However, after several revisions of the accord, the capital requirement has increased to 10 percent of the RWA from 2009.

The risk-weighted asset (RWA) is calculated by assigning different risk weights against different categories of credit exposures of banks and financial institutions. Risk weights depend on the extent of risk possibilities involved with the credit exposures in respect of credit, market and operational risks (Bangladesh Bank, 2011b). However, an individual bank can use its own credit risk model for defining risk weights and capital requirements against the possible risk involved (Altman and Saunders, 2001).

The Bangladesh Bank has increased the capital adequacy requirement to 10 percent of total RWA from 2011, of which at least 50 percent of the required capital

must be Tier 1 capital following the BASEL Accord II (Bangladesh Bank, 2011b). There are three tiers of bank capital. Tier 1 capital is ‘core capital’, which comprises paid up capital, non-repayable share premium account, statutory reserve, general reserve, retained earnings, minority interest in subsidiaries, non-cumulative irredeemable preference shares and dividend equalization account. Tier 2 capital is ‘supplementary capital’, which consists of general provision, revaluation reserves: revaluation reserve for fixed assets, revaluation reserve for securities, revaluation reserve for equity instrument, all other preference shares and subordinated debt. Tier 3 capital is termed as ‘additional supplementary capital’, which includes short-term subordinated debt (original maturity less than or equal to five years but greater than or equal to two years) and, shall solely be meeting the capital requirements for market risk.

The negative capital position of the public sector banks has affected the banking sector of Bangladesh for a number of years. In recent time, the capital adequacy ratio for SCBs has become positive (but still not at the required level of 10 percent of the RWA), because of the valuation adjustment of the banks’ cumulative losses improves their balance sheets in a narrow sense. However, the capital adequacy ratio is negative for DFIs. Although the capital position of the SCBs has improved after the valuation adjustments, bringing in additional capital is important to improve their viability. Therefore, capitalization of public sector banks as well as some private sector banks should be actively pursued in order to increase the solvency and credit worthiness of the banks in Bangladesh.

2.4.2 Supervision

The primary role of bank supervision is to reduce the risk of capital loss to depositors. However, supervision fulfils a wider role in safeguarding the stability of individual banks and also of the banking system as a whole (Bangladesh Bank, 2011b).

The Bangladesh Bank as the central bank of the country derives its authority for supervision from various provisions: Bangladesh Bank Order 1972; Banking Companies Ordinance 1962, renamed as Banking Companies Act 1991(amended in 2003); Bangladesh Banks (Nationalization) Order 1972 and Foreign Exchange Regulations Act 1947. Supervision is conducted in order to attain certain objectives of banks in terms of solvency and liquidity, capital adequacy, proper management, productivity and profitability and balanced growth.

The Bangladesh Bank has introduced new asset classification and provisioning requirements and upgraded their rigor with an implementation schedule in line with the international standard. Apart from the traditional on-site bank examination by inspectors from the central bank, an off-site supervision arrangement (a separate department established in the central bank) has been put in place to collect and examine periodical returns and statements from banks on key variables affecting their financial health in order to detect and act upon early warning signs of trouble. The CAMEL ratings approach used by the Federal Reserve Systems of USA has been adopted for monitoring the healthiness of banks (Kazemi, 1998). The performance of banks is evaluated by grading them using 'CAMEL', a device judging five major indicators of banks (capital adequacy, asset quality, management, earnings and liquidity) on a scale of 1 to 5 in ascending order of performance deficiency (Kabir, 2004). For example, banks evaluated with CAMEL scores of 4 and 5 are considered as problem banks.

With a view to strengthening the prudential supervision and regulation, the Bangladesh Bank has made additional institutional reforms. These include revisions of capital adequacy ratios, deposit insurance, loan classification and provisioning modalities, Anti-Money Laundering Act, single-borrower exposure limit, appointment procedure of bank CEOs, introduction of a new loan ledger and International Accounting Standard (IAS-30) for scheduled banks and disclosure of financial information to public media.

2.4.2.1 Credit portfolio classification and provisioning policy

Banks and financial institutions in Bangladesh have been experiencing the burden of non-performing loans (NPLs) since 1970s. The total overdue loans in the banking sector stood about 30 to 70 percent of total loan portfolios at the end of June 1985 (GOB, 1986). The reason behind such a large extent of NPLs was mainly political influence on loan approval without examining the viability of the projects. Besides, faulty project appraisal in case of industrial lending, directed credit to non-prospective sectors, inadequate monitoring and supervision of the loan portfolio both from the part of the concerned bank and of the regulators and weak and lengthy legal framework of the country were responsible for the higher NPLs in banks.

At the advent of financial liberalization, a concerted package of further measures on several fronts has been initiated from 1989 in addition to the abolition of directed lending and interest rate liberalization. Banks were given new self-assessment criteria for mandatory periodic quality audit of their loan portfolios and new mandatory provisioning requirements to be made from current income against adversely classified loans. The Bangladesh Bank introduced rules for assessing loan quality and provisioning for classified loans in 1989. According to the rules, all loans were required to be classified into four categories, viz., unclassified, sub-standard, doubtful and bad/loss considering the duration of the overdue status. A revised policy for loan classification and provisioning was adopted effective from January 1999 with a view to attaining international standard. The revised policy emphasized independent assessment of each loan on the basis of qualitative factors and objective criteria. Table 2.1 presents a snapshot of loan classification and provisioning policy.

Table 2.1 demonstrates that broadly, loans which are overdue for six months and more are classified into three groups: sub-standard, if overdue period is 6 months and more but less than 9 months; doubtful, if overdue period is 9 months and more but less than 12 months; and bad debt, if overdue period is 12 months and more. Loans which remain overdue for 3 months and more but less than 6 months are considered as ‘special mention account (SMA)’ showing first sign of weakness.

Table 2.1: Loan classification and provisioning policy

Types of loan	Length of overdue	Classification status	Rate of provision (percent)
Continuous loan Overdue period will be accounted from the day following the date of expiry of such loan.	Less than 6 months	Unclassified	1
	6 months or more but less than 9 months	Sub-Standard	20
	9 months or more but less than 12 months	Doubtful	50
	More than 12 months	Bad/loss	100
Demand loan Overdue period will be accounted from the day following the date of expiry of such loan.	Less than 6 months	Unclassified	1
	6 months or more but less than 9 months	Sub-Standard	20
	9 months or more but less than 12 months	Doubtful	50
	More than 12 months	Bad/loss	100
Term loan payable within 5 years Overdue period will be accounted from the day following the date of expiry of the due date of payment of instalment of such loan	If default amount of instalment is equal to instalment payable in 6 months	Sub-Standard	20
	If default amount of instalment is equal to instalment payable in 12 months	Doubtful	50
	If default amount of instalment is equal to instalment payable in 18 months	Bad/loss	100
Term loan payable more than 5 years Overdue period will be accounted from 6 months following the expiry of the due date of payment of instalment of such loan	If default amount of instalment is equal to instalment payable in 12 months	Sub-Standard	20
	If default amount of instalment is equal to instalment payable in 18 months	Doubtful	50
	If default amount of instalment is equal to instalment payable in 24 months	Bad/loss	100
Short-term agri credit/micro-credit Overdue period will be accounted from 6 months following the expiry of the due date of payment of instalment of such loan.	Less than 12 months	Unclassified	5
	12 months or more but less than 36 months	Sub-Standard	5
	36 months or more but less than 60 months	Doubtful	5
	More than 60 months	Bad/loss	100

Source: Financial Sector Review (Bangladesh Bank, 2006)

An appropriate provisioning policy is instrumental in reflecting asset impairment fairly and, taking appropriate measures before signalling any major setback in the banking sector. As described in Table 2.1, the policy requires maintaining provisions against both unclassified and classified loans. The required provisions are: 20 percent (of the risk-weighted assets on relevant loan category) for sub-standard, 50 percent for doubtful loans and 100 percent, if the loan status is bad/loss. Besides, one percent provision should be kept against all unclassified loans as a precautionary measure. However, classification policy and provision requirement is different for short-term agricultural and micro credit loans (Table 2.1).

In 2003, the Bangladesh Bank introduced a write-off policy allowing banks to write-off loans that have been classified as ‘bad/loss’ and advising to maintain a separate account for the ‘bad/loss’ amount for five years and, also 100 percent provision following the loan classification regulation.³ If the provision amount is not sufficient to write-off bad loans, banks may write them off by debiting their current year’s income account as well. However, banks will require, if no legal action has been initiated earlier, filing a case in the court of law before writing off a bad loan. A separate debt collection unit shall be responsible for collecting the written-off loans. Despite writing off the loans, the concerned borrower shall be identified as ‘defaulter’ as usual and be reported to the credit information bureau (CIB) of the central bank. In spite of all these initiatives, the ratio of NPLs to total loan portfolio is still high especially in the state-owned commercial and development banks. The ratios are 22.2 and 32.8 percent respectively for commercial and development banks at the end of 2014 (Bangladesh Bank, 2014b). As a result, public sector banks have

³ According to the circular issued by the banking regulation and policy department (BRPD) of Bangladesh Bank dated 2 January 2003

been suffering from capital shortfall and lacking capacity to finance investment projects.

2.4.3 Banking policy issues

Bangladesh Bank initiated a series of banking policy reforms since the mid-1980s with a view to ensuring an efficient financial sector. This section contains discussion of various banking policy reforms, for example, introduction of independent monetary policy instruments, market determined interest rate, elimination of credit controls (with few exceptions), ease of foreign exchange transactions, strengthening the legal framework on financial matters and adoption of technology driven banking products and services.

2.4.3.1 Monetary policy

The Bangladesh Bank does not enjoy much autonomy. Like many other developing countries, monetary policy is largely determined by the government to complement its other objectives. The monetary policy of Bangladesh aims at maintaining relative price stability through controlling inflation, restoring equilibrium in balance of payments, promoting employment and economic development, ensuring productive use of resources, seeking adequate credit flows to the priority sectors and promoting social justice (Bangladesh Bank Order 1972).

There are some apparent conflicts between these objectives. If too much emphasis is placed on promoting employment through reducing unemployment, this may generate inflationary pressure. Again, if in an effort to restore equilibrium in balance of payments, imports are drastically cut, which may affect development and price stability due to serious underutilization of industrial capacity on account of shortage of imported raw materials (since food import usually cannot be reduced unless huge food production). Similarly, a limited inflationary financing may be conducive to development, but this may run counter to the objective of price stability. Apart from this, ensuring adequate credit flow to the priority sectors may

not always be compatible with the overall objective of containing domestic credit expansion. Therefore, monetary policy aims at harmonization of the above objectives as far as possible.

In a decentralized market economy, the central bank does not have much direct control over inflation, employment, economic growth or external balance. These goals are, however, influenced by monetary variables, credit for example, and therefore, may be selected as an intermediate target of monetary policy (Taslim, 2001). The central bank may use its monetary instruments, open market operation or discount rate to achieve that intermediate target. However, the Bangladesh Bank formalized the monetary policy framework in the late 2005 incorporating growth target in its stated objective. Another unstated objective of the monetary policy, to maintain a stable nominal exchange rate becomes crucial especially after shifting from pegged exchange rate system to floating exchange rate system in April 2004.

Prior to the financial reform initiated in the late 1980s, the monetary policy performance revealed mixed experiences in both monetary and real sectors in the economy. The actual rate of domestic credit expansion was higher than the rate programed for most of the years except in 1976-77, 1981-82 and 1982-83. In some years, the behaviour of the foreign sector turned out to be significantly different from what was projected; substantial surplus being recorded which created a difficulty in keeping the monetary expansion within the target. The rate of expansion in broad money exceeded the real GDP growth rate except in 1974-75. The rate of credit expansion to the public sector markedly increased to 54.10 per cent in 1974-75 since all the sectors were nationalized during that period. In contrast, the role of the private sector remained limited. However, there was marked increase in the rate of expansion in credit to private sector in the late 1980s because of the adoption of liberal policy on private sector investment (GOB, 1986).

The central bank implemented liberalized monetary policy with indirect control over money supply in the early 1990s after the financial reform program initiated. The instruments of direct control (credit ceilings and interest rate

prescriptions) were no longer available for attaining the targeted levels of domestic credit; instead new instruments of indirect control had to be adopted. In the new environment, the central bank has the rediscounting rate (bank rate), reserve and statutory liquidity requirements and open market operations (bills auctions) to influence money supply and net domestic credit. A 'reserve money programing' routine has been adopted as the monetary targeting framework aimed at matching the supply of reserve money (currency and cash balance of commercial banks with the central bank) with the projected demand for money in the economy. Apart from using the rediscounting rate and the reserve/statutory liquidity requirements, regular periodic auction of central bank bills (later government treasury bills) was introduced as a means of regulating liquidity in the banking system. The Bangladesh Bank introduced repo (repurchase agreement) and inter-bank repo operations in order to manage liquidity positions in the money market and thus strengthened indirect monetary operations.

2.4.3.2 Interest rate structure

The interest rates were generally kept at a low level in the 1970s reflecting the Mckinnon-Shaw (1973) financial liberalization hypothesis of financial repression in a developing economy. The real rates of return on term deposits were negative in most of the years during this decade (Kazemi, 1998). The objective of these controls was to limit the cost of financial intermediation with a view to enforcing a reasonable structure of lending and deposit rates. The range of interest rates on savings and other deposits remained unchanged at 3-6 percent, having a weighted average rate of 4 percent, while the lending rates ranged between 7.50 and 10 percent (GOB, 1986). The directed interest rate regime was also believed conducive to mobilizing adequate savings, investment spending, and eventually delivering higher economic growth.

To bring back an environment where financial institutions can mobilize savings and efficiently allocate resources to optimally yielding investments, three major reforms were simultaneously put in place from 1990, viz. interest rates liberalization, abolition of directed lending and sectoral refinancing from the central

bank. Under interest rate liberalization, banks were left free to set their own deposit and lending interest rates, initially within prescribed bands. In 1992, the Bangladesh Bank accelerated the interest rate flexibility eroding interest rate bands in all sectors except loans for agriculture and exports and term loans to small and cottage industries and, also abolished sector-specific concessional refinance facility. Besides, banks were given freedom to decide on the rates of non-interest fees and commissions for various banking services by themselves. However, abolition of central bank refinancing meant that banks no longer had first resort access to central bank funding and, had to mobilize deposits actively and/or to borrow from inter-bank money market which would reward deposit mobilizers with attractive market clearing interest rates.

A high interest rate spread (gap between lending rate and deposit rate) is indicative of high cost of financial intermediation. To a degree, the spread reflects institutional inefficiencies. The inefficiency originated from the government's 'interventionist policies' of the past and inadequate technical skills in the arena of risk and portfolio management, both of which are the major contributing reasons behind the high non-performing loan ratios (i.e., NPLs) and, consequently, high interest rate spread in Bangladesh. The average spread was 5.21 percent in 2014 (Bangladesh Bank, 2015). A lowering of the high interest rate spreads would require substantial improvement in the current situation of overstaffing, high administrative costs and the burden of NPLs.

2.4.3.3 Legal reforms

Prior to 1990, the legal enforcement side was very complicated and time consuming. As such, wilful defaulters always preferred to go to court, which would help them stay safe for a long time. Consequently, banks failed to settle any dispute or recover default loans within a reasonable time frame. This complex legal structure was liable for huge NPLs and thus capital shortfall was a common phenomenon in public sector banks as well as in some denationalized private banks. However, as part of legal reforms, the Money Loan Courts Act, 1990 was enacted and special courts were

instituted thereunder exclusively for the trial of loan recovery cases. Recent further amendment to the Act (amended in 2003) has empowered these courts to enforce their own decrees (which earlier required separate civil court proceedings). Provisions have been made for 'Alternative Dispute Resolution' to ensure early settlement of disputes through settlement, conference and negotiation.

The 'Bankruptcy Act, 1997' enacted in supersession of the insolvency Act 1920, facilitates dealing with long defaulted loans on the books of banks. Separate bankruptcy courts have been set up to deal with delinquent big defaulters. Apart from this, 'Money Laundering Prevention Act 2002' was enacted in April 2002 against the backdrop of the 9/11 incidence in the USA and, further amended twice in 2008 and 2011 incorporating some additional provisions for the prosecution of terrorist financing.

Moreover, the 'Banking Companies Act 1991' (amended in 2003), replacing the previous statute of 1962, includes provisions intended to prevent excessive build-up of insider lending and single party exposure; viz., loans to a bank's own directors to be limited to 10 percent of the bank's total advances and, to be reported regularly to the central bank; single party exposures exceeding 15 percent of a bank's total capital to require prior central bank approval and not to exceed 100 percent of the total capital in any case; write-offs on loans to bank's own directors to require prior central bank approval; bank directorship liable to cancellation by central bank directive on the ground of loan default. Similar provisions have been included in the statute, the 'Financial Institutions Act 1993' enacted to regulate the non-bank financial institutions (FIs). Besides, obtaining of a report from the central bank's 'credit information bureau (CIB)' has been made mandatory for all loans of Taka 5.0 million or above; a lending risk analysis (LRA) procedure has been made mandatory for all loan proposals of Taka 10.0 million or more. Disclosure of financial information of banks and financial institutions to the stakeholders has been another reform measure, where banks and financial institutions are supposed to disclose balance sheet and other financial statements in public media every six (6) months.

2.4.3.4 Foreign exchange policy

Foreign exchange policy has been eased particularly at the advent of globalization in the early 1990s to facilitate trade and investment (both FDI and portfolio). In 1975, a 58 percent devaluation of Taka took place for several reasons; to correct for accumulated large misalignment and multiple exchange rates practices existed up to 1991; to compensate foreign exchange earners for the rigidities in official rate adjustments (Kazemi, 1998). However, from January 1992, exchange markets were unified, with one single pool of receipts from all sources, which is accessible freely for all permissible purposes at rates based on the market clearing exchange rate prevailing in the inter-bank market. Concomitant with rapid trade liberalization, restrictions on current external settlements were brought down rapidly in the early 1990s and, the Taka attained full current account convertibility as per IMF Article VIII definition by April 1994. In 2003, the Taka was floated to ensure greater flexibility in foreign exchange transactions.

The Taka is now freely convertible for specified capital account transactions involving non-residents; inflows of direct investment in the industrial sector and of portfolio investments from non-residents. The outflows representing repatriation of these investments along with capital gains are also free of restrictions. The objectives of the move are three fold: to create confidence and economic management; to facilitate international trade and support trade liberalization; and to link the economy with international markets, particularly financial markets. BB's role in direct approval of foreign exchange transaction has gradually reduced.

2.4.3.5 Reforms in the central bank

Strengthening the Bangladesh Bank (central bank) is an important element of the financial reform. The Bangladesh Bank (BB) is being strengthened through a project (financed by the World Bank), which includes restructuring of the different departments of BB; capacity building in the core departments: monetary policy, banking regulation and research; computerization of its operations; and human

resources development through reforms in recruitment and promotion policies. In order to encourage greater operational efficiency, the 'Bangladesh Bank Order 1972', the 'Bangladesh Banks (Nationalization) Order 1972' and the 'Banking Company Act, 1991' have been amended in 2003. The amended Bangladesh Bank Order redefines the central bank's functions in a more focused way, by giving it enhanced authority and, makes it accountable for its performance. The 'Bangladesh Banks (Nationalization) Order 1972' has been amended with a view to improving the governance of state-owned commercial banks (SCBs). The Bangladesh Bank has been empowered more to regulate and supervise the banking sector with the amended 'Banking Company Act 1991'. The central bank has also been given the responsibility of regulating and supervising the non-bank financial institutions by the 'Financial Institutions Act 1993', which has provisions for cash reserve requirement, limits and central bank surveillance on large single party exposures and director's loans.

The Bangladesh Bank has been implementing major on-going institutional reforms including commissioning of enterprise resource planning solutions (ERP), banking and data warehouse facilities with all BB offices in an online integrated IT platform. BB also has undertaken extensive and sustained training programmes, higher education programmes for its staffs for upgrading of skills and acquisition of technical knowledge of markets demanded by the new environment.

The enterprise resources planning (ERP) solution covers digitization of procurement (e-procurement), cash management and access control. Meanwhile, the recruitment process under the Bangladesh Bank has been digitized (online application, sorting, validation etc.). Besides, automation has been done for all the accounts of banks, financial institutions and the government with Bangladesh Bank, foreign exchange management, currency management, treasury and securities systems/module, public debt management module, and establishment of a central depository system (CDS) to build a platform for secondary trading of treasury bills and bonds. The enterprise data warehouse (EDW) creates an electronic data bank

which provides information and statistics of monetary, trade and fiscal areas of the national economy for further policy analyses.

2.4.3.6 Credit information bureau (CIB)

Credit Information Bureau (CIB) was set up in the Bangladesh Bank in 1992 (which came into operation in 1993) to restore credit discipline and to provide reliable information regarding the credit worthiness of borrowers. CIB reports have been available online since June 2011. Lender banks and financial institutions are allowed to access the central CIB data base of BB and thus obtain the credit report of the concerned borrower quickly. Online CIB is expected to minimize the extent of default loans by providing accurate credit reports about the borrowers. Hence, lending institutions would not encounter any credit risk while extending loans or rescheduling loans and advances.

2.4.3.7 Technology-driven banking

Payment systems are the means by which funds are transferred between banks. A well-designed payment system can contain the transmission of shocks and limits adverse consequences of vulnerabilities. Banks including state-owned banks have been gradually adopting advanced banking technology in banking services. There are three different modes of payment and transactions available in banking in Bangladesh: cash transaction, transaction through clearing and transaction through transfer.

Compared to other two kinds, cash transaction is predominant medium of payment in Bangladesh banking. The transaction through clearing is the settlement of non-cash payment instruments such as cheque, drafts and payment orders. The third category, transactions through transfer include fund transfer between the accounts of the same bank and also inter-bank transfers.

Table 2.2: Payment instruments offered by banks in Bangladesh

	Traditional		Modern (Technology driven)
SCBs	Local currency Bank Cheque Demand Draft Payment Order Telegraphic Transfer	Foreign currency Bank Cheque Demand Draft Travellers' Cheque Telegraphic Transfer	Both local and foreign currency Debit Card ATM SWIFT
DFIs	Bank Cheque Demand Draft Payment Order Telegraphic Transfer	Bank Cheque Demand Draft Travellers' Cheque Telegraphic Transfer	 SWIFT
PCBs & FCBs	Bank Cheque Demand Draft Payment Order Telegraphic Transfer	Bank Cheque Demand Draft Travellers' Cheque Telegraphic Transfer	Net Banking (e-banking) Mobile Banking Debit Card Credit Card Pre-paid gift Card POS ATM SWIFT ROUTER

Source: Annual Report (Bangladesh Bank, 2014a); Note: SCBs= State-owned commercial banks, DFIs = State-owned development banks; PCBs= Private commercial banks; FCBs= Foreign commercial banks

Table 2.2 shows different types of transactions and payment products offered by banks in Bangladesh. Table 2.2 reveals that there are two types of non-cash

transaction instruments: traditional and modern (technology driven). The existing traditional products include cheque, demand draft, payment order, telegraphic transfer, mail transfer and bills. Banks have introduced technology driven non-cash transaction instruments, such as debit card, credit card, ATM (automated teller machine), POS (point of service) , SWIFT, net banking (e-banking) and mobile banking, particularly in the post-reform period.⁴

The Bangladesh Bank established an automatic clearing system ‘Bangladesh automated clearing house (BACH)’ for payment and settlement of bank instruments in January 2011. Applying sophisticated technology, the system needs only images and corresponding information of the submitted bank instrument instead of physical one. As a result, cheque clearing time is down to a single day for countrywide payment. Bangladesh Bank also has introduced e-banking recently. Banks are allowed to make online money transactions, payment of utility bills through internet, transfer of funds (account to account), payments for trading goods and services and online credit card payments in local currency.

Introduction of innovative technological solutions, such as mobile phone banking has accelerated the financial inclusion process in Bangladesh. Mobile banking (m-banking) extends banking services to the door step of the unbanked people in the remote areas across the country. A total of 16 commercial banks have received approval for mobile banking operation using the outlets of mobile

⁴ POS is an electronic device which identifies special plastic cards encoded with information on a magnetic strip. The device functions as a receiving desk of cash counter of a bank branch. SWIFT stands for ‘Society for Worldwide Interbank Financial Telecommunications’, which is a global network that facilitates 24-hour secure international fund transfer through banking channel.

companies. It helps accelerate inward remittance extending banking services to the rural people.

Although the financial liberalization program was initiated in the late 1980s aiming for increased financial intermediation and efficiency of the financial institutions, the expected outcome is yet to be achieved. The efficiency of the sector remains as issue particularly due to non-performing loans and high intermediation cost. The management of both public and private sector banks are not free from undue influences. Bangladesh Bank as a regulatory authority also has not been entrusted with absolute autonomy. Consequently, an independent monetary policy execution is still far from the reality. However, modernizing the banking infrastructure and payment systems are expected to reduce systemic risks and increase efficiency.

Comprehensive guidelines on corporate governance issues need to be fast-tracked. There is a need for clearly defined legal provisions governing beneficial ownership, minority shareholder rights, remuneration of directors, and roles and responsibilities of external and internal auditors. Besides, full conformity to the international accounting and auditing standards should be actively pursued.

2.5 Performance of the banking sector

This section evaluates the performance of the banking sector in response to the policy changes due to financial reforms. The analysis explains the patterns of structural changes in sectoral credit allocation, deposit mobilization and transformation of asset structure of the banking sector in Bangladesh during pre- and post-reform periods.

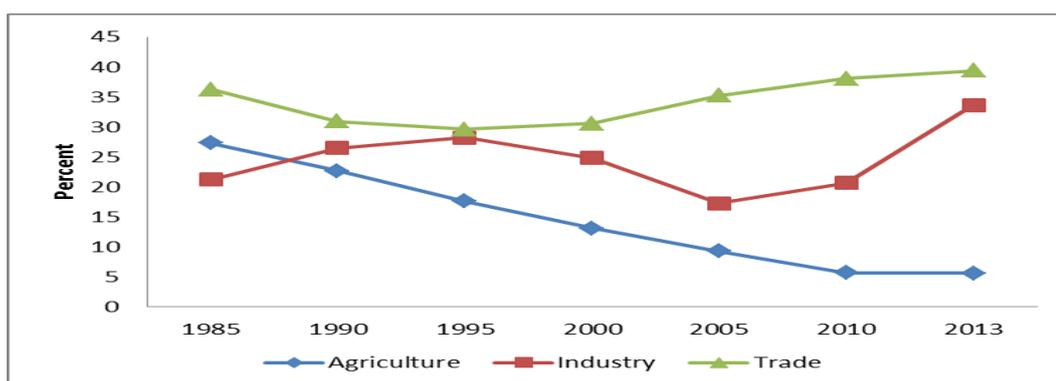
2.5.1 Sectoral credit distribution

The sectoral credit allocation pattern is perhaps the most important aspect to look at after abolition of directed lending. Figure 2.5 presents a pronounced post-reform shift

from agriculture to industry and trade. The shift from agriculture is consistent with the structural transformation of the economy where the overall share of agriculture in GDP is declining from 33.2 percent in 1980 to 16.3 percent in 2014, while the contribution of industrial sector rises from 17.1 percent to 29.6 percent during the period 1980-2014 (BBS, 2014).

Figure 2.5 demonstrates that the banks are extending more credit to trade finance and industrial sector shifting funds from the agriculture sector. Therefore, a paradigm shift in bank finance, from development oriented agrarian sector to profit maximizing manufacturing sector has been observed in the post-reform period. The share of agriculture in bank advances declined from 27.3 percent in 1985 to 5.6 percent in 2013.

Figure 2.5: Sectoral allocation of bank credit



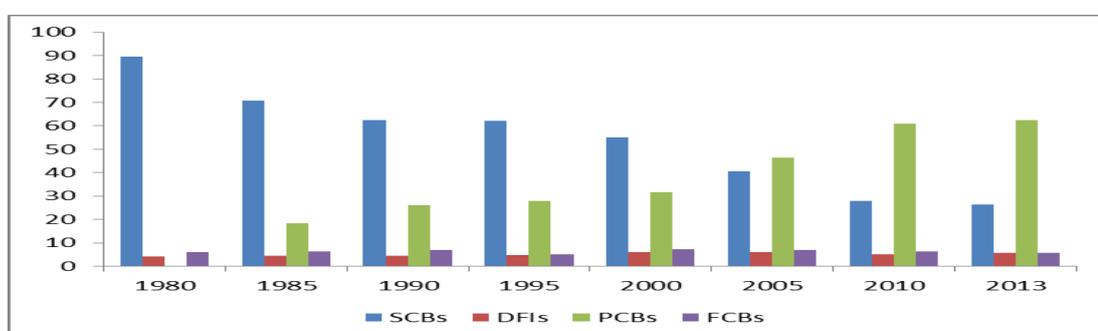
Source: Schedule Bank Statistics(Bangladesh Bank, 2014c); Note: values are as of 31st December of the respective years

2.5.2 Savings mobilization

The growth of output depends on capital accumulation, which in turn requires investment and an equivalent amount of savings to match it. The expansion of bank branches increases the extent of financial development and financial deepening with concentration of deposit and loans in Bangladesh. However, there are concerns about the weakness of term savings mobilization by banks and, also weakness of capital

markets in attracting savings toward investments in bonds and equities. Banks have been unable to raise long-term deposits in volumes sufficient to match the demand for long-term loans. During the period 1994-95, the state-owned commercial banks used their large liquidity overhangs from short-term deposits in making industrial term loans (Kazemi, 1998). Therefore, maturity mismatch between liabilities and investment assets landed them into considerable liquidity difficulties shortly afterwards. The limited success of banks in raising longer term deposits is attributable to the above-market interest rates offered by the government's own national savings scheme instruments of comparable maturity, along with tax breaks that are unavailable on bank savings.

Figure 2.6: Deposit share of different types of banks, 1980-2013



Source: Schedule Bank Statistics (Bangladesh Bank, 2014c); Note: values are as of 31st December of the respective years; SCBs= State-owned commercial banks, DFIs = State-owned development banks; PCBs= Private commercial banks, FCBs= Foreign commercial banks

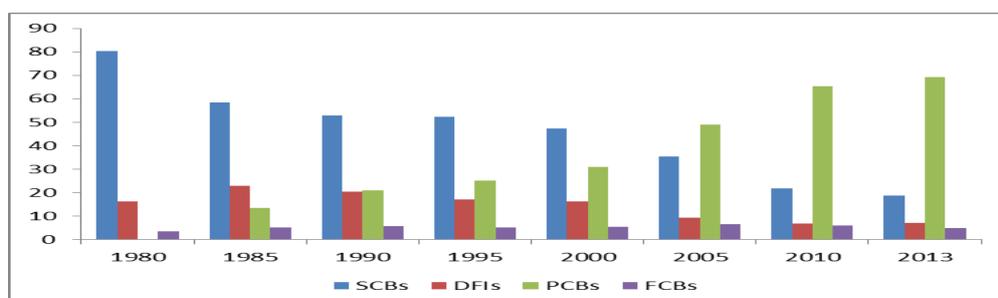
Figure 2.6 shows that deposit mobilization by banks gradually shifts from public sector banks to private sector banks in the post-reform period. The deposit mobilization of FCBs and DFIs are of similar magnitude and pattern during the period 1980-2013. On the other hand, deposit share shifts from state-owned commercial banks (SCBs) to domestic private banks (PCBs), particularly after financial liberalization in 1990. The deposit share of SCBs was 89.5 percent in 1980 (when there were no PCBs in Bangladesh), which declined to 26.4 percent in 2013. The trend in deposit mobilization demonstrates that PCBs have been consistently performing better in deposit collection after the allowance of private sector banking in the mid-1980s. Therefore, the deposit share increased from 18.4 percent in 1985 to

62.5 percent in 2013, perhaps due to gaining increased confidence of the depositors and, providing technology driven cost-effective banking products and services.

2.5.3 Asset Structure

The banking sector alone accounts for 90 percent of the total financial sector's assets (Shah, 2009). The dominance of the state-owned commercial banks is declining, while private sector banks, particularly PCBs, have been gaining asset market share in recent years, reflecting a gradual shift of the financial assets from public sector banks to private sector banks. Figure 2.7 depicts the asset transformation of the banking sector in Bangladesh during the pre- and post-reform period, 1980-2013.

Figure 2.7: Asset transformation of banks, 1980-2013

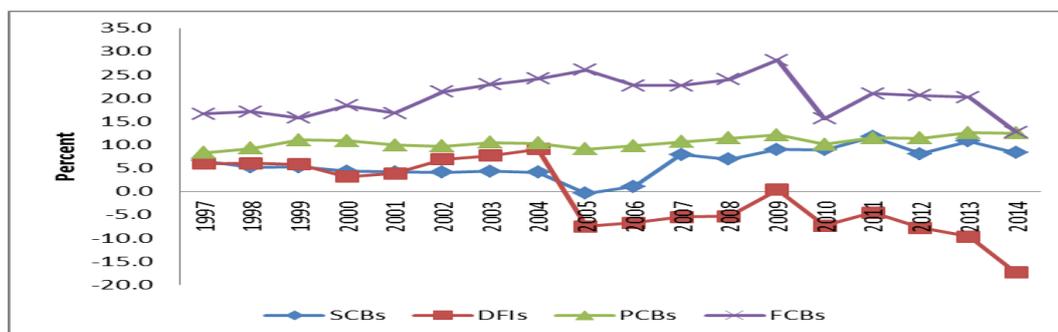


Source: Schedule Bank Statistics, Bangladesh Bank; Note: values are as of 31st December of the respective years; SCBs= State-owned commercial banks, DFIs = State-owned development banks; PCBs= Private commercial banks, FCBs= Foreign commercial banks.

Figure 2.7 reveals that the asset share of SCBs declined sharp from 80.2 percent in 1980 to 18.8 percent in 2013. A similar pattern is observed for DFIs declining from 16.2 percent to 7.0 percent during the period, 1980-2013. However, the asset structure of FCBs remains at the same magnitude. The private sector banks have overtaken their public sector counterparts, capturing 13.5 percent of the total banking assets by 1985, as PCBs were allowed to start banking operations in 1983, and have been increasing the holdings of banking assets, reaching 69.2 percent by the end of 2013. However, the asset structure does not provide the full information about the real strength of the banks.

The capital adequacy ratio reveals the capacity of a bank to protect its depositors and other creditors from the potential shocks or losses that banks might incur. Hence, adequate capital helps absorbing all possible financial risks such as credit risk, market risk, operational risk, interest rate risk and liquidity risk. Following the Basel recommendations, banks in Bangladesh are obligated to maintain a minimum capital of Taka 4.0 billion or 10 percent of the risk-weighted assets (RWA) whichever is higher, effective from 2011. However, an individual bank can determine its level of capital (using its own model or measure), which would be adequate to compensate all possible risks involved with the business. Figure 2.8 shows the capital to risk-weighted assets ratio of banks during the period, 1997-2014.

Figure 2.8: Capital adequacy ratio of banks in Bangladesh



Source: Bangladesh Bank Quarterly (Bangladesh Bank, 2014b), Annual Report (Bangladesh Bank, 2014a); Note: SCBs= State-owned commercial banks, DFIs = State-owned development banks; PCBs= Private commercial banks, FCBs= Foreign commercial banks.

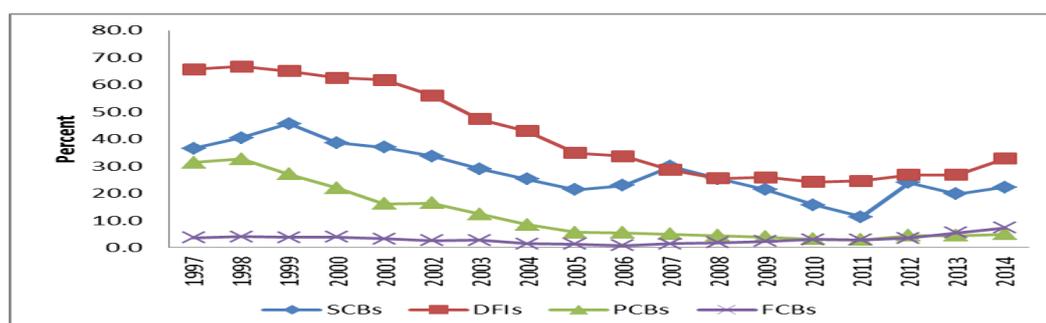
Figure 2.8 demonstrates that there is capital shortfall in public sector banks as the capital adequacy ratio remains below the level of 10 percent of the risk-weighted assets. The capital shortfall for DFIs has been negative since 2005. Therefore, the state-owned banks are virtually unable to absorb any financial risk or shock. Perhaps the increased volume of NPLs is the main reason for the insolvency as low quality of asset portfolio bears high risk weightage. Due to significant increase in classified loans for two SCBs (Sonali and Rupali) and three DFIs (Bangladesh Krishi Bank, Bangladesh Small Industries and Commerce Bank and Rajshahi Krishi Unnayan Bank), the capital shortfall becomes so large for public sector banks (Bangladesh

Bank, 2014a). However, private sector banks (both domestic and foreign) maintained the required capital adequacy ratio during the period, 1997-2014.

2.5.4 Asset Quality

The solvency risk of a financial institution often originates from the quality of its asset portfolio. An indicator of asset quality is the ratio of non-performing loans to total loans. The non-performing loans (NPLs) have been constituted a larger portion of total bank assets (loans and advances) for a long time in the banking sector in Bangladesh. However, a declining trend in the ratio of NPL to total loans for both public and private sector banks is observed since the late 1990s due to substantial amount of bad loan write-off in the post-reform period. Figure 2.9 shows the asset quality of different types of banks in Bangladesh.

Figure 2.9: NPL to total loans ratio of banks in Bangladesh



Source: Bangladesh Bank Quarterly (Bangladesh Bank, 2014b), Annual Reports (Bangladesh Bank, 2014a); Note: SCBs= State-owned commercial banks, DFIs = State-owned development banks; PCBs=Private commercial banks, FCBs= Foreign commercial banks.

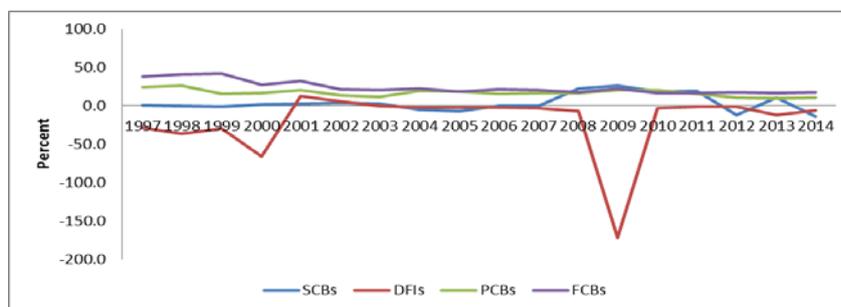
It is evident from Figure 2.9 that the NPL ratio is still high, 22.2% for SCBs and 32.8% for DFIs in 2014 (Bangladesh Bank, 2014a). The main reason for such high NPL ratio for SCBs and DFIs is directed credit on poorly appraised projects. The public sector banks were used to bailout state-owned enterprises (Salim, 1999). Unlike private banks, public banks face a ‘soft budget constraint’. The bank lending goes to politically motivated projects which are not economically viable resulting

high NPLs. The principal and interest losses emanating from NPLs have precluded profitable operations resulting enormous capital deficiencies.

2.5.5 Earnings and Profitability

Earnings and profitability determines the capacity to absorb losses by building an adequate capital base and expansion of the banking business. Although there are various measures of earning and profitability, however, return of equity (ROE) and return of assets (ROA) are widely used to assess the scope for bank's earnings to offset losses relative to capital or assets, and their (bank's) efficiency in using capital or assets.

Figure 2.10: ROE of banks in Bangladesh



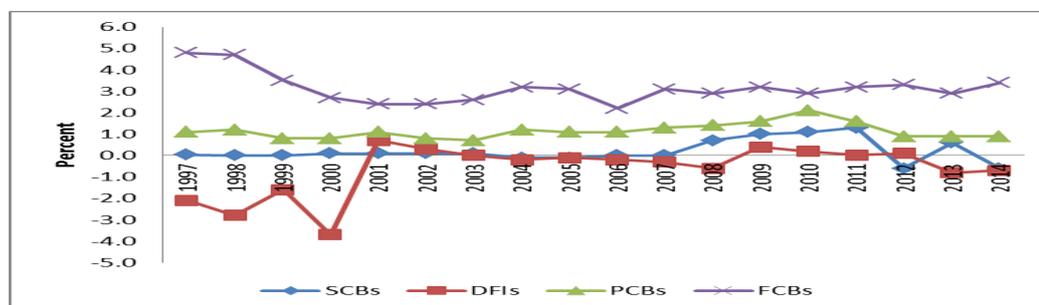
Source: Bangladesh Bank Quarterly (Bangladesh Bank, 2014b)Annual Report(Bangladesh Bank, 2014a); Note: SCBs= State-owned commercial banks, DFIs = State-owned development banks; PCBs= Private commercial banks, FCBs= Foreign commercial banks

ROA, measured as the ratio of total net profits and total assets, reflects how well a bank's assets are managed. Therefore, a better managed bank has higher ROA. On the other hand, ROE is the rate of return that management earns on the equity capital provided by the owners of a bank. It is measured as the ratio of total net profits and total equity capital. Figure 2.10 presents the ROE and Figure 2.11 shows the ROA of different banks in Bangladesh.

Figure 2.10 and Figure 2.11 demonstrates that the foreign banks (FCBs) perform the best compared to their competitors in terms of earnings and profitability measured by ROA and ROE. Of late, the PCBs have started to close the gap with

FCBs in earning profits. The figures indicate that ROA and ROE differ largely within the industry.

Figure 2.11: ROA of banks in Bangladesh



Source: Bangladesh Bank Quarterly (Bangladesh Bank, 2014b)Annual Report(Bangladesh Bank, 2014a); Note: SCBs= State-owned commercial banks, DFIs = State-owned development banks; PCBs= Private commercial banks, FCBs= Foreign commercial banks

The ROA of the SCBs has been less than industry average because of provision shortfall and that of DFIs even worse. The ROA of PCBs shows consistently strong position during the period 1997-2010, and that of FCBs has been much higher than industrial average. However, a relatively declining trend in ROA has been observed for both PCBs and FCBs during the past four years, 2011-2014. On the other hand, the pattern of ROE for SCBs shows instability; ROE was 6.9 percent in 2005 and again rose to 18.4 percent in 2010 and then went down to negative in 2014 perhaps owners’(i.e., government) equity increased comparatively at a higher rate than after tax profit.

In case of DFIs, both ROA and ROE remains negative; the main source of such inefficiency is negative net interest income (NIM). In fact, interest expenditures are higher than interest earnings for DFIs because higher non-performing assets cause substantial loss in revenue generation. The FCBs and the PCBs have been maintaining a steady and higher ROE during the past two decades, which signals growing competition between both types of banks.

2.5.6 Technology driven banking

Information and communication technology (ICT) has substantially transformed the banking industry in Bangladesh during the post-reform period. Introduction of technology driven innovative banking products and services, such as debit card, credit card, net banking (e-banking), mobile banking and use of ATM has emerged as convenient strategy for banks to attract customers. Table 2.3 provides the number of ATM booths and POS (point of service) terminals of different banks installed in Bangladesh in the period, 1998-2013.

Table 2.3: ATM booths and POS terminals of banks in Bangladesh

	1998		2000		2005		2010		2013	
	ATM	POS	ATM	POS	ATM	POS	ATM	POS	ATM	POS
SCBs	0	0	0	0	2	0	14	0	75	0
DFIs	0	0	0	0	1	0	4	0	9	0
PCBs	0	0	0	1	15	7	2872	2438	4966	22,224
FCBs	1	0	2	0	4	0	101	0	182	0

Source: Annual Reports of Banks in Bangladesh; Note: SCBs= State-owned commercial banks, DFIs = State-owned development banks PCBs= Private commercial banks, FCBs= Foreign commercial banks.

The FCBs have played the pioneering role in adopting ICT based innovative technology in banking services in Bangladesh in the 1990s. Table 2.3 exhibits that neither the public sector banks nor the domestic private sector banks had any ATM booths until 2000. This reveals the fact that these banks could not provide any bank card (debit or credit) to their customers. Only foreign banks had ATM booths. However, PCBs introduced technology based banking products and services in a limited scale in 2000 to keep pace with market competition. As a result, currently, the PCBs are leading the market in terms of number of ATMs and POS. The public

sector banks, both SCBs and DFIs have been gradually increasing the number of ATMs in order to keep pace with the increased demand.

2.6 Conclusion

This chapter provides an overview of the financial sector in Bangladesh in the context of financial reforms initiated in the late 1980s. Although the banking sector is burdened with non-performing loans because of management inefficiency, corruption, and political interference on loan portfolio decisions, the allowance of private sector banking operation creates competition in the sector. Both the public and private sector banks have been using advanced technology in providing competitive banking services particularly in the post-reform period. However, banks need to be capable enough to comply with the prudential regulations and supervisions following the international banking regulations. For example, public sector banks' insolvency results non-compliance of the Basel accord. Besides, most of the banking institutions in Bangladesh are lacking corporate governance structure as recommended by the Basel committee. In fact, poor governance and political instability discourage financial deepening in developing countries like Bangladesh (Addison et al., 2002). Hence, increased efficiency and productivity of the financial institutions is crucial for the development of the sector, which in turn is expected to promote economic growth. The subsequent chapters of the thesis examine the efficiency and productivity prospects of the banking sector in Bangladesh.

Chapter 3

Financial liberalization, banking efficiency and productivity growth: a review of the literature

3.1 Introduction

Banking efficiency and productivity continue to be important issues in the economics and finance literature, especially at the onset of financial liberalization and globalization of financial markets. Efficiency measures how well a system generates the maximum output from a given set of inputs, while productivity growth is measured as the difference between the growth of output and the growth of inputs, i.e., it is the growth of output not attributable to the growth of inputs. Farrell (1957) is the pioneer in constructing the measurement of technical efficiency in terms of realized deviations from an idealized frontier isoquant. Similarly, the measurement of productivity growth goes back to the pioneering works of Abramovitz (1956) and Solow (1957) where productivity change, either across producers or through time, is a residual. There is an extensive literature investigating the effect of financial deregulation on banking efficiency and productivity growth. These have been dominated by studies in the competitive banking markets of the USA, Europe and other developed countries.

From the mid-1970s onward many developing countries, most notably in Latin America (e.g., Argentina, Brazil, Columbia, Chile, Mexico and Uruguay) and also in Asia (e.g., Bangladesh, Indonesia, India, Malaysia, Philippines, Pakistan, South Korea, Sri Lanka and Thailand), have implemented various financial sector reform programs (FSRPs). Studies on efficiency and productivity of financial institutions have become critically important, especially in the developing country context due to increased competition in the financial market in a liberalized environment. Both parametric and non-parametric techniques have been followed in the literature to measure efficiency and productivity change. The parametric approach, such as the stochastic frontier analysis (SFA), was pioneered by Aigner et

al (1977) and Meeusen and Boreck (1977). And the non-parametric approach, such as data envelopment analysis (DEA), was suggested by Charnes et al. (1978) and extended by Färe and Lovell (1978).

This chapter reviews the literature on efficiency and productivity growth focusing on banking institutions. It explores the pertinent theoretical and empirical literature linking financial deregulation with bank performance and, provides rationales for the approaches to be followed in empirical analyses in subsequent chapters of this thesis.

The remainder of the chapter unfolds as follows. Section 3.2 explains the concepts of efficiency and productivity growth. This is followed by a survey of empirical literature on banking efficiency and productivity growth in the context of financial liberalization in Section 3.3. Section 3.4 contains empirical studies on South Asia and Bangladesh and, finally, Section 3.5 concludes the chapter.

3.2 Efficiency and productivity concepts in the literature

The terms, productivity and efficiency, are not interchangeable concepts. Productivity is generally defined in terms of efficiency where inputs are transformed into useful outputs within the production process (Cowing and Stevenson, 1981). Productivity varies due to differences in production technology, differences in efficiency of the production process, and differences in the environment in which production occurs. Grosskopf (1993) defines productivity growth or total factor productivity (TFP) change as the net change in output due to change in efficiency and technical change. This results from a combination of technical change, due to technological progress and measured by the shifts in the production frontier, and technical efficiency change, measured by the observed distance from the frontier of technology.

Conventional approaches (e.g., growth accounting method) of productivity measurement do not distinguish between these two TFP change components. Instead,

TFP growth is often used synonymously with technological progress (Salim, 1999, Mahadevan and Kalirajan, 1999, Grosskopf, 1993), which produces biased technical progress if changes in technical efficiency are not taken into account. Moreover, higher technical progress can coexist with deteriorating technical efficiency and vice versa.

Efficiency can be measured by comparing observed output to maximum potential output obtainable from given inputs, or comparing observed inputs to minimum potential inputs required to produce the output or some combinations of the two (Fried et al., 2008b). The measurement of efficiency begins with the seminal work of Farrell (1957), following the ideas of Debreu (1951) and Koopmans (1951). This work provides a measure of total economic efficiency containing two components: technical efficiency and allocative efficiency. Technical efficiency reflects the ability of a firm to produce possible output from a given set of inputs and technology, and allocative efficiency reflects the capacity of a firm to use inputs in optimal proportions, given their respective prices and production technology, i.e., equate marginal value products with marginal input cost (Heshmati, 2003, Coelli et al., 2005).

There are several difficulties with Farrell's measure. It measures technical efficiency relative to an isoquant rather than to an efficient subset, which may identify a decision making unit (DMU) as technically efficient when it is not. Moreover, it is a radial measure as it assumes a given input mix, although there is no reason to measure technical efficiency radially, even for homothetic technologies. Furthermore, Farrell's restrictive assumptions on the production function limit the types of technology (Färe and Lovell, 1978).

An alternative approach to measuring productivity involves explicit specification of a production function and direct linkage of productivity growth to the parameters of the function. Solow's (Solow, 1957) pioneering work develops this residual approach, which is an effort to minimize measurement error in the construction of output and input quantity indices. This approach is followed in

several empirical studies (e.g., Krueger and Tuncer, 1982, Nishimizu and Robinson, 1984, Perkins, 1996, Nishimizu and Page, 1982, Kumbhakar and Heshmati, 1996).

Solow's general index of disembodied technical change requires three restrictive assumptions: constant returns to scale, Hicks-neutral technical change and perfect competition in both output and factor input markets, which limits its application. For example, economies of scale may exist in regulated firms or industries such as electricity, telephone and banking services. The assumption of the competitive equilibrium condition of constant returns to scale may be acceptable at more aggregate levels of productivity analysis, but it is unlikely to be appropriate in regulated firms or industries. Total factor productivity change ($T\dot{F}P$) is calculated as the difference in the percentage change in output (\dot{Q}) less the percentage change in a Divisia index of inputs, where the Divisia input index depends on the cost share (S_i) multiplied by the percentage change in inputs (\dot{w}_i):

$$T\dot{F}P = \dot{Q} - \sum_i \frac{P_i w_i}{C} \dot{w}_i = \dot{Q} - \sum_i S_i \dot{w}_i$$

The equivalence between total factor productivity growth and technical change breaks down with more general production technologies, such as technologies exhibiting increasing returns to scale. The growth in total factor productivity may be attributable to movements along the production function (Baltagi and Griffin, 1988).

3.2.1 Measurement of efficiency and productivity growth

This section describes two broad paradigms of frontier estimation approach for measuring economic efficiency, non-parametric programming approach and econometric (i.e., parametric) approach, to estimate theory-based models of production, cost or profit. The econometric approach is stochastic, which enables distinguishing the effects of noise from those of inefficiency and provides the basis for statistical inference. The parametric technique specifies a functional form for the

production, cost or profit function and measures inefficiencies with reference to the estimated function, assuming a half-normal or truncated-normal distribution for the one-sided error term and normal distribution for the two-sided error term (Mester, 1996).

The non-parametric programming technique, though having limitation in regard to measurement error, can avoid the effects of misspecification of the functional form of both technology and inefficiency. Berger and Humphrey (1997) find similar efficiency estimates from studies using non-parametric and parametric frontier models except for a few variations. As such, both parametric and non-parametric approaches have been employed in the literature to estimate efficiency and productivity of financial institutions.

The non-parametric approaches, such as data envelopment analysis (DEA), a Farrell-type mathematical programming approach to frontier estimation, identify the best-practice frontier as the envelope of the observed production possibilities, and put relatively little structure on the specification of the best-practice frontier. Therefore, DEA does not require any explicit specification of the functional form of the underlying production function.

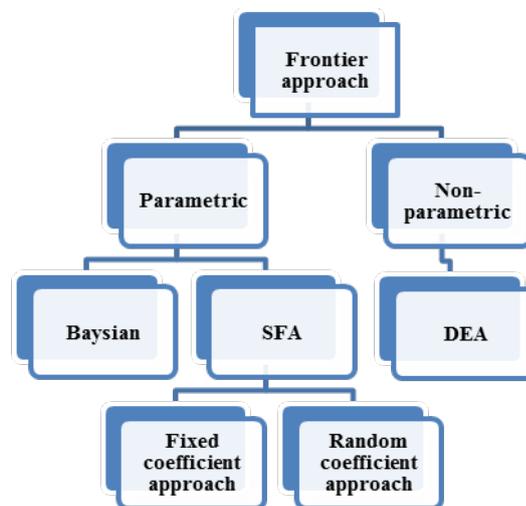
Alternatively, the parametric approaches, such as stochastic frontier analysis (SFA), specify a functional form for cost, profit or production relationship among inputs, outputs and environmental factors allowing for a compound error term. The essential idea behind the stochastic frontier model is that the error term comprises two parts. One is a symmetric component (two-sided), which permits random variation of the frontier across firms, and captures the effects of measurement error, statistical noise or random shocks. The other is a one-sided component containing the effects of inefficiency relative to the frontier.

The SFA deals with both fixed and random coefficients for parametric representation of technology. The fixed coefficient approach of the 'stochastic production function' assumes that production frontier shifts neutrally as marginal

rate of technical substitution (MRTS) remains unchanged at any input combination. An alternative approach for modelling the observation-specific characteristics is the random coefficient approach of the stochastic frontier analysis. Swamy (1970) popularized the random coefficient model which allows for modelling heterogeneity in functional relationships between dependent and independent variables. This approach implies a non-neutral shift of the frontier from the actual production function. Analysing the production behaviour of 48 Chinese state-owned enterprises, Kalirajan and Obwona (1994) show that individual contributions of inputs to outputs vary across enterprises, which supports the hypothesis that the existing constant-slope but varying intercept approach of modelling the production behaviour is inappropriate.

Figure 3.1 shows the branches of frontier estimation methods to estimate the efficiency and productivity. All the methods reported are originated either from the parametric or the non-parametric approach.

Figure 3.1: Frontier estimation methods



Another recent development of parametric estimation is the Bayesian approach proposed by van den Broeck, Koop, Osiewalski and Steel (1994). This approach specifies prior distributions for parameters and inefficiency term. Hence, the Bayesian models overcome the need for imposing *a priori* sampling distribution

on the efficiency term of the composed error term that characterizes the conventional stochastic frontier models. However, the specification of prior distributions for parameters puts extra uncertainty to the outcome of such modelling, particularly when there is no information about how to parameterize *a priori* the unknown parameters (Greene, 2005a, Feng and Serletis, 2009).

Research on banking efficiency and productivity has been developed employing both parametric and non-parametric approaches, with no consensus on the best method. For example, Ferrier and Lovell (1990) report fairly close estimates on cost economies and cost efficiencies applying both the econometric and the programming techniques on U.S. banking. Similarly, Resti (1997) finds very high rank-order correlations between DEA and SFA estimates. On the other hand, Bauer et al. (1998) find SFA estimates are higher than DEA scores, in a panel data analysis on 683 U.S. banks for the period 1977-1988.

3.2.2 Duality theorem, production and cost frontier

A more recent development for the measurement of productivity is the cost function model, based upon duality theory and the earlier work of Shephard (1970). The duality theory provides a fundamental link between the productivity measures in terms of value, e.g., revenue and cost, and the distance function productivity measures linked to technology described in terms of input and output quantities (Färe et al., 2008). Schmidt and Lovell (1979) first explain the duality between stochastic frontier production and cost functions. According to the dual specification of production, a firm can be above its cost frontier (i.e., cost inefficiency) by being below its production frontier (i.e., technical inefficiency). The property of duality in production economics suggests that both production function and cost function contain essentially the same information on technology if producers are at a cost-minimizing equilibrium and facing fixed input prices (Zheng and Bloch, 2014, Paul, 1999). The key idea of the duality theory is that production and cost functions are

dual to each other. The cost function is a specification equivalent to that of the production function under the assumption of cost minimization.

There are further developments in duality theory which allow more general and flexible specifications of neo-classical technology, such as translog, quadratic and generalized Leontief models. These require fewer restrictions compared to Cobb-Douglas specifications (Kumbhakar and Lovell, 2000, Cowing and Stevenson, 1981). The translog cost function is one of the popular choices of functional form in empirical production economics due to its correspondence to a flexible underlying production technology that places minimum a priori restrictions (Zheng and Bloch, 2014). However, translog cost functions may fail to satisfy the concavity condition, resulting in positive own-price elasticity of the input quantities (Du and Girma, 2011). Employing the translog cost function, Greene (1980) defines allocative inefficiency as the departure of the actual cost shares from the optimum shares. The definition does not explain the relationship between allocative inefficiency and increase in cost from such inefficiency. Bauer (1990b) indicates this problem as the 'Greene problem'.

Changes in the productivity of firms arise from the adoption of technology and also from the improvement in technical and allocative efficiency. The performance of a firm can be inferred from technical efficiency relative to competition, which involves construction of a best practice production frontier and the measurement of distance to it. It can also be inferred from cost, revenue or profit efficiency relative to the competition, which involves construction of best practice cost, revenue or profit frontier and the measurement of distance to it (Färe et al., 2008).

Both primal (production frontier) and dual (cost frontier, profit frontier) approaches have been employed in econometric studies of productivity change to define production technology (Kumbhakar and Lovell, 2000, Kumbhakar et al., 2000). The choice basically depends on the behavioural assumptions on the part of the producers and/or availability of data, especially price data. A considerable

advantage of the dual approaches is that the productivity change can be decomposed within a multiple-output framework, banks for example, which produce multiple outputs. The cost frontier requires input price data to vary across firms. In reality, firms in an industry face the same prices in many cases (Coelli, 1995). However, non-parametric approaches can be followed particularly when price data are unavailable, even though there is possibility of measurement errors in such estimation.

3.2.3 Decomposition of TFP change and cost efficiency

Productivity refers to total factor productivity (TFP) if it involves all factors of production and all outputs in a multiple-output setting (Coelli et al., 2005). TFP change can be decomposed into technological progress and efficiency change using either a production or cost function (Bauer, 1990a, Nishimizu and Page, 1982). The key difference in two approaches is in the treatment of the function and the inefficiency in the definition of TFP change.

Nishimizu and Page (1982) define TFP change to be the shift in production function over time. The authors estimate the production function following a deterministic frontier and decompose the TFP change into two distinct elements, technical progress and changes in technical efficiency, where, technological progress is the movement of the best practice or frontier production function over time and all other productivity change is technical efficiency change. Bauer (1990a) decomposes TFP change into various components stemming from changes in returns to scale, changes in technical and allocative efficiency and technological progress using both production and cost functions.

Battese and Coelli (1995) argue for time-varying technical change and technical inefficiency, given that inefficiency effects are stochastic and have a known distribution. Using a cost-minimization framework, Kumbhakar (1990) accommodates time-varying technical inefficiency and allocative inefficiency across firms. The model considers the usual distributional assumptions on technical and

allocative inefficiency. However, Cornwell et al. (1990) estimates time-varying efficiency level for individual firms without making any strong distributional assumptions for technical inefficiency or random noise. The model includes a flexible function of time in the production function with coefficients varying over firms. This is indeed similar to the work of Sickles, Good and Johnson (1986), and an improvement over the previous work of Schmidt and Sickles (1984), where the level of efficiency for each firm is assumed to be time-invariant.

Balk (2001) proposes a component-based approach to productivity growth measurement, identifying various sources of productivity growth: technical change, efficiency change and a change in the scale of operations. Technical change results from a shift in the production technology. Efficiency change is the source of productivity of a firm which can be achieved by making more efficient use of its inputs with the available technology. Scale efficiency change, the third source of productivity, is the improvement in the scale of operations of the firm and its move towards the technologically optimum scale of operations. Other sources of productivity change are output mix effect (OME) and input mix effect (IME), which measure the effects of changes in the composition of output and input vectors respectively over time.

Employing the newly developed geometric Young (GY) input index (which satisfies a suite of common sense axioms from index number theory in addition to the transitivity and multiplicatively completeness axioms, key requirements for an economically meaningful decomposition of TFP change), O'Donnell (2014a) includes a new component of TFP change, i.e., environmental change. Therefore, TFP change decomposes into measures of technical progress (a measure of outward movements in the production frontier due to new technological innovation), environmental change (a measure of movements in the frontier due to changes in production environment), technical efficiency change (a measure of movements towards or away from the frontier) and scale and mix efficiency change (measures of movements around the frontier surface to capture economies of scale and scope). The

author uses the least squares method (i.e., econometric approach) to estimate the components. However, if no environmental variable is involved in the production process the GY index turns into the Färe-Primont TFP index as defined by O'Donnell (2014b). Applying the parametric approach, Feng and Serletis (2010) estimate three TFP growth components: technical change, efficiency change and economies of scale in a panel data analysis on U.S. banking.

In terms of costs, inefficiency can arise from two sources: technical inefficiency, which arises due to output falls short of the ideal, given the inputs; and allocative inefficiency, which arises from sub-optimal input choices, given the prices and output. Therefore, cost inefficiency is a blend of technical and allocative inefficiency (Greene, 2008). However, the decomposition of cost inefficiency into its components in a theoretical appropriate manner (which is termed the 'Greene problem) has remained a challenge in the literature (Greene, 1997,1993). Therefore, the estimation of allocative inefficiency and the decomposition have received much less attention due to the persistent absence of a practical theoretically consistent solution to the original problem (Greene, 2008).

Employing the non-parametric DEA approach, cost efficiency can be decomposed into three components: pure technical efficiency, scale efficiency and allocative efficiency when the production technology represents variable returns to scale (Thanassoulis et al., 2008). Isik and Hassan (2002) decompose cost efficiency into its allocative and technical efficiency components. Following the DEA approach, the authors report technical inefficiency as the dominant source of cost inefficiency vis-à-vis allocative inefficiency in Turkish banking.

The above literature survey on efficiency and productivity presents a wide range of arguments over the sources of TFP change and its measurement. The efficiency and productivity estimates depend on the underlying functional form of the production or cost function and distributional assumptions. The next section discusses the empirical studies on banking efficiency and productivity in the context of financial deregulation.

3.3 Financial liberalization, banking efficiency and productivity

McKinnon (1973) and Shaw (1973), the proponents of the financial liberalization hypothesis, argue that financial liberalization leads to significant economic benefits through a more effective domestic saving mobilization, financial deepening and efficient resource allocation. The existing literature provides no conclusive evidence on the relationship between financial liberalization, and banking efficiency and productivity. For example, banking efficiency in the U.S. has remained relatively unchanged after financial deregulation in the early 1980s (Elyasiani and Mehdiian, 1995, Bauer et al., 1993). Similarly, no significant effect has been observed in Korean banking efficiency after financial reforms in 1991 (Hao et al., 2001).

Berger and Mester (2001) provide the evidence that cost efficiency of the U.S. banking decreased 4.2 and 12.5 percent annually during the post-reform periods, 1984-91 and 1991-97 respectively. Increased competition among banks in the post-reform period perhaps empowered the depositors to receive higher interest on their bank deposits, which eventually increased the banks' cost of funds. Using the Malmquist productivity index, Wheelock and Wilson (1999) also find that U.S. commercial banks became more technically inefficient between 1984 and 1993. The declining productivity trend was associated with small banks. The deregulation process perhaps benefited the larger banks more than the smaller ones in terms of scale and scope of banking.

Employing the Malmquist TFP index, Lee et al. (2010) observe a lower TFP growth in the post-reform period, 2000-2005 compared to the pre-reform period in Singaporean banking. The study suggests that the main driver of TFP change is efficiency change, particularly pure technical efficiency change and scale efficiency change, originated largely from mergers amongst the local banks. However, the estimates are statistically insignificant due to a small sample size of 26 banks.

There is contrary evidence where deregulation has a positive impact on bank productivity. Isik and Hassan (2003) observe substantial improvement in

productivity in Turkish commercial banking after deregulation. Employing a DEA-type Malmquist TFP index, the study reveals that productivity gain is mostly driven by efficiency increases rather than technical progress. The efficiency increases due to better management practices, but not for the improvement in scale. Replicating the same methodology (Malmquist indices) for Norwegian banks for the period 1980-89, Berger et al. (1992) find that productivity declines first, but eventually improves following deregulation.

In a panel data analysis, using a multi-product translog cost function, Kumbhakar and Lozano-Vivas (2005) find that deregulation contributes positively to TFP growth for Spanish savings and commercial banks for the period 1986-2000. However, Grifell-Tatjè and Lovell (1999) reports declining productivity at the initial stage of deregulation and an improvement at the later stage in Spanish banking employing a flexible variable profit function. Berger and Humphrey (1997) argue that industry conditions prior to deregulation may explain these unexpected consequences.

The empirical literature on scale economies provides the evidence of scale inefficiencies in both small and large banks (Clark, 1996). Using a non-parametric DEA approach, Drake et al. (2003) observe substantial economies of scale for the smaller banks, but diseconomies of scale for the larger banks in the Japanese banking sector. However, the study finds improved scale and technical efficiency after controlling for the exogenous impact of non-performing loans (NPLs) on efficiency.

Conversely, Chinese large state-owned banks are more efficient than medium sized banks (Chen et al., 2005). Applying DEA technique on 43 Chinese banks for the sample period 1993-2000, this study reveals that overall efficiency of banks

improved at the initial stage of deregulation. Employing an input distance function for TFP decomposition, Kumbhakar and Wang (2007) find a positive contribution of scale economies, technical change and technical efficiency gain in TFP change for Chinese joint-equity banks.⁵

Feng and Zhang (2012) document that large banks experienced a higher level of productivity growth compared to small community banks in the U.S. over the period 1997-2006. Using a true random effects stochastic distance frontier (SDF) model within a Bayesian framework, the estimates provide exact statistical inferences on productivity and efficiency measures. The results show a declining TFP change for all categories of banks where technical change mainly drives the decline.

Using the Hicks-Moorsteen TFP index, Arjomandi et al.(2012) draw similar conclusions for Iranian banking. The authors observed deterioration of technical efficiency during the post-reform period, 2006-2008. The decline in overall technical efficiency after 2006 is attributed to the scale and mix inefficiency of the private sector banks, the worst bank group in the Iranian banking system.

A post-reform cost efficiency analysis of Chinese banking reveals that total factor productivity has increased for both domestic and foreign banks equally owing to efficiency improvement and technological progress (Rezvanian et al., 2011). Applying a non-parametric approach, the study finds that, on average, domestic banks outperformed their foreign counterparts over the sample period, 1998-2006, in terms of overall and allocative efficiencies but they fall behind in terms of technical efficiency.

⁵ The joint-equity banks are either entirely private-owned or jointly owned by private enterprises and local governments. This type of commercial bank operates at both the national and regional level.

In a deregulated Australian financial environment, establishment of new banks (both domestic and foreign) contributes to efficiency gains (Sturm and Williams, 2004). However, Sathye (2001) observes low levels of overall efficiency in commercial banks in Australia compared to the banks in Europe, and in the USA. Avkiran (2000) finds that total factor productivity of 10 Australian banks increased mainly due to technological progress rather than technical efficiency change during the period, 1986-1995. Similarly, the TFP growth of Australian banks is attributed to the technology-based delivery of financial services (Salim et al., 2010).

Using a directional technology distance function, Park and Weber (2006) find that technological progress offsets efficiency declines and, thus contributed to the productivity growth in Korean banking during the period, 1992-2002. However, there is evidence where both technological progress and technical efficiency change drive the TFP growth. Das and Kumbhakar (2012) observe 3.5 percent TFP growth annually in the Indian banking sector during the post deregulation period, 1996-2005, where both technological progress and technical efficiency change contributed.

Constructing a new index, input slack-based productivity (ISP) index, Chang et al. (2012) find that technical improvement of capital productivity is the main source of TFP growth while investigating the sources of productivity of 19 Chinese banks for the period, 2002-2009. One limitation of the new ISP index is the assumption of constant returns to scale. Hence, this index is not applicable for decomposing TFP change where the production technology exhibits variable returns to scale.

The review of the above literature shows that non-parametric Malmquist productivity index has been employed for the decomposition of TFP change in majority of the banking studies. The popularity of the Malmquist productivity index, introduced by Caves, Christen and Diewert (1982), in efficiency and productivity analysis stems in part from the fact that price data are not required for its construction. However, Orea (2002) provides a parametric method to decompose the generalized Malmquist productivity index incorporating scale economies. The

method is based on the estimation of translog distance functions with variable returns to scale as proposed by Balk (2001).

O'Donnell (2010) argues that Malmquist TFP index is an incomplete measure since it is neither additively nor multiplicatively complete and, thus produces unreliable or biased (except some special cases) measure of TFP change. He suggests using the Färe-Primont or Hicks-Moorsteen index (proposed by Bjurek, 1996) to decompose the TFP change irrespective of the returns to scale and the scope of the production technology. These indices satisfy the axiom of multiplicative completeness, a key requirement for an economically meaningful decomposition of TFP change (Lovell, 2003, O'Donnell, 2008).

It is evident from the above literature survey that empirical studies on financial deregulation and banking efficiency provide mixed results. There are several caveats to the McKinnon-Shaw hypothesis which might have been responsible for such conclusions. The assumption of perfect competition in financial markets is unrealistic since banking sector is rather oligopolistic in most of the cases and, therefore, credit rationing is a pervasive feature of the banking sector. Besides, financial markets are characterised by asymmetries of information where 'market failures' are more prevalent in financial markets than many other markets in the economy (Stiglitz, 1993). However, Stiglitz and Weiss (1981) argue that credit rationing is a rational strategy of banks in a liberalized environment.

It is plausible that the presence of any binding constraint (banking regulation, for example) in the allocation of financial resources increases the cost of production. On the other hand, cost saving is expected in a deregulated environment which induces productivity growth. The findings of the empirical literature on financial deregulation and banking efficiency depends on the prevailing market and regulatory conditions as well as research design (Avkiran, 2000). Because of the differences in model specifications, variable measurement and assumptions, it is really hard to find a common platform for comparing the efficiency scores or productivity measures across various studies.

3.3.1 Correlates of inefficiency

Identifying the determinants of inefficiency is another focus of the banking efficiency literature. The relative technical efficiency of financial institutions has been found to be significantly affected by environmental and market factors. There is no specific set of factors that explains inefficiency well. Different empirical studies find different sets of correlates of inefficiency, such as macro-economic characteristics, ownership, regulations, risk-management, market share and concentration. Ariff and Can (2008) observe significant influence of environmental variables such as bank ownership, risk profile, bank size and profitability on Chinese bank inefficiency during the period, 1995-2004. In a Tobit regression analysis, the study reveals that joint-stock banks (national and city-based) on average appear to be more cost and profit efficient than state-owned banks, whereas medium-sized banks are significantly more efficient than small and large banks.

The efficiency estimates of banks may vary across countries due to differences in environmental conditions. The cost-efficiency scores of Spanish banks are quite low compared to those of the French banks due to the exclusion of environmental variables, such as macroeconomic conditions, structure and regulation of the banking industry and accessibility of banking services from the specification of the common frontier (Dietsch and Lozano-Vivas, 2000). Hao et al. (2001) find that the average efficiency of Korean private banks during the period, 1985-1995 is positively correlated with foreign equity ownership in the banks and a broad measure of money, but negatively correlated with the level of long-term private sector debt and the level of real goods exports. Using DEA and the Herfindahl-Hirschman Index (HHI) of market concentration, another study on Korean banking postulates that bank's market share and concentration have positive effects on bank efficiency (Shin and Kim, 2011). Denizer et al. (2007) find that macroeconomic indicators affect bank efficiencies. Applying a non-parametric approach, the authors find that volatile inflation and growth rates reduced bank efficiencies in Turkish banking during the period, 1974-1994.

3.3.1.1 Ownership structure

Bank efficiency varies across different ownership structures. Bhattacharyya et al. (1997), employing two competing approaches, the DEA and the SFA, find that public-owned banks are most efficient and privately-owned banks are the least efficient while investigating on 70 Indian commercial banks for the period 1986-1991. Similarly, Sensarma (2005) suggests that state-owned banks exhibit higher cost efficiency compared to private banks in India. Employing the SFA technique, the study reveals that cost efficiency of the Indian banking industry increased during the sample period, 1986-2003, while profit efficiency experienced a declining trend.

Bonin et al. (2005) draw the opposite conclusion while investigating banking efficiency for 11 Central and East European transitional countries for the period 1996-2000. The authors find significant effects of both foreign ownership and participation of international institutional investors on bank efficiency. Following the stochastic frontier estimation procedure, the study shows that government ownership affects cost efficiency adversely, though it is statistically insignificant. One limitation of this cross-country analysis is that it could not differentiate between domestic private banks and foreign banks. Using the one-stage stochastic cost function, another study on Russian banking reveals that foreign banks are more efficient than domestic private banks (Karas et al., 2010).

Berger et al. (2009) compare the cost and the profit efficiency of different bank ownership groups of 38 Chinese banks and, find that foreign banks are the most profit efficient banks, followed by private domestic banks and state-owned banks, especially the 'Big Four' being the least profit efficient. Lin and Zhang (2009) present the evidence, replicating the analysis for the sample period 1997-2002, that the 'Big Four' are less cost efficient having a lower asset quality relative to other groups of bank ownership. This is consistent with the conclusion drawn by Kumbhakar and Wang (2005).

In the Hungarian banking context, Hasan and Marton (2003) find that banks with foreign ownership are significantly less inefficient than their domestic counterparts. The authors argue that the local market conditions in the Hungarian banking sector perhaps provide opportunities for foreign banks to exploit their comparative advantages into lower costs causing lower inefficiency.

3.3.1.2 Bank-specific characteristics

Risk management in financial institutions has received increased attention particularly after the Asian financial crisis followed by the recent global financial crisis. An empirical study on the banking sector in Philippines finds increased banking inefficiency attributed to the adverse effects of the Asian financial crisis (Manlagñit, 2011). Applying the stochastic frontier approach, the study states that capital risk and risk preference of a bank's management have negative effect on cost efficiency, which conforms to other empirical evidences, for example, Mester (1996), Girardone et al. (2004) and Altunbas et al.(2000).

Berger and De Young (1997) analyse the relationship between insolvency risk or capital adequacy (the ratio of equity to total asset) and cost efficiency of banks. The authors find a negative relationship between cost efficiency and insolvency risk. Since insolvency depends on the equity capital of the bank, insolvency risk raises the bank's cost because of paying the risk premium for the bank's borrowed funds. Thus, equity provides a cushion against insolvency as banks with higher level of capital have a greater capacity to absorb loan losses.

Evidence from Korean banking reveals that average technical efficiency of banks decreased during the financial crisis (Banker et al., 2010). The study documents that the capital adequacy ratio is positively associated with banks' technical efficiency and the non-performing loan (NPL) ratio is negatively associated with technical efficiency.

Mester (1996) finds a statistically significant negative relationship between inefficiency and the capital-asset ratio for U.S banking employing a logistic (logit) regression model. A similar conclusion has been drawn from the Italian banking efficiency estimates for the period, 1993-1996 (Girardone et al., 2004). The study shows that bank inefficiency is inversely correlated with financial capital and positively related to non-performing loans. In fact, efficient banks tend to have more profits and, thus are able to retain more earnings as capital. Following the Fourier-flexible stochastic cost frontier approach, the study also observe significant differences in cost efficiency across different ownership structures and regional locations despite improved cost efficiency apparent in the Italian banking system after financial reforms.

European cross-country studies suggest that lower bank efficiency with respect to costs and revenues Granger causes higher bank risk (Iannotta et al., 2007, Fiordelisi et al., 2011). Applying the Granger-causality techniques, the studies provide the evidence that cost (and profit) efficiencies positively Granger cause bank capital. Therefore, more efficient banks become well-capitalized. Hence, higher capital tends to have a positive effect on efficiency level.

Sun and Chang (2011) observe that risk measures (credit risk, operational risk and market risk) have significant effects on both the level and variability of bank efficiency in eight Asian banks. However, these effects may vary across countries and over time. Using a heteroscedastic and non-monotonic stochastic frontier model, the analysis shows that each risk measure presents a dissimilar effect on banks' efficiency. In general, the main caveat of cross-country studies is the common frontier built by pooling all banks across countries. Therefore, if the country-specific variables are important factors in explaining the efficiency differences, then the common frontier estimates may generate biased and overestimated inefficiency levels due to omission of the country-specific factors.

3.3.1.3 Corporate governance

Corporate governance has become a key environmental aspect for financial institutions, especially after the Asian financial crisis and subsequent corporate scandals, e.g., Enron and Worldcom in 2001. The recent global financial crisis has put forward the governance issue to be treated as an essential component of prudential regulations for banks. Berger et al. (2005) define 'governance' as different categories of bank ownerships - private, foreign and state ownerships. Shleifer and Vishny (1997) argue that corporate governance is primarily concerned with principal agency problems between ownership and control.

Pi and Timme (1993) address the corporate governance issue while investigating the cost efficiency and principle-agent conflicts for a sample of large publicly traded U.S. commercial banks for the period, 1988-1990. Using a cost efficiency metric derived from a stochastic cost frontier model, the study reveals that on average, banks where the CEO (Chief Executive Officer) is also the chairman of the board underperform those banks where the CEO is not the chairman of the board.

An European cross-country regression analysis shows how management and board ownership restrain the conflict of interest between shareholders and management and, thus improve the profitability of traditional and non-traditional banks (Westman, 2011). The study finds that corporate governance in banks is complex and, one solution does not fit all banks. More specifically, management ownership has positive impact on the profitability of non-traditional banks, whereas board ownership has a positive impact on the profitability of traditional banks. However, there may be issues related to endogeneity and sample selection bias because the level of profitability may trigger the selection of a particular ownership structure and, managers or board members may be rewarded with shareholdings after a successful year.

A South-East Asian cross-country study emphasizes bank governance in terms of ownership structure (Williams and Nguyen, 2005). The study reveals that

bank privatization is associated with superior profit efficiency performance vis-à-vis other types of bank governance. Berger et al. (2005) find state-owned banks with long-term poor performance and, observe improvements while they are privatized in Argentinean banking. However, the performance of private sector banks could be limited due to possible agency problems. A second-stage correlate of efficiency analysis on Turkish banking provides the evidence of strong association between X-efficiency and management-team structure (Isik and Hassan, 2002). The study indicates that banks where the board is independent of management are significantly more efficient than those banks with the same management and board.

Using a panel fixed effect model on Thai commercial banking for the period 1999-2003, Pathan et al.(2007) draw the conclusion that bank board independence is essential for its better performance. The authors find a statistically significant negative relation between Thai bank board size and performance, suggesting that smaller boards are more effective in monitoring bank managers.

Berger et al.(2012) provide the evidence of several consequences on risk-taking behaviour of banks in regard to age, gender and academic attainment of the bank board executives. Applying the difference-in-difference estimation technique combined with matching method and HHI on a sample of 3,525 German banks for the period, 1994-2010, the study documents that younger executive teams increase the risk-taking behaviour of banks. Similarly, a higher proportion of female executives in the bank board lead to a more risky conduct of business. In contrast, more representation of PhD degree holders in the bank board reduces risk-taking behaviour of banks.

Political corruption especially in the government-owned banks is pervasive in developing countries due to lack of governance and accountability. Political influence is evident in appointing the chairperson and top executives in state-owned banks. The government-owned banks channel funds to projects which satisfy politicians and their supporters, instead of economically or socially efficient projects (Shleifer and Vishny, 1994). A cross-country study, using bank level data from 92

countries, finds low productivity growth in banks where government ownership is prevalent (La Porta et al., 2002). Similarly, a panel data analysis on Turkish banking finds politically motivated bank finance to the provinces that are politically connected (Onder and Ozyildirim, 2011).

Sapienza (2004) find that lending behaviour of the government-owned banks is influenced by the electoral results of the party affiliated with the bank in Italian banking. Similar findings are reported from Japanese banking experience where the members of the ruling political party use state-owned bank loans for political purposes (Imai, 2009). Using bank level data on corporate lending in Pakistan for the period 1996-2002, Khwaja and Mian (2005) find that state-owned banks provide loans to high-risk borrowers who have political connections.

Shen and Lin (2012) examines several hypotheses on political interference in bank governance using bank level data from 65 countries for the period, 2003-2007. The authors observe deteriorating financial performance in government banks due to political interference. In this research, political interference is defined as the replacement of government bank executives within 12 months of country's national elections, such as presidential and parliamentary elections. The study indicates that the impact of political interference is more in developing countries vis-à-vis developed countries.

3.3.1.4 Banking regulations

Various regulatory measures which are determined outside the bank and, obviously beyond the control of bank managers may have effects on total factor productivity (TFP) growth of banks. A time series analysis on U.S. commercial banks reveals that regulatory initiatives had negative impact on overall TFP growth during the period 1946-1995 (Tırtıroğlu et al., 1998). The study concludes that regulations whether imposing restrictions (more government intervention or control) or removing restrictions (closer to market environment) do not produce productivity gains. In other words, restrictions increase substantial regulatory costs for the banking industry

and, removing restrictions may have led bankers to assume excessive risks causing financial distress which eventually causes low productivity growth.

Delis et al.(2011) provide the evidence that among the regulatory and supervisory policies related to the three pillars (capital requirement, supervision and market discipline) of the Basel accord II, market discipline has a positive and significant impact on productivity growth. Following a semi-parametric two-step approach using a sample of 582 banks of 22 transitional economies, the study finds that regulations related to first two pillars, capital requirement and supervision do not have, in general, a statistically significant impact on productivity but they appeared to gain importance at the onset of the global financial crisis in 2007.

The above reviewed empirical studies suggest that environmental conditions e.g., bank-specific characteristics, risk management and other macro-economic indicators have influence on banking efficiency and productivity growth.

3.4 Evidence from South Asia and Bangladesh

This section reviews empirical studies on South Asian countries including Bangladesh.⁶ The economies of this region are quite similar and also have been experienced financial reform programs in the 1980s. Perera et al.(2007) find that the average efficiency of South Asian banks declined during the period, 1997-2004. Using a translog stochastic frontiers model, the study reveals that Indian banks are the most efficient and Sri Lankan banks are least efficient. The estimates indicate

⁶ A regional forum 'SAARC', South Asian Association for Regional Cooperation, was established in 1985 comprising seven South Asian countries, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. In 2007, Afghanistan joined in the forum.

that, on average, South Asian banks with larger asset base are more cost efficient. Perhaps, a large size bank gets wider market penetration and generate revenue at least cost. However, the study excludes four South Asian countries, Afghanistan, Bhutan, Nepal, and Maldives due to non-availability of data. The study estimates cost efficiency using a sample of 111 banks out of 212 listed banks of four countries, Bangladesh, India, Pakistan and Sri Lanka. Therefore, about half of the listed banks of the sample countries are not included. Hence, the study presents a partial view of South Asian banking efficiency.

In regard to country specific studies, Indian banking studies dominate the banking efficiency literature of South Asian countries, while no empirical study on banking efficiency has been found so far for Afghanistan, Bhutan, Nepal, and Maldives. The studies on Indian banking indicate positive TFP change in the post-reform period, 1996-2005, where both technical progress and technical efficiency change contributed. The medium-sized public sector banks performed reasonably well compared to large and small size banks (Das and Kumbhakar, 2012, Bhattacharyya et al., 1997, Das and Ghosh, 2006). Zhao et al. (2010) observe improved performance and increased competition in the lending market as a consequence of financial deregulation in the Indian banking sector.

In Pakistan, banking efficiency falls during the initial stage of the financial reform process. Burki and Niazi (2010) provide the evidence that bank efficiency declined during the initial reform period, 1993-1996, because of the adjustment to the increased competition. However, the efficiency has been improved in the advanced stages of the reform program. Following the non-parametric DEA approach, the authors find variations in relative performance of different bank ownerships while estimating TFP change using a sample of 40 commercial banks. Foreign and private banks show superior efficiency and total factor productivity growth compared to government-owned banks. The former bank group is efficient in using right input-mix while the latter has inefficiently converted inputs into outputs.

The studies on Sri Lankan banking efficiency are sparse. This is mainly because of non-availability of banking sector data. Moreover, due to political unrest, particularly the internal conflict between the Northern and Eastern part of the country, the banking sector in Sri Lanka has not flourished as expected (Edirisuriya, 2007). Several factors, such as inadequate regulation, supervision and legal structures are responsible for the weak financial performance of the public sector banks in Sri Lanka. Besides, corruption, increased non-performing loans and political interferences are liable for banking inefficiency in Sri Lanka.

Perera et al.(2012) find no significant effect on Sri Lankan banks' net interest margin (NIM) as a consequence of financial deregulation. Employing a pooled price-concentration model for the sample period 1990-2008, the study reveals that Sri Lankan banks' NIMs are not significantly associated with banking market concentration. Nevertheless, the dominant Sri Lankan banks (with larger market shares in loan and deposit market segments) extract higher NIMs and, banks' cost structures are priced in their interest spreads. Conversely, the less-capitalized and high risk banks operate with narrow interest margins to attract deposits offering higher interest rates.

There is no comprehensive study examining the impact of financial deregulation on the efficiency and productivity of the banking sector in Bangladesh since the financial reform program initiated in the late 1980s. However, Akter et al. (2012) examines the efficiency of 19 private commercial banks and two government-owned banks for the period 2005-2008. Employing a two-stage network model, the study finds an inverted U-shaped pattern to inefficiency with a rising trend during 2005-2007 and a falling trend in 2008.

Apart from this, there are few studies on Islamic banking in Bangladesh (Ahmad and Hassan, 2007, Hassan, 1999). These studies emphasize the appropriate regulatory and supervisory framework of Islamic banking in Bangladesh. Analysing financial ratios, Ahmad and Hassan (2007) identify that the lack of inter-bank Islamic money market, presence of a discriminatory legal reserve requirement for

Islamic and conventional banking, prevalence of a restrictive environment in the capital market and inadequate legal protection against the risks involved in Islamic banking are the major obstacles for efficient functioning of Islamic banks in Bangladesh. Hassan (1999) examines various financial instruments conforming to the Islamic Shariah principle and their applicability in Bangladesh. The study also provides some descriptive statistics on Islamic banking in Bangladesh.

Moreover, Hassan and Tufte (2001) estimate the cost efficiency of the Grameen Bank (GB), the largest microfinance institution, using branch-level cost data for the period, 1988-1991. Employing the stochastic frontier approach, the study documents that average inefficiency score lies in between 3% to 6%, and, female branches are found to be more efficient than other types of branches. Besides, there are differences in managerial performance.

The paucity of empirical studies on the banking sector in Bangladesh justifies the scope and originality of this research. Hence, this thesis intends to analyse the cost efficiency and productivity of the commercial banks in Bangladesh in the context of financial reforms.

3.5 Conclusion

This chapter reviews both theoretical and empirical literature on banking efficiency and productivity growth. The review analyses different views on productivity and efficiency concepts going back to Farrell's explanation of productivity measurement in the 1950s. The components of TFP change may vary depending on the functional relationship and also distributional assumptions. Using a production function, the estimated TFP change components are mainly technical change (due to technological progress) and technical efficiency change. The technical efficiency change can be further decomposed into scale efficiency change, pure efficiency change and mix efficiency change. For cost function, the efficiency components are generally technical efficiency, allocative efficiency and scale efficiency.

Chapter 4

Banking efficiency and productivity growth: an analytical framework

4.1 Introduction

The measurement of efficiency and productivity growth of financial institutions has been important in the literature during the past three decades particularly in the context of financial liberalization. Financial reforms have been initiated in different countries across the world since the mid-1970s. The advent of deregulation would have encouraged banks and financial institutions to increase output, and ensure efficient allocation of resources in a cost effective manner. However, the empirical studies do not provide any conclusive evidence about the impact of financial deregulation on banking efficiency and productivity, neither is there uniformity in or the methods that have been employed (Berger and Humphrey, 1997, O'Donnell, 2008). The findings vary depending on the prevailing market and regulatory conditions as well as research design (Avkiran, 2000).

Bangladesh initiated financial reform programs in the late 1980s. The financial market in Bangladesh in terms of policy, supervision, risk management and corporate governance has been changed remarkably since the early 1990s due to deregulation and globalization. Therefore, simple methods, for example, financial ratio analysis may not provide appropriate evaluation of the banking performance in the current complex banking environment. The recent banking literature suggests that regression-based approaches, stochastic frontier analysis (SFA) for example, can control different bank characteristics and environmental conditions associated with individual banks and, thus provide more accurate estimates of efficiency compared to accounting ratios (Kumbhakar and Wang, 2007).

This chapter develops the analytical approach to be followed for measuring efficiency and productivity growth of the commercial banks in Bangladesh. The literature reviewed in Chapter 3 suggests for both parametric (econometric) and non-

parametric (mathematical programming) approaches for the measurement of efficiency and productivity of financial institutions. Hence, this thesis applies the parametric technique SFA for estimating the cost efficiency, and the non-parametric approach DEA-based Färe-Primont TFP index to measure the total factor productivity (TFP) growth of the 12 sample commercial banks in Bangladesh.

The choice of an economic model depends on the behavioural assumptions of the decision making units (DMUs). The assumption of cost minimization has been argued to be a reasonable one to make for regulated firms, banks for example (Färe and Primont, 1995). The banking firms buy inputs such as capital, manpower (labour) and deposits in competitive markets and, therefore, the cost minimization assumption with fixed input prices is valid in this case. According to Berger and Humphrey (1997), 30 out of 38 studies that employed parametric techniques in the efficiency analysis of the US banking industry, were reported to employ cost functions, and the rest employed profit functions. The key advantage of employing the SFA, pioneered by Aigner et al (1977) and Meeusen and Boreck (1977), is allowing for random errors that can arise from measurement errors. The main drawback is that SFA imposes an assumed functional form on the cost function.⁷ Alternatively, the non-parametric data envelopment analysis (DEA) has the advantage of not imposing a specific functional form, but at the expense of assuming no random errors.

This thesis follows the maximum likelihood (ML) procedure of Battese and Coelli (1995) that permits one-stage SFA model estimation of the parameters of the cost function and the measures of bank inefficiencies. The model specifies both the

⁷ The detailed procedures of the SFA technique and the suitability of the one-stage SFA model of Battese and Coelli (1995) are explained on pages, 105-114.

stochastic frontier and the way in which the technical inefficiency u_i depends on z_i , the exogenous and environmental variables including the financial deregulation period dummy variables (Wang and Schmidt, 2002).

There is dual relationship between cost efficiency and TFP change. According to the dual specification of production, a firm can be above its cost frontier (i.e., cost inefficiency) by being below its production frontier (i.e., technical inefficiency) (Schmidt and Lovell, 1979). The TFP change can also be decomposed into various components stemming from changes in returns to scale, cost efficiency and technological progress. Since banks and financial institutions produce multiple outputs using multiple inputs, the parametric cost function approach is preferred to the production function approach because the latter is incapable of describing the production technology structure for such firms (Kumbhakar and Wang, 2007).

This thesis also uses the non-parametric DEA technique for computing TFP growth with a production technology involving both multiple inputs and multiple outputs (Mahadevan, 2004). Distance functions introduced by Shephard (1970) are used to characterize the multiple outputs and multiple inputs framework. The DEA-based aggregate quantity framework using the Färe-Primont TFP index, suggested by O'Donnell (2008, 2011c), is employed to compute and decompose the TFP change into measures of technical change, technical efficiency change, mix efficiency change and scale efficiency change. The Färe-Primont TFP index satisfies all the required properties (axioms and tests) of index number theory including multiplicative completeness (the popular Malmquist index does not satisfy this axiom) and additive completeness and transitivity test (the Hick-Moorsteen index does not satisfy this test). Although the Hicks-Moorsteen and the Färe-Primont TFP index are quite similar, the thesis employs the Färe-Primont TFP index because of several advantages. For example, according to O'Donnell (2011c, p.3), "the Färe-Primont index can be used to make reliable multi-lateral and multi-temporal comparisons (i.e., comparisons involving many firms and time periods) but the Hicks-Moorsteen index can only be used to make reliable binary comparisons (i.e.,

comparisons involving only two firms or two time periods). This is because the Hicks-Moorsteen index fails the transitivity test of Fisher (1922)”.

The remainder of the chapter is structured as follows. Section 4.2 discusses the competing paradigms of the frontier models, while Section 4.3 presents an analytical framework for measuring cost efficiency using the SFA. Section 4.4 provides an aggregate quantity framework for computing TFP change and its decomposition using the Färe-Primont TFP index. Section 4.5 constructs panel data regression models for investigating the determinants of TFP change and profitability measures and, finally, Section 4.6 concludes the chapter.

4.2 Frontier models

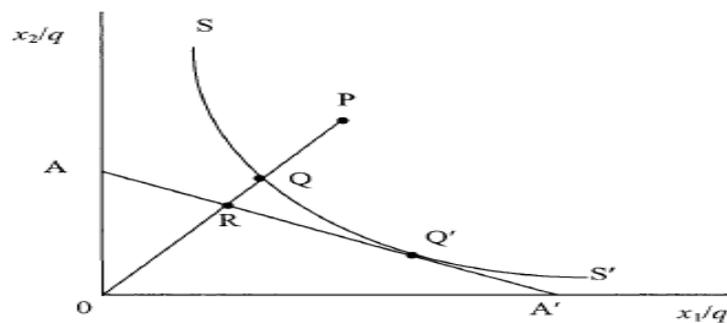
The frontier models have been used extensively in the literature to estimate the efficiency and productivity of banks and financial institutions. The notion of a frontier is consistent with the underlying economic theory of optimization. A deviation from the frontier measures the inefficiency.

A frontier refers to a bounding function. Microeconomic theory is awash with such functions, for example, production, cost or profit functions. Most of the empirical works use average functions, e.g., ordinary least squares (OLS), which fit a line of best fit through the sample data rather than over the data, as would be appropriate for production or profit function, or under the data, as would be appropriate for a cost function (Coelli, 1995). The estimation of an average function provides the shape of the technology of an average firm, while the frontier function reflects the technology of the best performing firms. A firm is considered to be fully efficient if it operates on the frontier. If the firm operates beneath the production

frontier (above the frontier in case of cost function), it is not fully efficient. Farrell (1957) illustrates the efficiency measurement method for a single output case following Debreu (1951) and Koopmans (1951), under the assumption of constant returns to scale.⁸

Figure 4.1 demonstrates the Farrell's measurement of technical efficiency, allocative efficiency and total or economic efficiency using two inputs (x_1 and x_2) to produce a single output (q) (Coelli, 1995).

Figure 4.1: Technical and allocative efficiencies



If a firm uses the input quantity defined by the point P to produce a unit of output, the technical efficiency is OQ/OP . Q is technically efficient as it lies on the efficient isoquant SS' . If the input price ratio is known and represented by the isocost line AA' , allocative efficiency is OR/OQ , because RQ represents the reduction in production costs which would occur if production level is at point Q' , the allocatively (and also technically) efficient point, instead of technically efficient but

⁸Farrell's method also accommodates more than two inputs, multiple outputs and non-constant returns to scale (Coelli, 1995)

allocatively inefficient point Q. Therefore, total economic efficiency can be defined as the ratio OR/OP , where the distance RP can be interpreted as the cost reduction possible through fully efficient production. The product of technical and allocative efficiency provides the overall efficiency (total economic efficiency), which is $OQ/OP \times OR/OQ = OR/OP$ and, all three measures are bounded by zero and one.

Two competing frontier paradigms, parametric and non-parametric approaches, have been followed in the literature for estimation of the frontier models. One uses econometric techniques and the other employs mathematical programming techniques. The following sub-sections discuss the application of the techniques in efficiency and productivity measurement.

4.2.1 The non-parametric approach

DEA is the most widely applied non-parametric technique in the frontier literature. DEA, a Farrell-type mathematical programming technique to frontier estimation, was pioneered by Charnes et al. (1978) and extended by Färe and Lovell (1978), Banker et al. (1984) and Färe et al. (1994). DEA identifies the best-practice frontier as the envelope of the observed production possibilities and puts relatively little structure on the specification of the best-practice frontier. The DEA approach suffers from criticism as this does not allow for random error and thus attributes any deviation from the efficient frontier as inefficiency. For this reason, DEA may overstate the true level of relative inefficiency for some economic units (Berger and Mester, 1997, Grosskopf, 1996). In spite of all these limitations, DEA has a very large following in the management science literature and in applications to service such as banking (Coelli, 1995). This approach has the advantage of removing the necessity to make arbitrary assumptions regarding the functional form of the frontier and the distributional form of the inefficiency term.

The other non-parametric frontier model, e.g., free disposal hull (FDH) was pioneered by Deprins, Simar and Tulkens (1984) and extended by Tulkens (1993). The FDH approach relaxes the assumption of convexity and generates higher

estimates of the efficiency score. However, slack is a more serious problem in FDH than in DEA. The next sub-section discusses the DEA framework.

4.2.1.1 Data envelopment analysis (DEA)

The DEA constructs a non-parametric envelopment frontier over the data points in such a way that all observed points lie on or below the production frontier. The DEA method determines a piece-wise linear efficiency frontier from the most efficient firms and derives the relative efficiency measures for all other firms. Suppose, there are N inputs, M outputs with each of K firms. The $N \times K$ input matrix X , and the $M \times K$ output matrix Y represent the data for all K firms. The input and output vectors for firm i are x_i and y_i respectively. The input-oriented constant returns to scale (CRS) DEA model can be specified in terms of mathematical programming problem following Coelli (1995) :

$$\text{Max}_{u,v} (u'y_i / v'x_i), \quad (4.1)$$

$$\text{Subject to, } u'y_j / v'x_j \leq 1, j = 1, 2, \dots, K$$

$$u, v \geq 0,$$

where, u is an $M \times 1$ vector of output weights and v is an $N \times 1$ vector of input weights. This involves finding values for u and v such that the efficiency measure for i -th firm is maximized subject to the constraints that all efficiency measures must be less than or equal to one (Coelli et al., 2005).

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

$$\text{Min}_{\theta, \lambda} \theta$$

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

$$\theta x_i - X\lambda \geq 0, \text{ where, } \lambda \geq 0 \quad (4.2)$$

where, θ is a scalar and λ is a $K \times 1$ vector of constants. This envelopment form involves fewer constraints than the multiplier form, and hence, is generally the preferred form to solve. The value of θ is the efficiency score for i -th firm, and $\theta \leq 1$, with a value of 1 indicating a point on the frontier and thus technically efficient.

The CRS model is appropriate when all firms are operating at an optimal scale. However, many firms may not operate at optimal scale due to market imperfections. Therefore, authors including Afriat (1972), Färe, Grosskopf and Logan (1983) and Banker, Charnes and Cooper (1984) suggest an extension of the CRS DEA model in order to account for variable returns to scale (VRS) by imposing an additional convexity constraint, $K1'\lambda = 1$.

$$\text{Min}_{\theta, \lambda} \theta,$$

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

$$\theta x_i - X\lambda \geq 0 \quad (4.3)$$

$$K1'\lambda = 1,$$

$$\lambda \geq 0,$$

where, $K1$ is a $K \times 1$ vector of ones. The convexity constraint ($K1'\lambda = 1$) ensures that an inefficient firm is only 'benchmarked' against firms of a similar size. In contrast, in a CRS DEA model, a firm may be 'benchmarked' against firms that are substantially larger (or smaller) than it. Therefore, the sum of λ weights is less than (or greater than) one (Coelli et al., 2005).

The input-oriented model measures technical inefficiency as a proportional reduction in input usage with output levels held constant. Similarly, output-oriented

models can be constructed to measure technical inefficiency as a proportional increase in output with input levels held fixed. Therefore, the selection of orientation depends on which quantities (inputs or outputs) can be controlled. However, the choice of orientation has only a minor effect on technical inefficiency scores (Coelli and Perelman, 1999, Coelli et al., 2005). Therefore, output-oriented models are very similar to the input-oriented ones. An output-oriented VRS model can be written as:

$$\begin{aligned}
 & \text{Max}_{\phi, \lambda} \phi, \\
 & \text{Subject to, } -\phi y_i + Y\lambda \geq 0 \\
 & x_i - X\lambda \geq 0 \qquad \qquad \qquad (4.4) \\
 & K1'\lambda = 1, \\
 & \lambda \geq 0,
 \end{aligned}$$

where, $1 \leq \phi < \infty$ and $(\phi - 1)$ is the proportional increase in outputs achieved by the i -th firm while input quantities held constant. $1/\phi$ is defined as technical efficiency score varies from zero and one.

Since the non-parametric approach assumes no measurement error in constructing the frontier, the measured efficiency may be confounded with random deviations from the true efficiency frontier. Moreover, it is computationally difficult to obtain the measures of reliability for efficiency scores, and eventually, results may be sensitive to outliers, and the technical efficiency estimates are upwardly biased in case of small samples (O'Donnell, 2011b). However, Simar and Wilson (2000) suggest a bootstrap procedure of DEA estimators in order to obtain unbiased parameter estimates.

4.2.2 The parametric approach

The parametric or econometric technique is stochastic, which enables distinguishing the effects of noise from those of inefficiency and, provides the basis for statistical inference. Thus, the parametric approaches specify a functional form for the production, cost or profit function, and measure inefficiencies with reference to the estimated function assuming half-normal or truncated-normal distribution for the one-sided error term and normal distribution for the two-sided error term (Mester, 1996).

There are three main parametric models that have been used in the frontier literature, the stochastic frontier analysis (SFA), the distribution free approach (DFA) and the thick frontier approach (TFA). The SFA and the DFA both specify functional forms for the production technology but differ in imposing distributional assumptions on the inefficiencies or random errors. The DFA, introduced by Schmidt and Sickles (1984) and Berger (1993), separates the inefficiencies from random errors in a different way than the SFA.

As applied to bank studies, Berger (1993) for example, DFA assumes a functional form for the cost frontier. The inefficiency of each bank in a panel is assumed constant over time, whereas the random errors tend to average out over time. The estimate of the inefficiency of each bank is then measured as the difference between its average residual from the estimated cost function and that of the bank on the cost efficiency frontier. One limitation of the DFA is that it may provide misleading results if the inefficiency component of the error term is not constant over time or the sample period is not sufficient enough to average out the random error term. The sample period should be at least 6 years to address these issues (De Young, 1997). Unlike SFA and DFA, the TFA does not impose any pre-conceived functional form on the technology. It provides an estimate of a general level of overall efficiency rather than an individual DMU level of efficiency as explained in Bauer et al.(1993). However, the most popular parametric method for estimating efficiency is the SFA. The next sub-section discusses the SFA model and its recent developments.

4.2.2.1 Stochastic frontier analysis (SFA)

The stochastic frontier analysis (SFA), developed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977), has been applied frequently to the bank efficiency literature (e.g., Kumbhakar and Lozano-Vivas, 2005, Frerier and Lovell, 1990). It specifies a particular functional form for production or cost function and assumes a composite error term containing both a symmetric noise component (two-sided) and an inefficiency component (one-sided) with half-normal or truncated-normal distribution for the one-sided error term and normal distribution for the two-sided error term. The symmetric noise component accounts for random statistical noise representing factors such as measurement errors and other unpredictable aspects outside the control of a firm. The other part of the composite error is intended to capture the technical inefficiency of firms.

Aigner, Lovell and Schmidt (1977) and Meeusen and Broeck (1977) independently propose the estimation of a stochastic frontier production function adding a symmetric error term (v_i) to the non-negative error or inefficiency (u_i):

$$\ln(y_i) = f(x_i; \beta) + v_i - u_i, \quad (4.5)$$

where, y_i is the scalar output of firm i ($i=1, 2, \dots, N$); x_i is a $(1 \times k)$ vector of inputs. The parameters (β_i) of this model are estimated by ML method, given suitable distributional assumptions for the error terms. Aigner, Lovell and Schmidt (1977) assume that v_i is independent and has normal distribution, i.e., assumed to be i.i.d $N(0, \sigma_v^2)$ and u_i has the half-normal. However, an exponential distribution of u_i , is suggested by Meeusen and Broeck (1977).

The SFA model has limitations as well. Although the approach can handle statistical noise, there is no prior justification for the selection of any particular distributional form for the inefficiency (u_i). However, the specification of more general distributional forms, such as the truncated-normal (Stevenson, 1980) and the

two-parameter gamma (Greene, 1990), has partially solved this problem. Still, the resulting efficiency measures may be sensitive to distributional assumptions. Nonetheless, recent developments of stochastic frontier estimation require less restrictive distributional assumptions about the inefficiencies and, eventually, provide consistent estimators of firm efficiencies. The next sub-section explains the SFA model using panel data.

4.2.2.2 Panel data SFA model

Much of the criticism surrounding the SFA estimates has been concerned with the strength of the distributional assumptions, especially in regard to the measurement of technical efficiency (u_i). However, such strong assumptions are not required for panel data SFA model. The panel data model is an extension of models for inefficiency effects in stochastic frontiers for cross-sectional data (Battese and Coelli, 1995).

The panel data has potential advantages over a single cross-section of data in frontier estimation. It increases degrees of freedom for the estimation of parameters; provides consistent estimators of firm efficiencies with sufficiently large time periods; removes the necessity of making specific distributional assumptions regarding the inefficiency term u_i , and also relaxes the assumption that inefficiency and factor inputs are independent (Schmidt and Sickles, 1984, Coelli, 1995). Because of the repeated observations on a sample, the panel data model can serve as a substitute for strong distributional and independence assumptions. For example, with panel data, a model can be estimated as a ‘fixed effects’ model without any distributional assumptions (Schmidt, 1985), since the fixed effects (“within”) estimator does not require any assumption of independence between the effects and the explanatory variables. However, assumptions can be imposed and, in such cases, more efficient estimation is possible and the assumptions are testable as Hausman (1978) proposes. Also, the technical efficiency of each producer in the sample can be estimated consistently as time period increases (e.g., $T \rightarrow \infty$) and, thus repeated

observations on a sample resolves the inconsistency problem that lies with the technical efficiency estimation technique of Jondrow, Lovell, Materov and Schmidt (1982) (Kumbhakar and Lovell, 2000).

Pitt and Lee (1981) specify a panel data version of the Aigner, Lovell and Schmidt (1977) half-normal model:

$$\ln(y_{it}) = f(x_{it}; \beta) + v_{it} - u_{it}, \quad (4.6)$$

where y_{it} is the scalar of the logarithm of output for firm i ($i= 1,2,\dots,N$) at time t ($t= 1,2,\dots,T$), x_{it} is a $(1 \times k)$ vector of the logarithm of inputs used by firm i at time t , β is a $(k \times 1)$ vector of unknown parameters.

The literature suggests for two panel regression models. First, the estimation of the parameters is done conditionally on fixed values of the u_i 's, which leads to the 'fixed effects' model and the 'within' estimator of the frontier coefficients. Second, the estimation is carried out marginally on the firm-specific effects u_{it} 's which leads to 'random effects' model (Kalirajan and Shand, 1999).

The SFA deals with both fixed and random coefficients for parametric representation of the technology. The fixed coefficient approach of the 'stochastic production function' of Aigner et al.(1977) and Meeusen and Broeck (1977) assumes that production frontier shifts neutrally as marginal rate of technical substitution (MRTS) remains unchanged at any input combination. Kalirajan and Shand (1999) oppose this view addressing the neutral shift as special case. The diversity of individual DMU leads to parameter variations across units.

An alternative approach for modelling the observation-specific characteristics is the random coefficient approach of the SFA, i.e., the stochastic varying coefficient frontier approach (SVFA). This approach allows a non-neutral shift of the frontier from the actual production function, since individual contributions of inputs to

outputs vary across enterprises or DMUs (Swamy, 1970, Kalirajan and Obwona, 1994, Salim, 1999).

Simar (1992) shows that fixed effects model may provide a poor estimation of the intercepts and of the slope coefficients of the frontier production function and, eventually, unreasonable measures of technical efficiency. The estimated model can only be used to measure efficiency relative to the most efficient firm in the sample and, thus estimates may be unreliable if the number of firms is small (Coelli et al., 2005).

The random effects model can be estimated either using the least squares or the maximum likelihood techniques. The Generalized Least Squares (GLS) method provides consistent and unbiased estimates of the parameters, if the regressors x_{it} are not correlated with the technical inefficiency effects u_{it} . If they are correlated, Hausman and Taylor (1981) propose a testing and estimation procedure. Both the models assume that the technical inefficiency is time invariant. This is likely to be a questionable assumption in a long panel (Greene, 2005b).

It is expected that managers would learn from experiences and, therefore, their technical efficiency levels will change systematically over time, particularly as sample period T gets larger. Following this idea, Kumbhakar (1990) proposes a model that allows for time-varying technical inefficiency:

$$u_{it} = [1 + \exp(\theta t + \delta t^2)]^{-1} u_i, \quad (4.7)$$

where, u_{it} is an exponential function of time, θ and δ are parameters to be estimated; u_i is time-invariant but varies across firms and is assumed to be random and distributed as i.i.d $N(0, \sigma_i^2)$ and truncated at zero $u_i \leq 0$.

$$\text{Let, } \eta(t) = [1 + \exp(\theta t + \delta t^2)]^{-1} \quad (4.8)$$

with the following features:

$\eta(t) \geq 0$ for all t , which implies $u_{it} \leq 0$ since $u_i \leq 0$

$\eta(t)$ is bounded between (0,1)

$\eta(t)$ can be monotonically increasing (decreasing) or concave (convex) depending on the signs and magnitude of θ and δ

Similarly, using the ML method, Battese and Coelli (1992) suggest an alternative estimation of panel data model assuming the time-varying technical efficiency effects u_{it} to be an exponential function of time:

$$u_{it} = \{\exp[-\gamma(t-T)]\}u_i, \quad (4.9)$$

where, u_i is assumed to have truncated normal distribution and only one parameter γ is to be estimated. The inclusion of a time trend in the production function or cost function permits the estimation of both technical change and changes in the technical inefficiencies over time (Cornwell et al., 1990). Orea (2002) also suggests a time-varying technical efficiency (TE), adding one additional parameters γ_2 into the Battese and Coelli (1992) model to relax the monotonic temporal pattern of the technical efficiency (TE). Thus, the number of unknown parameters (γ_1, γ_2) associated with TE increases from one to two:

$$u_{it} = \{\exp[-\gamma_1(t-T) - \gamma_2(t-T)^2]\}u_i, \quad (4.10)$$

The panel data SFA model accommodates exogenous variables affecting firm's efficiency in the technical inefficiency component (u_i) in a single-step estimation procedure (Battese and Coelli, 1995). The next sub-section describes the one-stage panel data SFA model.

4.2.2.3 Single-stage panel data SFA model

In the conventional two-stage regression, the estimated inefficiency measures (u_i) obtained from the SFA estimation (in the first-stage) are regressed on a set of environmental variables in the second stage. The main caveat of the two-stage analysis is the violation of the assumption made in the first stage that the inefficiency components of the composite error term from the production or cost frontier are independently and identically distributed (Fries and Taci, 2005). The second-stage involves the specification of a regression model for the predicted technical inefficiency effects, which contradicts the assumption of identically distributed inefficiency effects in the stochastic frontier.

Battese and Coelli (1995) address this econometric problem of the two-stage procedure while investigating both the determinants of technical inefficiencies and the degree of technical change over time within a panel regression framework. The authors propose an estimation procedure for panel data, where the non-negative inefficiency term is assumed to have a truncated distribution with different mean values for each firm. The distribution of the inefficiency terms are not the same, but are expressed as functions of explanatory variables. The inefficiency terms are then independently but not identically distributed. They are obtained by truncation at zero of the $N(\gamma z_{it}, \sigma_u^2)$ distribution, where, z_{it} is a vector of exogenous variables that affect technical efficiency, and γ is a vector of parameters to be estimated.

Following Battese and Coelli (1995), the one-stage panel data SFA model specification can be expressed as:

$$y_{it} = f(x_{it}; \beta) + v_{it} - u_{it} \quad (4.11)$$

$$u_{it} = \gamma z_{it} + \varepsilon_{it} \quad (4.12)$$

where, γz_{it} is the explained and ε_{it} is the unexplained component of technical inefficiency. ε_{it} is defined by the truncation of the normal distribution with zero

mean and variance σ^2 such that the point of truncation is $-\gamma z_{it}$, i.e., $\varepsilon_{it} \geq -\gamma z_{it}$. These assumptions are consistent with the u_{it} having non-negative and independently distributed truncations at zero of the $N(\gamma z_{it}, \sigma_u^2)$ distribution, which is different from $N(0, \sigma_v^2)$. The noise component v_{it} is assumed to be normally distributed with zero mean and constant variance. i.e., $v_{it} \sim \text{i.i.d } N(0, \sigma_v^2)$. Furthermore, we assume that u_{it} and v_{it} are independent. The technical efficiency of the production for i -th firm at the t -th observation can be defined as:

$$TE_{it} = \exp(-u_{it}) = \exp(-\gamma z_{it} - \varepsilon_{it})$$

Considering the merit of the one-step approach and its compatibility with panel data, this thesis follows the one-stage SFA model proposed by Battese and Coelli (1995) for cost efficiency estimation of the sample banks. The following section specifies the cost frontier model to be estimated in Chapter 5.

4.3 Cost frontier model

Cost efficiency measures the proportional reduction in costs that can be attained if the firm is both allocatively and technically efficient. Allocative efficiency measures the proportional reduction in costs if the firm (bank, in this study) chooses the right mix of inputs given the prices (the point of tangency between the isoquant and iso-cost line). Technical efficiency measures the proportional reduction in input usage if the firm operates on the efficient frontier.

The choice of cost function instead of production function depends on the behavioural assumptions of the producers and/ or the availability of data. The cost function approach is widely used to model the technology of a firm operating in regulated service sectors such as electricity, telephone, airlines and banking. Since banks produce multiple outputs, a cost function is more appropriate. In fact, the cost function approach has the advantage over the production function approach in handling multiple outputs (Kumbhakar and Lozano-Vivas, 2005).

Following Aigner et al. (1977), Meeusen and van den Broeck (1977) and Frerier and Lovell (1990), the single-equation stochastic cost function model can be expressed as:

$$C_i = f(y_i, p_i; \beta) + \varepsilon_i ; \quad (4.13)$$

where, C_i is the observed total cost, y_i is a vector of outputs or services produced by banks, and p_i represents input-price vector, β is a vector of technology parameters to be estimated, and the composite error term is $\varepsilon = u + v$; u and v are independently distributed, where u is assumed to be distributed as half-normal $u \sim N(0, \sigma_u^2)$, i.e., a positive disturbance capturing the effects of inefficiency, and v is assumed to be distributed as two-sided normal with zero mean and variance σ_v^2 , capturing the effect of the statistical noise. The error component u is the asymmetric measure representing bank's cost deviations from the stochastic cost frontier. This component also assumes that all the observations lie on or above the frontier. The other error component v represents the factors outside the bank's control. The above cost function should satisfy certain properties, which are as follows (Coelli et al., 2005):

- i. Non-negativity: $f(y, p) > 0$ for $y > 0$ and $p > 0$, implies that an output incurs cost.
- ii. Non-decreasing in output y : if $y_1 > y_2$, then $f(y_1, p) > f(y_2, p)$, which states that cost cannot be decreased as output increases.
- iii. Non-decreasing in input prices p : if $p_1 > p_2$, then $f(y, p_1) > f(y, p_2)$, which means that an increase in input prices leads to an increase in costs.
- iv. Homogeneity of degree one in input prices p : $f(y, kp) = k f(y, p)$ for $k > 0$. This implies that a proportional increase or

decrease in input prices will lead to the same proportional change in total costs

- v. Concavity in input prices $p: f(y, \theta p_1 + (1-\theta)p_2) > \theta f(y, p_1) + (1-\theta)f(y, p_2)$ for all $0 \leq \theta \leq 1$

The frontier approach maintains that managerial or controllable inefficiencies only increase costs above the frontier or best practice levels and, random fluctuations can either increase or decrease costs. Since uncontrollable factors are assumed to be symmetrically distributed, the cost frontier $C_i = f(y_i, p_i; \beta) + \varepsilon_i$ is clearly stochastic. The joint density function $f(\varepsilon_i)$ for a half-normal distribution can be expressed as:

$$f(\varepsilon_i) = \frac{2}{\sigma} f^*\left(\frac{\varepsilon_i}{\sigma}\right) [1 - F^*(\varepsilon_i \lambda \sigma^{-1})] \quad (4.14)$$

where, f^* and F^* are standard normal density and standard normal cumulative distribution functions respectively. Moreover, $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\lambda = \frac{\sigma_u}{\sigma_v}$.

Following Jondrow et al.(1982), the bank-specific estimates of u_i can be obtained by the expected value of u_i conditional on the composite error. Hence, the mean of this conditional distribution for the half-normal model is as follows:

$$E(u_i \mid \varepsilon_i) = \frac{\sigma \lambda}{(1 + \lambda)} \left[\frac{f(\varepsilon_i \lambda / \sigma)}{1 - F(\varepsilon_i \lambda / \sigma)} + \frac{\varepsilon_i \lambda}{\sigma} \right] \quad (4.15)$$

where, $f(\cdot)$ and $F(\cdot)$ are the standard normal density function and the standard normal distribution respectively. $E(u_i \mid \varepsilon_i)$ is an unbiased but inconsistent estimator of u_i and, the variance of the estimator remains non-zero (Greene, 1993).

The translog cost function is the most popular form of stochastic cost function since it is flexible enough to envelop the data more closely (Schmidt, 1985).

Also it accommodates multiple outputs without necessarily violating curvature conditions. This function imposes minimum *a priori* restrictions on the cost structure. The general form of the logarithmic specification of the cost frontier using panel data can be written as (Wang and Schmidt, 2002):

$$C_{it} = f(Y_{it}'; \beta) + v_{it} + u_{it}(z_{it}; \gamma), \quad (4.16)$$

where, $u(z, \gamma) \geq 0$; C_{it} is total cost in logarithm form, Y_{it}' is a matrix of outputs and of input prices in logarithm form, u_{it} (non-negative) is the technical inefficiency term (as higher bank inefficiency is associated with higher cost), β is a vector of technology parameters to be estimated, v_{it} is random error, z_{it} is a vector of exogenous variables that affect technical efficiency, and γ is a vector of parameters for the inefficiency function to be estimated. The underlying assumptions of the cost frontier model (Equation 4.16) are as follows:

$$v_{it} \sim iidN(0, \sigma_v^2)$$

$$u_{it} \sim N^+[0, \sigma_u(z, \gamma)^2]$$

$$E(v_{it}, u_{it}) \equiv 0$$

$$E(Y_{it}, u_{it}) \equiv 0$$

The computer program FRONTIER 4.1 (Coelli, 1996) is used to estimate the cost efficiency of the sample banks using the translog stochastic frontier model in Chapter 5 following Equation (4.16). The rationale of output, input prices and other explanatory variables used in the empirical model is discussed in Chapter 5. The next sub-section develops the analytical framework to compute TFP change and its components.

4.4 Total factor productivity (TFP)

Productivity is essentially a level concept. Productivity change refers to the movements in productivity performance of a firm or an industry over time. The recent literature focusing on TFP measurement has tended to use estimated frontier production functions. This is considered as the superior method compared to the traditional econometric TFP measures as in Solow (1957). The reason is that the traditional econometric measures are based on ordinary least squares (OLS) average production functions which cannot separate technical efficiency from technological change or progress (Colwell and Davis, 1992).

The frontier may be specified to be either deterministic or stochastic. The deterministic non-parametric frontier approach (e.g., DEA), pioneered by Farrell (1957), has been followed substantially in the applied work on banking. It is common to use estimated output and input distance functions to estimate the rate of productivity change. Depending on the behavioural assumptions i.e., cost minimization (the bank chooses a smaller input combination without reducing output level) or revenue maximization (bank expands output holding inputs constant), distance functions may be, respectively, input oriented or output oriented (Färe and Primont, 1995).

The econometric estimation of distance functions is not straight forward because there is a possibility that some of the explanatory variables may be correlated with the composite error term (Coelli et al., 2005, Färe and Primont, 1995). O'Donnell (2013) makes a similar observation that more than one variable in the econometric estimation of distance functions may be endogenous and, in such cases, maximum likelihood estimation can lead to biased and inconsistent parameter estimates. Hence, this thesis follows non-parametric DEA technique to compute the Färe-Primont productivity index, suggested by O'Donnell (2011c), to estimate the TFP growth of the sample banks.

The estimated Färe-Primont TFP index can be decomposed into technical change and various efficiency change components. Without such decomposition, TFP may be synonymously equated with technological progress (technical change), which leads to incorrect conclusion. The DEA method is chosen mainly because DEA assumes the production function is only locally linear and does not require specific assumptions concerning the error term representing statistical noise (O'Donnell, 2012a).

4.4.1 The Färe-Primont TFP index

The Färe-Primont index is employed to estimate the TFP change of the sample banks. TFP change can be decomposed into a measure of technical change and several measures of efficiency change. The efficiency measures include a measure of overall productive efficiency and component measures of technical, scale and mix (or scope) efficiency. Technical change reflects movements in the production frontier and technical efficiency change measures the movements towards or away from the frontier. Scale efficiency change measures the movements around the frontier surface to capture economies of scale and mix efficiency change measures the movements around the frontier surface to capture economies of scope.

The total factor productivity of a firm is the ratio of an aggregate output to an aggregate input (Jorgenson and Griliches, 1967). let $y_{it} = (y_{1it}, \dots, y_{jit})'$ and $x_{it} = (x_{1it}, \dots, x_{kit})'$ denote the output and input vectors respectively for firm i in

period t . Therefore, the multi-factor productivity (MFP) or total factor productivity (TFP) of a firm can be expressed as:⁹

$$TFP_{it} = Y_{it} / X_{it} \quad (4.17)$$

where $Y_{it} = Y(y_{it})$ is an aggregate output, $X_{it} = X(x_{it})$ is an aggregate input and $Y(\cdot)$ and $X(\cdot)$ are non-negative, non-decreasing and linearly homogeneous aggregator functions. The associated index number that measures the relative TFP of firm i in period t and firm m in period s is:

$$TFP_{ms,it} = \frac{TFP_{it}}{TFP_{ms}} = \frac{Y_{it} / X_{it}}{Y_{ms} / X_{ms}} = \frac{Y_{ms,it}}{X_{ms,it}} \quad (4.18)$$

where $Y_{ms,it} = Y_{it}/Y_{ms}$ and $X_{ms,it} = X_{it}/X_{ms}$ are output and input quantity indices respectively. Equation (4.18) expresses TFP growth as a measure of output growth divided by a measure of input growth, which is defined as productivity change (Jorgenson and Griliches, 1967).

Following Shephard (1953,1970), output and input distance functions, which are indeed non-negative, non-decreasing and linearly homogeneous, can be expressed as (O'Donnell, 2011a):

$$Y(y) = D_o(x_o, y, t_o)$$

$$X(x) = D_l(x, y_o, t_o)$$

⁹ The terminology ‘multi-factor productivity (MFP)’ is used in the literature considering the fact that multiple but not all factors of production are accounted for production process. However, O'Donnell (2008, 2011b) uses the term total factor productivity (TFP) instead of MFP in productivity analysis.

where y and x are vectors of output and input quantities respectively and $D_O(\cdot)$ and $D_I(\cdot)$ are output and input distance functions. The Färe-Primont index can then be expressed as:

$$TFP_{ms,it} = \frac{D_O(x_o, y_{it}, t_o) D_I(x_{ms}, y_o, t_o)}{D_O(x_o, y_{ms}, t_o) D_I(x_{it}, y_o, t_o)} \quad (4.19)$$

4.4.2 Technical change (TC) and TFP efficiency (TFPE)

The Färe-Primont TFP index can be exhaustively decomposed into measures of technical change and efficiency change. The technical change is the change in the maximum productivity possible using the production technology. The TFP efficiency (TFPE) is an overall measure of productive efficiency defined as the difference between observed TFP and the maximum TFP possible using the available production technology.

Therefore, TFP efficiency of firm i in period t can be defined as:

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{Y_t / X_t}{Y_t^* / X_t^*} \quad (4.20)$$

where, TFP_t^* denotes the maximum TFP possible using the period- t technology and Y_t^* and X_t^* denote the aggregate output and aggregate input at the TFP-maximizing point.

A similar equation holds in period s :

$$TFPE_s = \frac{TFP_s}{TFP_s^*} = \frac{Y_s / X_s}{Y_s^* / X_s^*} \quad (4.21)$$

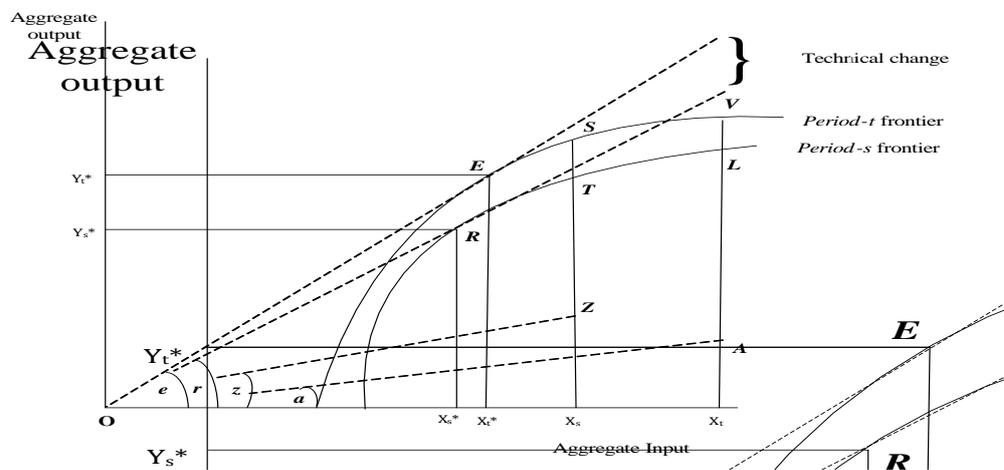
Technical change (TC) between the two periods (period t and period s) technology can be expressed as the shift in the production frontier (Figure 4.2), i.e.,

the ratio between the maximum TFP in period t (TFP_t^*) and the maximum TFP in period s (TFP_s^*):

$$TC_{t,s} = \frac{TFP_t^*}{TFP_s^*} \quad (4.22)$$

where, the industry experiences technological progress or regress if TFP_t^* / TFP_s^* is greater than one and less than one respectively.

Figure 4.2: Technical change (TC)



Source: O'Donnell(2008)

4.4.3 TFP Efficiency decomposition

Following O'Donnell (2012a), TFP efficiency change can be further decomposed into technical efficiency change, scale efficiency change, mix efficiency change, residual scale efficiency change and residual mix efficiency change.

4.4.3.1 Technical efficiency

Figure 4.3 depicts the output- and input-oriented technical efficiency. The vertical distance between point A and point C measures the output-oriented technical

efficiency while the horizontal distance between point A and point B measures the input-oriented technical efficiency. In terms of slopes of rays through the origin,

$$OTE_t = \frac{SlopeOA}{SlopeOC} \quad (4.23)$$

Therefore, OTE_t is the ratio of TFP at point A (i.e., observed TFP) to TFP at point C (i.e., the maximum TFP possible while holding the input vector and the output mix fixed). Similarly, input-oriented technical efficiency can be expressed as follows:

$$ITE_t = \frac{SlopeOA}{SlopeOB} \quad (4.24)$$

Therefore, ITE_t is the ratio of TFP at point A (i.e., observed TFP) to TFP at point B (i.e., the maximum TFP possible holding the output vector and the input mix fixed).

4.4.3.2 Scale efficiency

Pure scale efficiency is defined as the difference between TFP at technically efficient point and TFP at the point of mix-invariant optimal scale (MIOS). This is pure scale efficiency because input and output mixes are being held fixed. Figure 4.3 shows that improvements in technical efficiency imply an increase in TFP and yet the TFP of firm A is not maximized by moving to either of the technically efficient points B or C. Instead, firm A maximizes its TFP by moving to point D (the point of mix-invariant optimal scale) if input and output mixes are held fixed.

Figure 4.3: Output- and input-oriented technical, scale and mix efficiency

4.4.3.3 Mix efficiency

Mix efficiency is a measure of change in productivity when the restrictions on input and output mix are relaxed. In Figure 4.3, the curve passing through the points U, E and V is an example of an unrestricted production frontier exhibiting the assumed VRS production technology. The horizontal movement from point B to point U reflects the relaxation of the input mix. On the other hand, the vertical movement from point C to point V corresponds to the removal of the restrictions on output mix.

Pure mix efficiency is a measure of the difference between TFP at a technically efficient point on the mix restricted frontier and TFP at a point on the unrestricted frontier holding either the input vector or the output vector fixed. The term pure here refers to the input vector or the output vector is fixed and, thus this change in TFP is a pure mix effect. Pure output-oriented mix efficiency (OME) is the ratio of TFP at point C to TFP at point V, while pure input-oriented mix efficiency (IME) is the ratio of TFP at point B to TFP at point U (Figure 4.3).

The measures of output-oriented mix efficiency (OME) and input-oriented mix efficiency (IME) can be expressed as:

$$OME_t = \frac{\bar{Y}_t / X_t}{\hat{Y}_t / X_t} = \frac{\bar{Y}_t}{\hat{Y}_t} \leq 1 \quad (4.29)$$

$$IME_t = \frac{Y_t / \bar{X}_t}{Y_t / \hat{X}_t} = \frac{\hat{X}_t}{\bar{X}_t} \leq 1 \quad (4.30)$$

In terms of slopes of rays through the origin, the measures are:

$$OME_t = \frac{\text{Slope}OC}{\text{Slope}OV} \quad (4.31)$$

$$IME_t = \frac{\text{Slope}OB}{\text{Slope}OU} \quad (4.32)$$

4.4.3.4 Residual scale efficiency

Residual scale efficiency is the ratio of TFP at a technically- and mix-efficient point to TFP at a point of maximum productivity (MP). The term scale means any movement from one technically- and mix-efficient point to another and thus any improvement in TFP is essentially a scale effect. The term residual is used because, although all the points on the unrestricted frontier are mix-efficient points, they may nevertheless have different input and output mixes, for example, points V and U in Figure 4.3. Hence, what is essentially a measure of scale efficiency may contain a residual mix effect. While comparing TFP at the observed point A with TFP at the point of maximum productivity (point E in Figure 4.3), the residual scale efficiency is the component that remains after accounting for pure technical and pure mix efficiency effects.

The measures of residual output-oriented scale efficiency (ROSE) and residual input-oriented scale efficiency (RISE) are:

$$ROSE_t = \frac{\hat{Y}_t / X_t}{Y_t^* / X_t^*} \leq 1 \quad (4.33)$$

$$RISE_t = \frac{Y_t / \hat{X}_t}{Y_t^* / X_t^*} \leq 1 \quad (4.34)$$

In terms of slopes of rays through the origin, the measures are:

$$ROSE_t = \frac{\text{Slope}OV}{\text{Slope}OE} \quad (4.35)$$

$$RISE_t = \frac{\text{Slope}OU}{\text{Slope}OE} \quad (4.36)$$

4.4.3.5 Residual mix efficiency

Residual mix efficiency (RME) is the ratio of TFP at a point of mix-invariant optimal scale (MIOS) to TFP at a point of maximum productivity (MP), i.e.,

$$RME_t = \frac{\tilde{Y}_t / \tilde{X}_t}{Y_t^* / X_t^*} \leq 1 \quad (4.37)$$

In Figure 4.3, the measure of RME is the ratio of TFP at point D on the mix-restricted frontier to TFP at point E on the unrestricted frontier. In terms of slopes of rays through the origin, the measure is:

$$RME_t = \frac{\text{Slope}_{OD}}{\text{Slope}_{OE}} \quad (4.38)$$

The mix effect can be interpreted as the movement from an optimal point on a mix-restricted frontier (i.e., point D in Figure 4.3) to an optimal point on an unrestricted frontier (i.e., point E in Figure 4.3). Therefore, the change in TFP is essentially a mix effect. The term residual is used for two reasons: first, the movement from point D to point E may involve a change in scale and, second, the measure comparing TFP at points A and E, can be viewed as the component that remains after accounting for pure technical and pure scale efficiency effects.

4.4.3.6 TFP efficiency decomposition

Recalling Equation (4.20), the total factor productive efficiency (TFPE) of a firm is the ratio of observed TFP to the maximum TFP possible using the available technology. The technology exhibits variable returns to scale. For such technologies, it is generally possible to find finite non-zero input and output vectors that maximize TFP. Therefore,

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{Y_t / X_t}{Y_t^* / X_t^*} \leq 1 \quad (4.39)$$

In Figure 4.3, the measure of TFPE is the ratio of TFP at the observed point A to TFP at the point of maximum productivity E. In terms of slopes of rays through the origin,

$$TFPE_t = \frac{SlopeOA}{SlopeOE} \quad (4.40)$$

Several meaningful decompositions of TFP efficiency (both output- and input- oriented) can be expressed in terms of aggregate quantities. In terms of slopes of rays (through the origin) in aggregate quantity space, TFPE can be expressed as follows:

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{slope0A}{slope0E} = \left(\frac{slope0A}{slope0C} \times \frac{slope0C}{slope0V} \times \frac{slope0V}{slope0E} \right) \quad (4.41)$$

Following Equations (4.23), (4.31) and (4.35), $TFPE_t$ can be written as follows:

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = OTE_t \times OME_t \times ROSE_t \quad (4.42)$$

Again,

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{slope0A}{slope0E} = \left(\frac{slope0A}{slope0C} \times \frac{slope0C}{slope0D} \times \frac{slope0D}{slope0E} \right)$$

Following Equations (4.23), (4.27) and (4.38), $TFPE_t$ can also be written as follows:

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = OTE_t \times OSE_t \times RME_t \quad (4.43)$$

Again,

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{slope0A}{slope0E} = \left(\frac{slope0A}{slope0B} \times \frac{slope0B}{slope0U} \times \frac{slope0U}{slope0E} \right)$$

Further, following Equations (4.24), (4.32) and (4.36), $TFPE_t$ can be written as follows:

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = ITE_t \times IME_t \times RISE_t \quad (4.44)$$

Again,

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{slope0A}{slope0E} = \left(\frac{slope0A}{slope0B} \times \frac{slope0B}{slope0D} \times \frac{slope0D}{slope0E} \right)$$

Finally, following Equations (4.24), (4.28) and (4.38), $TFPE_t$ can be written as follows:

$$TFPE_t = \frac{TFP_t}{TFP_t^*} = ITE_t \times ISE_t \times RME_t \quad (4.45)$$

The measures of residual scale and residual mix efficiency are the measures of productive performance associated with economies of scale and scope. O'Donnell (2010, 2011a) suggests the following derivation for a combined measure of scale and mix efficiency change for output- and input-oriented approaches:

The output-oriented scale-mix efficiency is:

$$OSME_t = OME_t \times ROSE_t = OSE_t \times RME_t \leq 1 \quad (4.46)$$

The input-oriented scale-mix efficiency is :

$$ISME_t = IME_t \times RISE_t = ISE_t \times RME_t \leq 1 \quad (4.47)$$

4.4.4 TFP change and its components

Following Equations (4.18), (4.20) and (4.21), the multiplicatively-complete TFP index in period- t relative to period- s can be defined as:

$$TFP_{s,t} = \frac{TFP_t}{TFP_s} = \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{TFPE_t}{TFPE_s} \right) \quad (4.48)$$

The first term in parentheses measures the change in the maximum TFP over time and, thus, is a natural measure of technical change. The second term in parentheses is a measure of overall efficiency change.

The TFP index that compares the productivity (output-oriented) in periods s and t can be decomposed further using Equations (4.42), (4.43) and (4.46) as:

$$TFP_{s,t} = \frac{TFP_t}{TFP_s} = \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{OTE_t}{OTE_s} \right) \times \left(\frac{OME_t}{OME_s} \right) \times \left(\frac{ROSE_t}{ROSE_s} \right) \quad (4.49)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{OTE_t}{OTE_s} \right) \times \left(\frac{OSE_t}{OSE_s} \right) \times \left(\frac{RME_t}{RME_s} \right) \quad (4.50)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{OTE_t}{OTE_s} \right) \times \left(\frac{OSME_t}{OSME_s} \right) \quad (4.51)$$

where, $OSME_t = OME_t \times ROSE_t = OSE_t \times RME_t$, denotes output-oriented scale-mix efficiency (a move from point C to point E in Figure 4.3).

Similar TFP decompositions can be obtained for input-oriented production technology using Equations (4.44), (4.45) and (4.47) as:

$$TFP_{s,t} = \frac{TFP_t}{TFP_s} = \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{ITE_t}{ITE_s} \right) \times \left(\frac{IME_t}{IME_s} \right) \times \left(\frac{RISE_t}{RISE_s} \right) \quad (4.52)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{ITE_t}{ITE_s} \right) \times \left(\frac{ISE_t}{ISE_s} \right) \times \left(\frac{RME_t}{RME_s} \right) \quad (4.53)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{ITE_t}{ITE_s} \right) \times \left(\frac{ISME_t}{ISME_s} \right) \quad (4.54)$$

This thesis uses both input-oriented and output-oriented distance functions to compute the Färe-Primont TFP index and its decomposition. Equations (4.51) and (4.54) reveal that productivity change can be broken into three intrinsically different components: a technical change component that measures movements (or shifts) in the production frontier, a technical efficiency change component which measures movements towards the frontier and a scale-mix efficiency change component that measures movements around the frontier surface.

4.4.5 Estimation of the Färe-Primont TFP index using DEA frontiers

This sub-section discusses how data envelopment analysis (DEA) method can be used to estimate the frontier and identify the measures of output- and input-oriented efficiency associated with a distance-based Färe-Primont index. The main assumption underpinning the use of DEA is that the frontier is locally linear (O'Donnell, 2010). This means that if firm i in period t is technically efficient, i.e., on the frontier, then in the neighbourhood of the point (y_{it}, x_{it}) the frontier takes the linear form, e.g., $y_{it}'\alpha = \gamma + x_{it}'\beta$. Therefore, the (local) output distance function representing the technology available in period t is:

$$D_o(x_{it}, y_{it}, t) = (y_{it}'\alpha) / (\gamma + x_{it}'\beta) \quad (4.55)$$

where, α and β are non-negative and γ represents for returns to scale. If $\gamma=0$, the technology exhibits constant returns to scale, while if $\gamma \geq 0$ the technology exhibits local non-increasing returns to scale.

The standard output-oriented DEA problem involves selecting values of the unknown parameters in Equation (4.55) to minimize the output-oriented technical efficiency function, $OTE_{it}^{-1} = D_o(x_{it}, y_{it}, t)^{-1}$. If the technology is permitted to exhibit variable returns to scale, then the constraints that need to be satisfied are $\alpha \geq 0$, and $\beta \geq 0$ and $D_o(x_{it}, y_{it}, t) \leq 1$ for all observations. However, this constrained optimization problem has an infinite number of solutions. Therefore, by setting another constraint, $y'_{it}\alpha = 1$, the DEA problem takes the form of a linear program (O'Donnell, 2011c):

$$D_o(x_{it}, y_{it}, t)^{-1} = OTE_{it}^{-1} = \min_{\alpha, \beta, \gamma} (\gamma + x'_{it}\beta : \gamma l + X'\beta \geq Y'\alpha; y'_{it}\alpha = 1; \alpha \geq 0; \beta \geq 0) \quad (4.56)$$

where, Y is a $J \times M_t$ matrix of observed outputs, X is a $K \times M_t$ matrix of observed inputs, l is an $M_t \times 1$ unit vector and M_t is the number of observations used to estimate the frontier in period t . (O'Donnell, 2011c) Similarly, the distance function representing the technology available in period t is :

$$D_I(x_{it}, y_{it}, t) = (x'_{it}\eta) / (y'_{it}\phi - \delta) \quad (4.57)$$

The input-oriented DEA problem is to maximize $ITE_{it} = D_I(x_{it}, y_{it}, t)^{-1}$ subject to the constraints $\phi \geq 0$, $\eta \geq 0$ and $D_I(x_{it}, y_{it}, t) \geq 1$ for all M_t observations. A unique solution can be obtained by setting $x'_{it}\eta = 1$. Hence, the input-oriented problem takes the form a linear program is:

$$D_I(x_{it}, y_{it}, t)^{-1} = ITE_{it} = \max_{\phi, \delta, \eta} (y'_{it}\phi - \delta : Y'\phi \leq \delta l + X'\beta; x'_{it}\eta = 1; \phi \geq 0; \eta \geq 0) \quad (4.58)$$

The computer program DPIN3.0 developed by O'Donnell (2011a) uses variants of Equations (4.56) and (4.58) to estimate TFP and various components of TFP change. The aggregate outputs are computed using the following aggregator functions (O'Donnell, 2011c):

$$Y(y) = y'p_o^* \quad (4.59)$$

$$X(x) = x'w_o^* \quad (4.60)$$

where,

$$p_o^* = \partial D_o(x_o, y_o, t_o) / \partial y_o = \alpha_o / (\gamma_o + x_o' \beta_o) \quad (4.61)$$

$$w_o^* = \partial D_l(x_o, y_o, t_o) / \partial x_o = \eta_o / (y_o' \phi_o - \delta_o) \quad (4.62)$$

The Färe-Primont index aggregate output is then computed using Equations (4.59) and (4.61):

$$Y_{it} = (y_{it}' \alpha_o) / (\gamma_o + x_o' \beta_o) \quad (4.63)$$

Finally, the Färe-Primont index aggregate input can be computed using Equations (4.60) and (4.62):

$$X_{it} = (x_{it}' \eta_o) / (y_o' \phi_o - \delta_o) \quad (4.64)$$

where, α_o , β_o , γ_o , η_o , ϕ_o and δ_o provide the solutions to Equations (4.56) and (4.58). All of these aggregator functions are linear in outputs or inputs.

The maximum TFP in period t can be computed as $TFP_t^* = \max_i TFP_{it} = \max_i Y_{it} / X_{it}$. Thus, the measures of efficiency (as defined in Section 4.4) can be computed residually (O'Donnell, 2011c):

$$TFPE_{it} = TFP_{it} / TFP_t^* \quad (4.65)$$

$$OSME_{it} = TFPE_{it} / OTE_{it}, \quad (4.66)$$

$$ISME_{it} = TFPE_{it} / ITE_{it} \text{ and} \quad (4.67)$$

$$RME_{it} = OSME_{it} / OSE_{it} = ISME_{it} / ISE_{it} \quad (4.68)$$

Once the Färe-Primont TFP index and its components are estimated, the next step is to investigate the drivers and determinants of TFP change. The next subsection explains panel data regression models to estimate (1) the influence of different bank-specific and environmental variables on TFP change components; (2) to identify the determinants of profitability measures.

4.5 Panel data regression framework

This thesis employs two panel data regression frameworks, one for investigating the drivers of the estimated TFP change and its components and, the other for identifying the determinants of profitability measures. The next two sub-sections present the construction of the regression models.

4.5.1 Sources of productivity change

A panel data regression model is constructed following Suyanto, Bloch and Salim (2012) to estimate the influence of various bank-specific and environmental variables on the estimated Färe-Primont TFP index and its components separately. The model is:

$$FPI_i^{s,t} = \alpha_i + \beta X_{it} + \varepsilon_{it} \quad (4.69)$$

where, $FPI_i^{s,t}$ is the measure of productivity change for bank i between two time periods s (the base period) and t (the reference technology period). FPI represents TFP change (ΔTFP), technical change (ΔTC) and other efficiency change components, such as ΔOTE , ΔOME , $\Delta ROSE$ and $\Delta OSME$. The independent variable

X represents bank-specific and environmental variables, α is the constant term, β is a vector of parameters to be estimated and ε denotes the error term. The Hausman (1978) test is undertaken to choose the model that best represents the sample data.

4.5.2 Determinants of profitability measures

Another panel data regression model is estimated to identify the determinants of profitability measures, such as net interest margin (NIM), return on assets (ROA) and return on equity (ROE). The bank-specific and environmental variables are regressed on the three estimated profitability measures separately. The regression model is:

$$Z_{it} = \beta_i + \gamma Y_{it} + \nu_{it} \quad (4.70)$$

where Z_{it} represents the measures of profitability for bank i . Y_{it} indicates the selected explanatory variables, ν_{it} denotes the error term, β is the constant term and γ is the vector of regression coefficients.

4.6 Conclusion

This chapter presents the competing paradigms of the frontier models used in efficiency and productivity analysis. Since each method has its own advantages and limitations, no method suggested in the literature is necessarily the best method to follow. The chapter explains the analytical framework to estimate the banking performance of the commercial banks in Bangladesh in terms of cost efficiency, productivity growth and profitability.

The one-stage panel data SFA model of Battese and Coelli (1995), which follows the maximum likelihood (ML) procedure, will be followed for estimating cost efficiency in Chapter 5. The method permits a single-stage estimation of the parameters of the cost function and measures of bank inefficiencies.

The Färe-Primont TFP index computation and decomposition of the total factor productivity (TFP) change are also discussed. The index satisfies all the required properties (axioms and tests) of index number theory and is useful within the DEA framework. The Färe-Primont TFP index can be decomposed into a measure of technical change and several measures of efficiency change. The efficiency measures include a measure of overall productive efficiency and several measures of technical, scale and mix (or scope) efficiency.

Panel data regression models are constructed to investigate the sources of productivity change and, also identify the determinants of profitability measures, such as net interest margin (NIM), return on assets (ROA), and return on equity (ROE). The analytical approach developed in this chapter is going to be followed in the next three subsequent empirical chapters.

Chapter 5

Financial deregulation and cost efficiency analysis of the commercial banks in Bangladesh

5.1 Introduction

This chapter focuses on the estimation of cost efficiency of the commercial banks in Bangladesh. Following the methodology explained in Chapter 4, this chapter employs the single-stage stochastic frontier analysis (SFA) of Battese and Coelli (1995) in order to estimate the cost efficiency of the sample banks with a particular focus on investigating the impact of financial deregulation. The financial sector reform program, implemented in the late 1980s, has brought substantial changes in the financial structure of Bangladesh, predominantly in the banking sector. Therefore, banking in Bangladesh has become relatively competitive and less state-directed. Banks have been enjoying freedom in determining interest rates and managing credit portfolios. A good number of private banks, both domestic and foreign, and non-bank financial institutions are allowed for banking operation. The number of private commercial banks has increased to 38, foreign banks 9 and non-bank financial institutions 30 at the end of 2014. Therefore, the extent of financial deepening in terms of broad money as a percentage of GDP has increased from 14% in 1974 to 61% in 2013 (World Bank, 2013).

Cost efficiency has been considered as a performance measure of banks in the banking literature over the past three decades (e.g., Boucinha et al., 2013, Du and Girma, 2011, Wang and Kumbhakar, 2009, Ferrier and Lovell, 1990, Fries and Taci, 2005, Rezvanian et al., 2011, Resti, 1997, Kumbhakar and Wang, 2007, Humphrey, 1993). Although there is an extensive literature on the cost efficiency of banks for different countries, there is no comprehensive study on the banking sector in Bangladesh investigating the impact of financial deregulation on banking performance in terms of cost efficiency. There are few studies on the efficiency of individual banks or problem banks in Bangladesh, but these have been lacking

appropriate data and technique (Akther et al., 2012, Khanam and Khandoker, 2005, Hassan, 1999, Perera et al., 2007). Therefore, this is the first study of its kind in investigating the impact of financial deregulation on the cost efficiency of banks in Bangladesh.

Applying the parametric technique SFA, developed by Aigner et al.(1977) and Meeusen and Van den Broeck (1977), the estimation uses a unique balanced panel dataset for the period 1983-2012 for the sample commercial banks in Bangladesh. Following the maximum likelihood (ML) procedure of Battese and Coelli (1995), the cost frontier analysis allows single-stage estimation of the parameters of the cost function and correlates of bank inefficiencies.

It is noteworthy to mention that there are some limitations in applying two-stage procedures. The main caveat of two-stage analysis is the violation of the assumption made in the first stage that the inefficiency component of the composite error term of the cost frontier is independently and identically distributed. The second-stage involves the specification of a regression model for the predicted technical inefficiency effects, which contradicts the assumption of identically distributed inefficiency effects in the stochastic frontier (Fries and Taci, 2005).

The remainder of the chapter is organized as follows. Section 5.2 contains the research design which includes methodology, data and variable construction. Section 5.3 discusses model specification and estimation procedure. Section 5.4 provides empirical results and analysis and finally, Section 5.5 concludes.

5.2 Research design

This thesis estimates a stochastic cost frontier for 12 Bangladeshi commercial banks, of which four banks are public or state-owned (SCBs) and eight are private banks (PCBs). Since the focus of the thesis is to examine the impact of financial deregulation, the sample consists of banks which have operational history for both pre- and post-reform periods. As noted in Chapter 2, the financial sector reform

program (FSRP) had been implemented during the period 1991-1995. Therefore, the efficiency estimates are analysed for three time periods, 1983-1990 as the pre-reform period, 1991-1995 as the transition period and 1996-2012 as the post-reform period.

A single multi-year cost frontier is constructed for the sample period, 1983-2012, because it is assumed that efficiencies do not fluctuate markedly over short periods of time. Several other studies also suggest that efficiency is reasonably persistent over time (Eisenbeis et al., 1996, Berger and Humphrey, 1991). Furthermore, a relatively long period is required for reform initiatives (e.g., regulatory changes) and other macro-financial developments to exert their influence upon the banking technology (Isik and Hassan, 2002). Nevertheless, separate cost frontier for each of the three periods has been estimated; however, the estimates do not provide any meaningful results due to less number of observations. Fries and Taci (2005) suggest that there is minimum requirement of data period to distinguish reliably between random noise and bank inefficiency.

5.2.1 Methodology

Cost efficiency of an individual bank is measured relative to the efficient cost frontier (the best-practice bank). Therefore, cost efficiency can be defined as the ratio of the minimum cost to the cost actually incurred. Thus, if the cost incurred in producing a given level of output is TC and the cost of the same level of output using technically efficient combination of factors of production is TC*, then cost efficiency is, $CE = TC^*/TC$. This implies that it would be possible to save the cost by $(1-CE) \%$ in producing the same level of output under the same production conditions. The reason for not attaining the efficient cost frontier may be either for technical inefficiency (not using minimum inputs) or allocative inefficiency (not using optimal mix of inputs given relative factor prices) or both.

A variety of functional forms (of SFA) such as Cobb-Douglas, transcendental logarithmic (translog), generalized Leontief, constant elasticity of substitution (CES) have been followed in the banking literature to estimate cost efficiency. Each

functional form has merits and limitations. For example, Cobb-Douglas forms are first-order flexible, while the other functional forms are second-order flexible. A preferred specification for estimating efficiency can be determined by conducting a residual analysis and comparing different efficiency models with respect to statistical significance. All other things equal, functional forms that are second-order flexible are preferred although increased flexibility comes at the cost of more parameters to be estimated. This may lead to econometric difficulties, multicollinearity for example (Coelli et al., 2005).

The translog cost function developed by Christensen, Jorgenson and Lau (1973) has been widely used in the efficiency literature. Although the Cobb-Douglas functional form enables estimation of cost inefficiency in a simple way, it has several shortcomings. First, it cannot accommodate multiple outputs without violating the requisite curvature properties in output space. Second, the Cobb-Douglas specification implicitly assumes that technological change effect is constant over time. In practice, a time trend is included in the model which reflects technological change over time. Third, if the true structure of production technology is more complex than its Cobb-Douglas representation, the un-modelled complexity will show up in the error term and eventually it may lead to biased estimates of the cost inefficiency (Kumbhakar and Lovell, 2003,2000, Coelli et al., 2005). Alternatively, the translog cost frontier accommodates multiple outputs without necessarily violating curvature conditions and provides a second-order logarithmic approximation to an arbitrary continuous transformation surface, which generally gives a better fit to the frontier than the Cobb-Douglas functional form - in that the translog function does not impose restrictive assumptions such as constant returns to scale and an elasticity of substitution equal to unity (Mahesh and Bhide, 2008).

The stochastic frontier analysis in this thesis specifies a translog form of cost function for estimation. It assumes a composite error term that contains inefficiencies. The inefficiency component of the error term follows an asymmetric distribution (usually a truncated or half normal distribution) and the random

component of the error term follows a symmetric distribution (usually standard normal distribution). The key reason for such structure of the composite error term is that, by definition, inefficiencies cannot be negative. Further, both inefficiencies and random error are assumed to be orthogonal to input prices, outputs and bank-specific variables as specified in the cost function (Fries and Taci, 2005).

Following Coelli et al.(2005) and Wang and Kumbhakar (2009) the translog cost frontier model can be written as:

$$\begin{aligned} \ln C_{it} = & \alpha_0 + \sum_{m=1}^M \alpha_m \ln y_{mit} + \sum_{n=1}^N \beta_n \ln w_{nit} + 1/2 \sum_m \sum_k \alpha_{mk} \ln y_{mit} \ln y_{kit} \\ & + 1/2 \sum_n \sum_j \beta_{nj} \ln w_{nit} \ln w_{jit} + \sum_m \sum_n \chi_{mn} \ln y_{mit} \ln w_{nit} + \theta_0 t + 1/2 \theta_{00} t^2 \\ & + \sum_m \phi_{mt} \ln y_{mit} + \sum_n \rho_{nt} \ln w_{nit} + \sum_q \tau_q z_{qit} + v_{it} + u_{it} \end{aligned}$$

$$m, k=1, \dots, M; n, j=1, \dots, N; i=1, \dots, I; t=1, \dots, T$$

(5.1)

where C_{it} is the observed cost of firm i , y_{mit} is the m -th output, w_{nit} is the n -th input price, z_{qit} represents other explanatory variables that affect the total cost, t is time trend accounts for technological change, and α , β , χ , θ , ϕ , ρ and τ are a vectors of unknown parameters, The components of composite error term $(u_{it} + v_{it})$, u_{it} captures cost inefficiency and v_{it} is a random error . The inefficiency component u_{it} is non-negative, and is assumed to be normally distributed with truncation below zero. The random error v_{it} is assumed to be distributed independently and identically according to standard normal distribution $N(0, \sigma_v^2)$. The cost function (Equation 5.1) is assumed to be non-decreasing, linearly homogenous and concave in input prices, if β_n are non-negative and satisfy the homogeneity constraint, $\sum_{n=1}^N \beta_n = 1$ and also imposes constraints on symmetry, $\alpha_{mk} = \alpha_{km}$ and $\beta_{nj} = \beta_{jn}$.

5.2.2 Data

This thesis uses a unique balanced panel dataset constructed from the balance sheets, income statements and other financial statements of the sample banks. The sample contains data from 12 commercial banks in Bangladesh for 30 years, 1983-2012. The bank level data are collected from hard copies of annual reports and other financial statements of individual banks. The aggregate level banking sector data are collected from the Central Bank of Bangladesh (Bangladesh Bank). The macro-financial data have been collected from the national statistical department, Bangladesh Bureau of Statistics (BBS), Ministry of Finance, the Government of Bangladesh, Bangladesh Security and Exchange Commission (BSEC), International Financial Statistics (IFS) of the IMF and World Development Indicator (WDI) of the World Bank.

5.2.3 Definition of inputs and outputs: different approaches

Specification of inputs and outputs for banks is not straightforward. There is long-standing debate in the banking literature about the specification of inputs and outputs of banking firms. Favero and Papi (1995) propose five approaches for input-output specification: production, intermediation, asset, user cost and value-added approach. Sealey and Lindley (1977), who first develop a positive theory for the behaviour of financial institutions, propose two further views, the technical view and the economic view of financial institutions. They argue that financial firms are involved in financial intermediation through transferring funds from surplus units to deficit units.

Two competing approaches are dominant in the banking literature. One is the production approach and the other is the intermediation approach. Both the approaches follow the application of traditional microeconomic theory of firms to banks and differ only in the specification of banking activities (Das and Kumbhakar, 2012).

The production approach, pioneered by Benston (1965), treats banks as providers of services to customers. The inputs under this approach are physical, such

as labour and capital or their associated costs, assuming that only physical inputs are required for banking activities, for example, transactions process, financial documents or financial advisory services to customers. The outputs are the services provided to customers and, are best measured by the number and type of transactions and documents processed. Under this framework, deposits are considered as output because they are viewed as part of the banking services offered.

The intermediation approach views banks as the mediator of funds between savers and investors. According to this approach, banks transform various financial and physical resources, such as deposits and other liabilities, into interest-earning assets such as loans, securities and other investments (Sealey and Lindley, 1977). Thus, the intermediation approach treats both operating and interest expenses as inputs and loans and other assets as outputs. The value-added approach is rarely used. This approach considers deposits (e.g., demand and time deposit) and loans (e.g., mortgages and commercial loans) as outputs because they are responsible for the significant proportion of value addition (Das and Kumbhakar, 2012).

Apart from the above mentioned approaches, the operating approach, which is based on the revenue aspect of the banking operation, has been followed in the literature for defining banks' inputs and outputs (Drake et al., 2006, Arjomandi et al., 2014, Arjomandi et al., 2011). According to this approach, banks' outputs and inputs are, respectively, total revenue (interest and non-interest income) and total expenses, i.e., interest expenses for borrowings plus non-interest (operating) expenses.

Both production and intermediation approaches have merits and limitations. According to Berger and Humphrey (1997), the production approach may be more appropriate for evaluating branch-level efficiency (since this approach deals with customers' transaction accounts, and thus has little influence from overall bank policy), while the intermediation approach is better for measuring the efficiency of banks as a whole. Like many other studies on banking efficiency, this thesis adopts the intermediation approach to define inputs and outputs in order to examine the bank-level cost efficiency (e.g.,Boucinha et al., 2013, Wang and Kumbhakar, 2009,

Isik and Hassan, 2002, Du and Girma, 2011, Wang and Kumbhakar, 2007, Resti, 1997, Berger and Mester, 1997, Casu et al., 2004, Kumbhakar and Lozano-Vivas, 2005).

5.2.4 Construction and rationale of the variables

Measurement of cost efficiency requires data on total costs, outputs and input prices. The dependent variable is total cost (TC), which includes both interest expenses and operating costs. Following the intermediation approach, this study models commercial banks as multi-product firms producing two outputs employing three inputs (e.g., Boucinha et al., 2013). Apart from output and input prices, the model considers some bank-specific variables and environmental variables both in the cost function and the inefficiency function as independent variables. The definition of the variables is reported in Appendix 5.1.

5.2.4.1 Input price and output variables

All input prices are calculated as flows over the year divided by the corresponding quantity: (1) price of labour (w_1) equals total expenditure on employees, such as salaries and allowances, divided by the total number of employees; (2) price of capital (w_2) equals total expenditure on premises and fixed assets, i.e., total operating expenses (except salary and allowances and charges on loan/investment losses) divided by the book value of physical capital and other fixed assets; and (3) price of loanable funds (w_3) equals total interest expenses on deposit and non-deposit funds divided by total loanable funds.

The output vectors are: (1) total loans and advances (y_1), which include loans, cash credits and overdrafts and bills discounted and purchased; (2) other earning assets (y_2) that comprise government securities, treasury bills, shares (fully paid), debentures, bonds and other investments (gross total assets less loans and physical capital/fixed assets).

As suggested by Du and Girma (2011), this analysis does not consider off-balance sheet (OBS) items as output mainly for two reasons. First, the total exposure of OBS items is comparatively small in the sample banks. Second, the way the other two output variables are calculated does not apply to OBS activities. The outputs, loans and advances and other earning assets (e.g., investment) are funded exposures of banks, while the OBS services are non-funded, e.g., issuance of letter of credit, guarantees and other obligations/commitments. These do not necessarily increase bank cost straight way. Moreover, it is hard to distinguish between variations due to changes in volumes and variations due to changes in prices. Since comprehensive information on off-balance sheet services is not available, the non-interest income earned from OBS activities cannot be separated from the non-interest income generated from traditional banking activities, such as fees earned from service charges on deposits or credits (Orea and Kumbhakar, 2004).

5.2.4.2 Bank specific variables and correlates of inefficiencies

Apart from outputs and input prices, there is another set of variables that characterizes the operations of banks. These variables may affect banking technology and service quality, which shift the cost frontier. Several bank characteristics may be the determinants of efficiency as well. Kumbhakar and Lovell (2003) suggest that bank-specific exogenous variables may belong to the frontier along with outputs and input prices and/or they may belong to the one-sided error component (i.e., inefficiency function) as the determinants of efficiency.

The proposed empirical model includes several bank-specific variables in the cost function which may affect the bank cost directly. These are: equity capital, the financial intermediation ratio (the ratio of loans to deposits), time trend, market concentration (3-bank concentration ratio) and deregulation period dummy variables. A few of these control variables are also included in the inefficiency function, such as time trend and deregulation period dummy variables. Some other additional variables are included in the inefficiency function as the determinants of efficiency. The variation in efficiency may be associated with these factors that affect incentives

and/or managerial selection at the bank level. The correlates that may affect efficiency are bank size, ownership structure, market concentration and board composition: independent and political directors in the bank board. The rationale for including each of these variables in the cost function and/or in the inefficiency functions is as follows:

(1) *Equity capital (EQ)*: Following Berger and Mester (1997), equity capital (EQ) is included in the cost function. The equity capital of a bank consists of paid-up capital, reserves, gains from revaluation and retained earnings; however, equity capital varies across banks. As a regulatory requirement (e.g., Basel accord), banks raise equity capital to ensure a cushion against portfolio losses and financial distress. This may increase bank cost (Lozano-Vivas and Pasiouras, 2010). However, equity capital provides an alternative to deposits and other borrowed funds as a source of loanable funds. Thus, the level of equity capital may have a direct impact on bank's cost of funds (Dong, 2009). The inclusion of this variable is particularly important because equity capital has been increased significantly in the sample banks in compliance to the regulatory measures.

(2) *Financial intermediation (FI)*: Financial intermediation is defined as the ratio of loans to deposits. The financial intermediation ratio reflects the extent of intermediation to which the banks convert deposits into loans. The higher the intermediation ratio, the lower the bank costs are (Fries and Taci, 2005, Dietsch and Lozano-Vivas, 2000). A lower ratio of financial intermediation causes higher cost to banks due to lack of efficiency in producing output (loans and advances) employing available inputs (deposits). As a consequence, banks incur cost due to interest payment on their idle deposits.

(3) *Time trend (t)*: A time trend variable is included in the cost function in order to account for technological change over time (Coelli et al., 2005). The time trend variable is also included in the inefficiency function. The time trend is defined as follows: $t=1$ for 1983, $t=2$ for 1984..... $T=30$ for 2012. The time trend variable could be in the frontier with the argument that the passage of time captures technical

change, whereas in the inefficiency function it captures time-varying cost efficiency (Kumbhakar and Lovell, 2003).

(4) *Deregulation*: A key objective of the financial reform program is to allocate resources efficiently and, thus improve bank performance (Berger and Humphrey, 1997). Although reform measures have been continuously carried out in the banking sector in Bangladesh since 1991, major reform initiatives took place during the period, 1991-1995, through the execution of the 'Financial Sector Reform Program (FSRP)', and it is likely that the effects of the reform measures become apparent at a later date (Das and Ghosh, 2006).

In many empirical studies, deregulation dummy variables are constructed to separate the pre- and the post- deregulation periods (Wang and Kumbhakar, 2007, Edirisuriya and O' Brien, 2001). Following the literature, three period dummy variables are constructed to indicate the pre-reform (DPr), transition (DTr) and post-reform periods (DPs). The coefficients for the transition and post-reform dummy variables are reported in the model, while the pre-reform period is considered as benchmark. The dummy variables are defined as: DTr =1 if transition period (1991-1995) and zero otherwise; and DPs =1 if post-reform period (1996-2012) and zero otherwise. The pre-reform period (1983-1990) dummy is treated as the base, so the coefficient of DTr (DPs) can be interpreted as the change in cost or efficiency from the pre-reform period to the transition (post-reform) period.

(5) *Ownership structure (OWN)*: Efficiency may vary due to differences in the ownership structure of banks. The relation between ownership and efficiency, which is captured by incorporating dummy variables for different ownership types in the inefficiency function, has been extensively explored in the literature (Das and Kumbhakar, 2012).

There is empirical evidence that state-owned banks are more cost efficient compared to their private sector counterparts (Bhattacharyya et al., 1997, Sensarma, 2005). There are also studies where the findings are opposite, i.e., state-owned banks

are less efficient (Lin and Zhang, 2009, Berger et al., 2009). In fact, different bank ownership may have different operating objectives, for instance, state-owned banks are committed to fulfilling social welfare under the privilege of a soft budget constraint, while the primary focus of private banks is profit maximization.

Banks with different ownership structure are required to comply with different regulatory conditions for the commencement of business, paid-up capital for example. Hence, omitting the ownership structure from efficiency analysis may lead to biases in efficiency scores. Therefore, an ownership dummy variable (OWN) is included in the inefficiency function. The variable is defined as: OWN=1 if the bank is state-owned and zero otherwise.

(6) *Bank size (SIZE)*: Bank efficiency may vary with its size. The larger banks might reap efficiency benefits from economies of scale and/or scope (Hunter et al., 1990, Leightner and Lovell, 1998, Hasan and Marton, 2003). There is contrary evidence where efficiency is inversely related to bank size, i.e., the smallest bank shows the greatest efficiency (Bauer et al., 1993, DeYoung and Nolle, 1996). Further, Avkiran (1999), Berger and Mester (1997) and Pi and Timme (1993) do not find any significant relationship between size and efficiency. Therefore, the variable ‘SIZE’ is included in the inefficiency function to observe the cost efficiency differences due to different size of the sample banks. Following the literature, bank size variable (SIZE) is defined as the logarithm of total assets (Ariff and Can, 2008, Das and Ghosh, 2006).

(7) *3-bank concentration ratio (CR3)*: The concentration ratio indicates the likelihood of intense competition between the sample banks and also in the market as a whole. The higher the value of concentration ratio, the more concentrated the banking system is and therefore, less competitive. The index of k-bank concentration ratio is constructed by summing up the market shares of k largest banks in the market, $CR_k = \sum_{i=1}^k S_i$. Theoretically there is no rule for the determination of the value of k. Therefore, the number of banks included in the concentration index is a

somewhat arbitrary decision (Al-Muharrami et al., 2006). The index approaches zero for an infinite number of equally sized banks and it equals unity if the banks included in the calculation of the index make up the entire industry.

Since the banking sector in Bangladesh is dominated by three major state-owned commercial banks (Sonali, Janata and Agrani), a 3-bank deposit concentration ratio (CR3) is constructed and included in both cost function and inefficiency function to evaluate how the deposit market concentration influences the cost frontier and the relative cost efficiency of the sample banks. A higher market concentration reflects market power of some banks which may increase the cost for the sector in general through slack and inefficiency (Fries and Taci, 2005). However, higher concentration can be associated with lower costs as well if the concentration is the result of either superior management or greater efficiency of the production process (Demsetz, 1973, Dietsch and Lozano-Vivas, 2000)

(8) *Board Composition:* Corporate governance research emphasizes the independence of the bank board (Berger et al., 2012, Andres and Vallelado, 2008). There are two possible sources of independent board members: outside directors and professional directors (Lefort and Urzua, 2008). Although ‘outside director’ and ‘independent director’ are sometimes used interchangeably in the literature there is a difference between these two concepts. Pathan, Skully and Wickramanayake (2007, p.212) indicate the distinction between the concepts as follows: “an ‘outside director’ is a non-executive director on the board whereas an ‘independent director’ is an outside director with no material relationship with the firm except for the board directorship.”

It is argued that independent board members may be more efficient in monitoring the management of the bank (Hermalin and Weisbach, 1991, Andres and Vallelado, 2008). Pathan et al. (2007) suggest that more independent directors in the bank board may enhance the performance of the bank. Choi and Hasan (2005) argue that outside directors, especially directors from foreign countries in the corporate board structure impacts bank performance.

As part of the reform measures on corporate governance, Bangladesh Bank (Central Bank of Bangladesh) and Bangladesh Securities and Exchange Commission (BSEC) introduced the regulation for appointing independent directors in the bank board in 2006. However, many of the banks, especially state-owned banks and some other private banks have not followed the regulation yet. A dummy variable (ID) for independent director is included in the inefficiency function to evaluate the efficiency differences due to the inclusion of independent directors in the bank board. The variable is defined as: ID=1 if there is independent director in the bank board and zero otherwise.

Political personality in the bank board is another major concern regarding bank governance. Shen and Lin (2012) observe a deteriorating financial performance in government banks due to political interference. Political directors influence the bank management and other banking operations especially the lending behaviour of the bank. In Bangladesh, the government appoints political personalities in the board of directors of the state-owned banks. Moreover, it is very common in Bangladesh that the leaders of the ruling political party obtain licenses for private banking operation. Thus political personalities become the board members in various private banks as well.

The recent empirical studies find that political directors in the bank board or political connections with the bank board have a significant negative effect on loan portfolio quality and, eventually on banking efficiency. Further, bank finance has been directed to politically motivated projects (may not be economically viable) due to political influence (Carretta et al., 2012, Onder and Ozyildirim, 2011, Khwaja and Mian, 2005, Imai, 2009). In light of the literature and the existing political influence on both state-owned and private sector banks in Bangladesh, a dummy variable is included in the inefficiency function indicating a political director in the bank board. The variable is defined as: PD=1 if there is a politically linked director in the board of directors and zero otherwise.

5.2.5 Descriptive statistics of the variables

Table 5.1 presents the summary statistics for the variables considered for the estimation. The mean and standard error for all the variables are shown in the context of three periods: pre-reform, transition and post-reform period. The descriptive statistics shows that on average total cost (TC) increases two-fold, while the outputs, loans and advances (y_1) and other earning assets (y_2) have increased by more than three-fold in the post-reform period compared to the pre-reform period. Since banks need more funds to increase outputs, such as, loans and investments, the growth of deposits and borrowed funds increases by about 168% in the post-reform period compared to the pre-reform period.

Table 5.1: Summary statistics of the variables

Variables	Pre-reform (1983-1990)		Transition (1991-1995)		Post-reform (1996-2012)	
	Mean	S.E	Mean	S.E	Mean	S.E
Total cost (TC)*	19.774	27.121	23.615	22.238	44.673	38.627
Outputs						
Total loans and advances (y_1)*	137.079	157.922	179.319	174.416	444.251	399.963
Other earning assets (y_2)*	78.714	86.077	134.451	154.188	282.760	346.167
Inputs						
Total employees	5925	7404	6737	7744	6866	6806
Total physical capital*	1.688	1.644	2.708	2.075	11.669	16.055
Total loanable funds (total deposits and borrowed funds)*	221.691	332.979	286.123	291.257	594.278	561.951
Input prices						
Price of labour (w_1)	632.163	197.0801	760.765	145.756	1662.762	722.161

Variables	Pre-reform (1983-1990)		Transition (1991-1995)		Post-reform (1996-2012)	
	Mean	S.E	Mean	S.E	Mean	S.E
Price of capital (w_2)	1.24815	0.726	1.124	0.630	0.689	0.473
Price of loanable funds (w_3)	0.077	0.078	0.063	0.015	0.053	0.011
Control variables and correlates of inefficiency						
Total Equity (EQ)*	4.466	4.817	13.312	15.766	30.831	49.081
Total Asset*	217.481	242.307	316.477	327.284	738.679	722.476
Financial Intermediation (FI)	0.739	0.230	0.669	0.099	0.801	0.349
Time trend (t)	4.5	2.303	11	1.426	22	4.911
Transition dummy (DTr)	0	0	1	0	0	0
Post-reform dummy (DPs)	0	0	0	0	1	0
Bank Size in logarithm (SIZE)	8.337	8.384	8.500	8.515	8.869	8.859
Concentration Ratio (CR3)	0.712	0.085	0.613	0.011	0.425	0.129
Ownership dummy (OWN)	0.333	0.474	0.333	0.475	0.333	0.472
Independent director (ID)	0	0	0	0	0.123	0.329
Political director (PD)	0.417	0.496	0.417	0.497	0.480	0.501

Note: *Figures are in million Taka (Bangladesh Currency), deflated by GDP deflator, base: 1996=100 (WDI, 2013); Source: Author's calculations based on the balance sheets and income statements of the sample banks.

Apart from deposits and borrowings, average total physical capital increases about nine-fold in the post-reform period compared to the pre-reform period resulting

in higher total costs. The average number of employees increases only 15% over the periods. One plausible reason for such low employment growth is the implementation of automation in banking and productive use of human resources (Isik and Hassan, 2002). Due to a sharp increase in salary and allowances in the banking sector over the years, the average price of labour (w_1) increases more than two-fold in the post-reform period compared to the pre-reform period. The growth rate of average labour price is significantly higher than the other two input prices (w_2 and w_3).

The increasing trend in average equity capital of the sample banks indicates growing strength of the banking sector in Bangladesh. Also, the average total assets increases about three-fold in the post-reform period compared to the pre-reform period. The increase in average financial intermediation ratio in the post-reform period indicates efficient financial intermediation after deregulation. The decreasing trend in 3-bank deposit concentration ratio reflects an increasingly competitive banking structure in Bangladesh after deregulation. The provision for independent directors in the bank board has been introduced in the post-reform period. However, the presence of political directors in the bank board is observed during the whole sample period 1983-2012.

5.3 Model specification and estimation procedure

Following the methodology described in Sub-section 5.2.1, a translog form of the stochastic cost function is employed for the estimation. The next sub-section 5.3.1 provides the model specification tests for the selection. The translog cost frontier model considers total cost (TC) as the dependent variable and two outputs (y_1 and y_2) and three input prices (w_1, w_2 and w_3) as independent variables.

The theoretical restrictions stemming from duality theory, i.e., symmetry and linear homogeneity in prices are implicitly imposed in the specification of the estimated equation. Since the cost function is homogenous of degree one in input

price, parametric restrictions are imposed to ensure that the estimated cost function satisfies this property. In practice, linear homogeneity restrictions are automatically satisfied if the cost and input prices are expressed as a ratio of one input price. We use physical capital price, w_2 as numeraire.

The data are expressed as deviations from the sample mean, dividing each variable by its geometric mean. The translog form represents a second-order Taylor approximation around the geometric mean to any generic cost frontier (Orea and Kumbhakar, 2004). The normalization of variables allows the first-order coefficient of the translog cost function to correspond to the elasticity evaluated at the sample mean (the point of approximation). The normalization reduces heteroscedasticity and allows banks of any size to have comparable residual terms (Du and Girma, 2011).

In calibrating an appropriate translog cost frontier model, three different translog cost frontier models are estimated. The results are presented in Appendix 5.2. Model 1 (M1) assumes a half-normal distribution of inefficiency term u , i.e., $u_{it} \sim N(0, \sigma_u^2)$ as suggested by Aigner, Lovell and Schmidt (1977). The model is constructed without control or environmental variables.

Since the Model 1 is restrictive (assuming majority of banks are efficient), a second model (M2) is constructed with a minor extension of the first model (M1) that the distribution of inefficiency is truncated normal instead of half-normal, i.e., $u_{it} \sim N(\mu, \sigma_u^2)$ following Stevenson (1980). However, the estimation results are similar for both the models (M1 and M2) in terms of sign, magnitude and the level of significance of the parameter estimates (Appendix 5.2). The log likelihood ratio tests also confirm that the models are not significantly different (the detail of the test procedures is shown in Sub-section 5.3.1).

Although the parameter estimates of the above models provide expected positive sign and significance level, neither of them includes bank-specific control and environmental variables. Therefore, a third model (M3), which includes bank-

specific control variables (c_{it}) and environmental variables (z_{it}), is estimated. The included control variables are time trend (t), equity capital (EQ), financial intermediation ratio (FI), 3-bank concentration ratio (CR3), and reform period dummy variables for transition period (DTr) and post-reform period (DPs). These variables may either directly influence the cost of production and alter the shape of the cost frontier or change the position of the frontier (Dong, 2009). The inefficiency term (u_{it}) is also an explicit function of some bank-specific control variables and environmental variables. The environmental and bank-specific variables included in the inefficiency function are ownership (OWN), board composition indicated by independent director (ID) and political director (PD) in the bank board, bank size (SIZE), and also reform period dummy variables for transition (DTr) and for post-reform period (DPs), time trend (t) and 3-bank concentration ratio (CR3). Table 5.2 shows the alternative specifications of cost frontier models discussed in this section in order to derive an appropriate model that describes the sample data.

Table 5.2: Different specifications of stochastic frontier models

Models	Specifications	Inefficiency u	Heterogeneity
Half-normal (M1)	$f(y_{it}, w_{it})$	$u_{it} \sim N(0, \sigma_u^2)$	None
Truncated (M2)	$f(y_{it}, w_{it})$	$u_{it} \sim N(\mu, \sigma_u^2)$	None
TE Effects (M3)	$f(y_{it}, w_{it}, c_{it})$	$u_{it} \sim N(\mu + \delta z_{it}, \sigma_u^2)$	Bank-specific and time-specific variables included in the cost function Heterogeneity in the mean of inefficiency distribution

Note: Models are presented in line with Coelli (1996) and Dong (2009)

Following the Equation (5.1), the empirical model for translog cost frontier (constrained to ensure linear homogeneity) can be expressed as:

$$\begin{aligned}
\ln(C_{it} / w_2) = & \alpha_0 + \alpha_1 \ln y_1 + \alpha_2 \ln y_2 + \beta_1 \ln\left(\frac{w_1}{w_2}\right) + \beta_2 \ln\left(\frac{w_3}{w_2}\right) \\
& + \frac{1}{2} \alpha_{11} (\ln y_1)^2 + \alpha_{12} \ln y_1 \ln y_2 + \frac{1}{2} \alpha_{22} (\ln y_2)^2 + \frac{1}{2} \beta_{11} \ln\left(\frac{w_1}{w_2}\right)^2 \\
& + \beta_{12} \ln\left(\frac{w_1}{w_2}\right) \ln\left(\frac{w_3}{w_2}\right) + \frac{1}{2} \beta_{22} \left(\frac{w_3}{w_2}\right)^2 + \chi_{11} \ln y_1 \ln\left(\frac{w_1}{w_2}\right) + \chi_{12} \ln y_1 \ln\left(\frac{w_3}{w_2}\right) \\
& + \chi_{21} \ln y_2 \ln\left(\frac{w_1}{w_2}\right) + \chi_{22} \ln y_2 \ln\left(\frac{w_3}{w_2}\right) + \theta_1 t + \frac{1}{2} \theta_2 t^2 + \phi_{1t} \ln y_1 t + \phi_{2t} \ln y_2 t \\
& + \rho_{1t} \ln \frac{w_1}{w_2} t + \rho_{2t} \ln \frac{w_3}{w_2} t + \tau_1 EQ + \tau_2 FI + \tau_3 CR3 + \tau_4 DTr + \tau_5 DPs \\
& + u_{it} + v_{it}
\end{aligned} \tag{5.2}$$

where, the random error term v is assumed to be independently and identically distributed, $N(0, \sigma_v^2)$ and the symmetry conditions, $\alpha_{mk} = \alpha_{km}$ and $\beta_{nj} = \beta_{jn}$ are imposed. The theoretical requirements, the monotonicity properties, i.e., non-decreasing in output y [$\partial \ln C_{it} / \partial \ln y_{mit} \geq 0$] and non-decreasing in input prices w [$\partial \ln C_{it} / \partial \ln w_{nit} \geq 0$] can be examined by the elasticity of outputs and input prices expressed in terms of coefficients of the fitted cost function.

The stochastic frontier analysis assumes that the inefficiency component u_{it} is positive, i.e., higher bank inefficiency is associated with higher cost. The Battese and Coelli (1992,1995) parameterisation of the inefficiency term u_{it} is used to allow for time-varying inefficiency. The inefficiency function can be specified as follows:

$$\begin{aligned}
u_{it} = & \delta_0 + \delta_1 OWN_{it} + \delta_2 ID_{it} + \delta_3 PD_{it} + \delta_4 SIZE_{it} + \delta_5 DTr_{it} + \delta_6 DPs_{it} + \delta_7 t \\
& + \delta_8 CR3 + e_{it}
\end{aligned} \tag{5.3}$$

where e_{it} is random error term which is defined by the truncation of the normal distribution with zero mean and variance σ^2 . The point of truncation is, $-\delta z_{it}$, i.e., $e_{it} \geq -\delta z_{it}$. These assumptions are consistent with u_{it} being a non-negative truncation of the $N(\delta z_{it}, \sigma^2)$ -distribution. Therefore, the inefficiency component of the composite error term of the translog cost function (5.2) has a truncated normal distribution, whose point of truncation depends on the bank-specific characteristics.

The parameters of both the Equations (5.2) and (5.3) are estimated simultaneously following the maximum likelihood method using the frontier econometric programme FRONTIER 4.1 developed by Coelli (1996). The likelihood function is expressed in terms of variance parameters $\sigma_s^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \frac{\sigma_u^2}{\sigma_s^2}$. If γ equals zero, then the model reduces to a traditional mean response function in which z_{it} can be directly included into the cost function.

5.3.1 Model specification tests

Given the general translog cost frontier model as specified in Equation (5.2), a number of null hypotheses are tested for finding the appropriate model for the sample data. The likelihood ratio is defined as $\lambda = L_R / L_U$, where L_R is the maximum of the likelihood function when the restrictions are imposed and L_U is the maximum of the likelihood function when the restrictions are not imposed. This ratio statistic can be expressed as follows: $LR = -2 \ln \lambda = -2(\ln L_R - \ln L_U)$ (Coelli et al., 2005). The LR ratio can also be expressed as $LR = -2[l(H_0) - l(H_1)]$, where $l(H_0)$ denotes the value of likelihood function based on the null hypothesis or the restricted frontier model and $l(H_1)$ is the value of likelihood function in the alternative hypothesis (Suyanto et al., 2009). If the sample size is sufficiently large, the log-likelihood test statistic is

asymptotically distributed as chi-square (χ^2) distribution with the degrees of freedom equal to the number of restrictions imposed.

Table 5.3 presents the relevant null hypothesis tests. The first null hypothesis is to confirm whether the Cobb-Douglas cost frontier is an appropriate specification for the dataset by imposing the following restrictions, the second order parameters equal to zero, i.e., $H_0: \alpha_{mk} = \beta_{nj} = \chi_{mn} = 0$ in Equation (5.2). The Cobb-Douglas cost frontier model is not an appropriate specification given the alternative of the translog cost frontier model, as the log-likelihood ratio test indicates a strong rejection of the null hypothesis at 1% level of significance (the test statistics exceeds the critical value). Therefore, the translog functional form of the cost frontier is the appropriate model that describes the sample data.

The second null hypothesis: the half-normal model (M1) is an appropriate model compared to the truncated normal model (M2) imposing the restriction, $H_0: \mu = 0$. The log-likelihood ratio test indicates that the null hypothesis cannot be rejected. However, the models are similar in terms of sign, magnitude, and statistical significance of the coefficients and the value of log-likelihood function (Appendix 5.2). Therefore, Model 2 (M2) is used for conducting further tests with other model specifications because the distribution of inefficiency (u_{it}) is assumed truncated normal instead of half normal (as assumed in M1), which is consistent with the cost frontier model.

The third null hypothesis is whether Model 2 (without control and environmental variables) is an appropriate model compared to the Model 3 (with control and environmental variables) imposing restrictions, $H_0:$

$$\theta_1 = \theta_2 = \phi_{1t} = \phi_{2t} = \rho_{1t} = \rho_{2t} = \tau_1 = \tau_2 = \tau_3 = \tau_4 = \tau_5 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0$$

The log-likelihood ratio test indicates that the model without control and environmental variables (M2) is not an appropriate specification given the translog

cost frontier model including control and environmental variables in the cost function (M3). The test statistic exceeds the chi-square critical values at 1% level of significance and, thus rejects the null hypothesis.

Table 5.3: Log-likelihood tests for model specification

Model Description	Restrictions (degrees of freedom)	Log-likelihood test statistic(λ)	Critical values		Decision
			1%	5%	
Cobb-Douglas vs Translog (M3)	$\alpha_{mk} = \beta_{nj} = \chi_{mn} = 0$ (10)	486.68	22.53	17.67	Cobb-Douglas model rejected
Translog :Half-normal (M1) vs Truncated(M2)	$\mu = 0$ (1)	0.055	5.41	2.71	Half-normal model not rejected
Translog: Truncated model without control variables (M2) vs model with control variables and environmental variables(M3)	$\begin{aligned} \theta_1 = \theta_2 = \phi_{1t} = \phi_{2t} = \rho_{1t} = \rho_{2t} \\ = \tau_1 = \tau_2 = \tau_3 = \tau_4 = \tau_5 = \\ \delta_1 = \delta_2 = \delta_3 = \delta_4 \\ = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0 \end{aligned} \quad (19)$	249.49	35.55	29.54	Truncated model without control and environmental variables (M2) rejected

Note: The critical values are based on the Chi-squared distribution (Kodde and Palm, 1986).

5.4 Empirical results and analysis

The translog cost function specified in Equation (5.2) and the inefficiency function specified in Equation (5.3) are simultaneously estimated following the maximum likelihood (ML) procedure of Battese and Coelli (1995). As discussed in Section 5.3, three different SFA models are estimated. The specification tests are conducted in Sub-section 5.3.1 for choosing an appropriate model for the sample. ML estimators are popular in empirical work irrespective of the type of model being estimated because of several desirable large sample (i.e., asymptotic) properties if the assumptions underlying the model are valid (Coelli et al., 2005). For example, if heteroskedasticity appears in the symmetric noise error component, still unbiased estimates of all parameters can be obtained describing the structure of the production frontier (Kumbhakar and Lovell, 2003). Maximum likelihood and least squares estimators are still unbiased and consistent in the presence of heteroskedasticity and autocorrelation, provided all other assumptions of the model are true. Although the translog cost function is more flexible than other functional forms, multicollinearity may exist among the variables due to second order terms as mentioned in Sub-section 5.2.1.

5.4.1 Parameter estimates: cost function

The maximum likelihood parameter estimates for both the translog cost function (Equation 5.2) and the inefficiency function (Equation 5.3) are reported in Table 5.4. The results for the estimated three models are reported in Appendix 5.2. Since total cost (dependent variable) and input prices and output variables in the cost function are normalized dividing by their respective sample mean (as mentioned in Section 5.3), estimated coefficients can be interpreted as the respective cost elasticity evaluated at the sample mean.

Table 5.4: Maximum likelihood estimates of the cost frontier model

Variables	Parameters	Estimated coefficients	Standard error	t-statistics
Intercept	α_0	0.250**	0.124	2.012
Lny ₁	α_1	0.824***	0.068	12.145
Lny ₂	α_2	0.348***	0.077	4.543
Ln(w ₁ /w ₂)	β_1	0.515***	0.069	7.449
Ln(w ₃ /w ₂)	β_2	0.599***	0.039	15.446
Lny ₁ Lny ₁	α_{11}	0.185***	0.585	3.159
Lny ₁ Lny ₂	α_{12}	-0.127	0.106	-0.120
Lny ₂ Lny ₂	α_{22}	-0.080	0.049	-1.630
Ln(w ₁ /w ₂)Ln(w ₁ /w ₂)	β_{11}	0.368***	0.053	6.898
Ln(w ₁ /w ₂)Ln(w ₃ /w ₂)	β_{12}	-0.555***	0.051	-10.791
Ln(w ₃ /w ₂)Ln(w ₃ /w ₂)	β_{22}	0.202***	0.010	19.706
Lny ₁ Ln(w ₁ /w ₂)	χ_{11}	-0.161**	0.081	-1.989
Lny ₁ Ln(w ₃ /w ₂)	χ_{12}	0.053	0.078	0.676
Lny ₂ Ln(w ₁ /w ₂)	χ_{21}	0.305***	0.093	3.276
Lny ₂ Ln(w ₃ /w ₂)	χ_{22}	-0.187**	0.088	-2.115

Variables	Parameters	Estimated coefficients	Standard error	t-statistics
Control Variables				
t (time trend)	θ_1	-0.005	0.007	-0.827
t^2	θ_{11}	0.0003*	0.0001	1.732
Lny _{1t}	ϕ_{1t}	-0.008*	0.004	-1.789
Lny _{2t}	ϕ_{2t}	-0.005	0.005	-1.088
Ln(w ₁ /w ₂)t	ρ_{1t}	-0.021***	0.005	-4.617
Ln(w ₃ /w ₂)t	ρ_{2t}	0.013***	0.003	4.482
z ₁ (equity)	τ_1	0.003**	0.001	2.194
z ₂ (Financial intermediation)	τ_2	-0.181***	0.014	-12.897
z ₃ (3-bank concentration ratio)	τ_3	-0.139	0.139	-1.000
DTr (1= transition period, 0=otherwise)	τ_4	-0.012	0.022	-0.566
DPs (1= post-reform period, 0= otherwise)	τ_5	-0.107***	0.037	-2.848
Correlates of bank inefficiencies				
Intercept	δ_0	0.869***	0.289	3.010

Variables	Parameters	Estimated coefficients	Standard error	t-statistics
OWN (1=Public, 0=otherwise)	δ_1	-0.037**	0.017	-2.117
ID (1=Independent director in the bank board, 0=otherwise)	δ_2	-0.024	0.081	-0.298
PD(1=Political director in the bank board,0=otherwise)	δ_3	0.094***	0.014	6.827
SIZE	δ_4	-0.058**	0.024	-2.459
DTr (1= transition period, 0=otherwise)	δ_5	-0.065*	0.034	1.934
DPs (1= post-reform period, 0= otherwise)	δ_6	0.269***	0.058	4.622
t (time trend)	δ_7	-0.024***	0.007	-3.591
CR3: 3-bank deposit concentration ratio	δ_8	-0.369	0.243	-1.522
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma_u^2$	0.002***	0.0003	6.117
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma_s^2}$	0.574***	0.111	5.156

Note: Log-likelihood function=701.751; total number of observations 360; asymptotic standard errors are in parentheses;*** denotes statistical significance at 1% level,** denotes statistical significance at 5% level,* denotes statistical significance at 10% level. Source: Estimation using the computer programme FRONTIER 4.1, developed by Coelli (1996).

Table 5.4 presents the estimated cost elasticity with respect to each output and input price term evaluated at the sample mean. The non-negative coefficients for outputs (y_1 and y_2) and input price terms (w_1/w_2 and w_3/w_2) satisfy the theoretical requirements for a valid cost function. The second order partial derivative of the cost function with respect to output y_1 is positive, i.e., $\partial^2 C / \partial y_1^2 = \alpha_{11} = 0.185$ and highly significant. The second order partial derivatives of the cost function with respect to other output y_2 is slightly negative (-0.08), but not statistically significant. Further, the first order derivatives with respect to the input price terms (w_1/w_2 and w_3/w_2) are positive and highly significant.

The estimated positive and statistically significant coefficient (at 1% level) for total loans and advances (output y_1) suggests that, on average, a one percent increase in the amount of loans and advances increases total costs by about 0.82 percent. Similarly, the estimated cost elasticity of other earning assets (output y_2) is 0.34, suggesting an increase in total cost by about 0.34% due to a one percent increase in other earning assets (e.g., Jha et al., 1991, Mahesh and Bhide, 2008).

The estimated coefficients for both the input price terms, β_1 and β_2 , are positive, 0.51 and 0.60 respectively, and statistically significant at 1% level. These indicate that total cost is very sensitive to both labour price (w_1) and total borrowed fund price (w_3). This is consistent with the study on Portuguese banking (Boucinha et al., 2013). The cost elasticity with respect to the omitted input price, physical capital price (w_2) can be recovered by using the linear homogeneity restrictions, calculated by $\beta_3 = (1 - \beta_1 - \beta_2) = -0.11$. Following the delta method (Greene, 2012), the estimated standard error (S.E) of β_3 is 0.079 and, the corresponding t statistics is -1.39, so the estimated coefficient of physical capital is negative but not significantly different from zero using the standard t-test.

The estimated coefficient for equity capital (z_1) is positive and statistically significant (at 5% level). This suggests that more equity capital may incur cost because equity is associated with higher financing costs (Lozano-Vivas and

Pasiouras, 2010). However, the magnitude of the cost elasticity with respect to equity capital at the sample mean is very small (0.003). This is consistent with several empirical studies (e.g., Das and Ghosh, 2006, Boucinha et al., 2013). Banks may increase equity capital to maintain the required capital adequacy (equity to total risk-weighted assets) in compliance to the Basel Accord. However, Fries and Taci (2005) find the opposite result. A higher bank capitalization may lower the bank cost through greater incentive for sound banking and efficiency.

The estimated coefficient for financial intermediation ratio (z_2) is negative (-0.181) and statistically significant (at 1% level). This indicates that higher intermediation ratio lowers bank costs. Fries and Taci (2005) find similar results in a cross-country study on cost efficiency. Since banks collect deposits at the cost of interest expenses, therefore, the higher the capacity to convert the deposited money to loans and advances (interest earning output), the lower the cost of the bank.

The estimated coefficient for post-reform period dummy variable (DPs) is negative (-0.107) and highly significant (at 1% level). This suggests a lower cost in the post-reform period compared to the pre-reform period. One possible reason for such reduced bank cost is the adoption of cost-effective banking regulations and policy initiatives in the post-reform period. Besides, cost diminution may occur as banks produce competitive and technology driven cost-effective banking products and services, such as mobile banking, on-line banking, and use of ATM due to increased competition in the industry after financial liberalization.

5.4.2 Parameter estimates: inefficiency function

The parameter estimates for the inefficiency function (Equation.5.3) are estimated simultaneously with the cost function are reported in Table 5.4. The estimated coefficient for ownership dummy variable (OWN) is negative (-0.037) and statistically significant (at 5% level). This indicates that public banks are cost efficient compared to their private sector counterparts. One possible explanation for private banks being less cost efficient is due to initial capital expenditure, borrowings

at high interest rates and other costs, such as higher salaries paid to their employees, decoration costs and so on (Mahesh and Bhide, 2008). The private banks are dependent on borrowed money especially in the initial years of their operation because it takes a reasonable time to achieve depositors' trust. In fact, depositors particularly in a developing country like Bangladesh always have a mind set to keep their money in public (state-owned) banks. Therefore, private banks borrow deposits at a higher interest rate for producing its outputs e.g., loans and advances.

The estimated coefficient for the dummy variable for political director (PD) in the bank board is positive (0.094) and highly significant. This indicates that the presence of politically linked personalities in the bank board makes differences in efficiency level across banks. Banks which have political directors are less cost efficient than the banks with no political person in the bank board. Due to political influence, bank finances support non-viable investment projects. Therefore, a significant cost is involved in servicing the default loans and provisioning against the loan losses in compliance to the international banking regulation. Many other empirical studies find similar evidence that political connections or political personalities in the bank board affect negatively in bank performance (Carretta et al., 2012, Onder and Ozyildirim, 2011, Khwaja and Mian, 2005, Imai, 2009).

The estimated coefficient (-0.024) for the dummy variable for independent director in the bank board (ID) is negative which is expected and also consistent other empirical studies (e.g., Pathan et al., 2007, Isik and Hassan, 2002). The negative sign of the coefficient suggests that banks with independent director in the board are more cost efficient than the banks with no independent voice in the board. Since independent directors have reputations and also have no other involvement in bank's internal affairs, they can better monitor the banking activities and performance without any bias. However, the estimated coefficient is not statistically significant.

The estimated negative (-0.058) and statistically significant coefficient for bank size (SIZE) suggests that large size banks control cost more effectively. This is

consistent with Berger and Humphrey (1992), suggesting cost advantages in expanding the bank size in terms of asset portfolio in the presence of economies of scale. Moreover, large banks may implement regulatory measures with least cost. The large banks have the capacity to invest in adopting new technological innovations and thus provide technology driven cost-effective products and services (Mahesh and Bhide, 2008, Boucinha et al., 2013, Das and Kumbhakar, 2012). However, the banking literature does not provide any agreement on the relationship between bank size and efficiency (Chen et al., 2005). Wang and Kumbhakar (2007) argue that bureaucratic problem associated with large size bank does harm to the performance. Therefore, it may be detrimental to the overall technical efficiency. In some cases, U-shaped relationship is observed (e.g., Rezvanian and Mehdian, 2002).

The estimated coefficient for transition period dummy variable (DTr) is negative (-0.065) and statistically significant. This indicates that on average, banks have become more cost efficient during the reform policy implementation period compared to the pre-reform period (e.g., Das and Kumbhakar, 2012). This reinforces the downward shift of the cost frontier due to reform measures reported in Sub-section 5.4.1. Not only has the frontier shifted downward, but banks have on average move closer to the frontier during this period. The estimated negative and strongly significant coefficient (-0.024) for time trend variable also implies that on average banks move towards the frontier (i.e., best-practice banks) due to gaining efficiency over time.

The estimated coefficient for the post-reform dummy variable (DPs) is positive (0.269) and significant. This indicates an increased average cost inefficiency which contradicts with the other estimated coefficients discussed above. Such inefficiency may stem from differential effects of regulatory measures on banks which are different in terms of size, ownership and the capacity to adopt international banking regulations and advanced technology, and therefore, the average movement towards the cost frontier may not be the same for all sample banks. The cost of regulatory measures, such as licencing fees, maintaining capital adequacy and

provisioning for loan losses may affect different banks to different extents. Berger and Humphrey (1997) argues that the environmental condition prior to deregulation and other incentives may be liable for such efficiency differences.

The estimated parameter γ (gamma) indicates the proportion of bank inefficiency in the composite error term ($v_{it} + u_{it}$). The estimated coefficient for gamma suggests that approximately 58 percent of the composite error term is attributed to inefficiency. The estimated coefficient of γ is statistically significant at 1% level.

5.4.3 Cost efficiency estimates

This sub-section discusses the average cost efficiency scores obtained from estimating the cost frontier model (Equation 5.2). Individual bank efficiency indices are measured by computing the deviations of costs from the cost frontier (constructed based on the 'best practice' banks). The cost efficiency score shows the rate of saving cost measured against the best practice frontier. Table 5.5 presents the summary statistics of the estimated cost efficiency scores. The analysis demonstrates the estimated average cost efficiency scores in respect of three periods, the pre-reform period 1983-1990, the transition period 1991-1995 and the post-reform period 1996-2012. The efficiency scores for individual banks are presented in Appendix 5.4.

5.4.3.1 Pre-reform and post-reform period

Table 5.5 shows that the average cost efficiency of the sample banks increases from 94% in the pre-reform period to 97% in the post-reform period. Perera, Skully and Wickramanayake (2007) find similar average cost efficiency scores for a sample of Bangladeshi banks while estimating cost efficiency of banks for four South Asian countries. However, banks can still reduce costs by about 3% in order to become fully efficient, i.e., best-practice banks. Although the average cost efficiency of public banks is higher than its private sector counterparts during the pre-reform

period, the efficiency difference shrinks in the post-reform period. Perhaps private sector banks have adopted reform measures and advanced technology rapidly and gained efficiency at a faster pace compared to the public banks in the post-reform period.

The reason for such converging trend may also be explained in terms of differences in behaviour and objectives between public and private banks. In the literature, several theories, for example, property rights theory, agency cost theory and transaction costs theory explain such phenomenon (Wei et al., 2002). These theories suggest that the objective of private banks is profit maximization while public banks do not necessarily pursue profit rather they pursue whatever the government demands. The government uses the public banks to support its political objectives to build their own fortunes at the expense of funds that banks owe to depositors. To control the banks, government retains a large number of unskilled or redundant employees. In fact, labour intensive policies in public banks are cost inefficient. The government even appoints the chief executive officer (CEO) according to their choice (i.e., not competitive basis) in order to promote politicians' welfare (Boycko et al., 1996, Reaz and Arun, 2006).

Table 5.5: Summary statistics of cost efficiency scores, 1983-2012

	Pre-reform			Transition			Post-reform		
	(1983-1990)			(1991-1995)			(1996-2012)		
	Public	Private	All	Public	Private	All	Public	Private	All
Mean	0.942	0.938	0.939	0.972	0.976	0.975	0.969	0.966	0.967
S.E	0.032	0.039	0.037	0.017	0.021	0.019	0.032	0.036	0.035
Max	0.989	0.986	0.989	0.991	0.996	0.996	0.995	0.997	0.997
Min	0.866	0.821	0.821	0.929	0.900	0.900	0.879	0.835	0.835

Source: Author's estimation; efficiency scores estimated using the computer programme FRONTIER 4.1 (Coelli, 1996)

Another difference is budget constraints. The private banks are subject to relatively 'hard' budget constraint and monitored by private owners and the board of

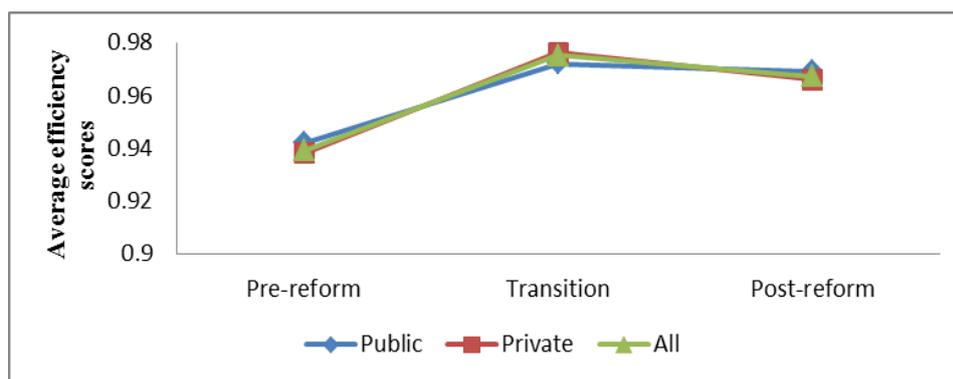
directors. This would obviously lead the private investment to more efficient places (Isik and Hassan, 2002). In contrast, the public banks are subject to ‘soft’ budget constraints. They are virtually not accountable to anyone. In many cases, public sector banks direct investment funds to politically desirable projects. The lending in public banks is directed by the politicians who are involved or have link with ruling political party especially in developing countries like Bangladesh (Onder and Ozyildirim, 2011, Khwaja and Mian, 2005).

The efficiency estimates show that the private banks were less efficient during the pre-reform period. This may happen due to the capital expenditures incurred during the initial years of their operation (since all the sample private banks commenced their operation in 1983, i.e., in the pre-reform period). This increases the fixed costs substantially. Isik and Hassan (2003) find a similar result for Turkish banking. Moreover, the new private banks borrow investment funds at a higher interest rate at the initial stage which incurs significant costs as well.

5.4.3.2 Further comparisons

Figure 5.1 depicts the graphical representation for the average cost efficiency of the sample banks over the three periods.

Figure 5.1: Average cost efficiency, 1983-2012



The average cost efficiency of public banks is higher than their private sector counterparts during the pre-form period (1983-1990). After the implementation of

the financial reform program in 1990s, both private and public sector banks have gained efficiency and, eventually, the average cost efficiency of the sample banks has increased by 3.6% in the transition period (1991-1996) compared to the pre-reform period. During the period, private banks' efficiency increases about 3.8%, while the public banks' efficiency increases about 3.0%. Therefore, the efficiency gains are higher in private banks than in public banks. However, the average cost efficiency level marginally declines (0.8%) in the post-reform period compared to the transition period, where the decline is about 1% for private banks and 0.3% for public banks. Perhaps the reason for such decline in cost efficiencies is difficulty in the compliance of regulatory requirements, e.g., Basel recommendations. According to such regulations, banks are required to maintain adequate equity capital against their risk-weighted assets which may reduce banks' capacity to produce more outputs, such as loans and advances.

5.5 Conclusion

This chapter estimates the cost frontier for 12 commercial banks which have both pre- and post-reform banking operation history. Employing the one-stage SFA model of Battese and Coelli (1995), the analysis estimates both the cost function and the inefficiency function simultaneously. The estimates demonstrate that financial reform policies significantly contribute in reducing bank cost. The coefficient for post-reform period dummy variable in the cost function is negative (-0.11) and highly significant (at 1% level). Similarly, the estimated negative and significant coefficient (-0.065) for transition period dummy variable in the inefficiency function indicates a decline in average cost inefficiency during the implementation of the reform program compared to the pre-reform period. Also the negative and significant coefficient for time trend variable (-0.024) in the inefficiency function indicates an average movement of banks towards the frontier (i.e., best-practice banks) due to gaining cost efficiency over time. However, the estimated positive (0.269) and significant coefficient for the post-reform dummy variable (DPs) in the inefficiency

function contradicts with other estimated coefficients reported above. The reform measures apparently incur more cost for some banks.

The analysis finds that large size banks are more cost efficient than the banks with small scale of operation. Therefore, banks may increase their size through merging. Besides, the public sector banks have a comparative advantage to attain greater efficiency utilizing their broader network and large volume of assets.

Political influence significantly affects cost efficiency. The estimated positive and strongly significant coefficient (0.094) for the political director dummy variable indicates that the presence of political personalities in the bank board increases cost inefficiency. Due to political intervention, bank finance may be directed to non-viable investment projects, which eventually deteriorates the asset quality/bank outputs and increases bank costs. Therefore, the government should not intervene in appointing directors particularly in the state-owned banks.

The estimated average cost efficiency scores indicate that both public and private sector banks have gained efficiency over the period of financial deregulation. The average cost efficiency of the sample banks increases about 3%, from 94% in the pre-reform period to 97% in the post-reform period.

The property of duality in production economics suggests that the cost function contains the same information on technology as production function does at the cost-minimizing equilibrium with input prices fixed (Zheng and Bloch, 2014). Therefore, there is dual relationship between cost efficiency and total factor productivity (TFP). An increase in cost efficiency increases productivity change. Hence, the next chapter examines the impact of financial reform policies on TFP change for the sample banks in Bangladesh.

Chapter 6

Financial deregulation and productivity change in the commercial banks in Bangladesh

6.1 Introduction

This chapter analyses the total factor productivity (TFP) change of 12 commercial banks in Bangladesh in the context of financial deregulation. The previous chapter (Chapter 5) estimates the cost efficiency of the sample banks. There is dual relationship between cost efficiency and productivity change. Schmidt and Lovell (1979) explain the duality between stochastic frontier production and cost functions, in that when a firm is above its cost frontier (i.e., cost inefficiency) it is below its production frontier (i.e., technical inefficiency). In other words, if a firm is technically inefficient the firm will be on above the cost frontier, i.e., the firm is also cost efficient. Bauer (1990a) shows how changes in cost efficiency over time affect the observed TFP change.

O'Donnell (2012b) argues that a firm may be technically efficient but may still be able to improve its productivity by exploiting scale economies (scale efficiency) and changing input combinations (mix efficiency). Moreover, if a time component is considered, i.e., productivity comparisons through time, an additional source of productivity change, technical change is possible. This technical change is represented by a shift in the production frontier. Thus, productivity change stems from efficiency change and technical change or some combination. As explained in Chapter 4, the Färe-Primont TFP index provides an aggregate quantity framework to compute TFP change and decompose it into measures of technical change, technical efficiency change, mix efficiency change and scale efficiency change. The TFP decomposition analysis provides a proper understanding about the contribution of the components in TFP growth particularly in the context of financial deregulation.

The TFP decomposition method, suggested by O'Donnell (2008, 2011b), has several advantages. It does not require any strong assumption concerning the structure of the production technology. The method also does not require any assumption concerning either the degree of competition in product markets or the optimization behaviour of the firms (e.g., minimizing cost, maximizing revenue or profit). Second, within the class of productivity indexes, the Färe-Primont TFP index satisfies all the required properties (axioms and tests) of index number theory, including multiplicative completeness, additive completeness and transitivity test. The Färe-Primont TFP index can be exhaustively decomposed in an economically-meaningful way into three different components; a technical change component that measures movements in the production frontier, a technical efficiency change component that measures movements towards or away from the frontier, and a scale-mix efficiency change component that measures movements around the frontier surface (O'Donnell, 2011c). This thesis uses the DEA-based Färe-Primont productivity index to estimate the TFP change of the sample banks in Bangladesh for the period 1983-2012.

The main contribution of this chapter is two-fold. First, it provides the first attempt to apply the Färe-Primont TFP index to compute and decompose TFP change in banking context. Second, there is no such empirical study yet available for the banking sector in Bangladesh. The analysis of this chapter involves two parts. First, the framework developed in Chapter 4 is applied to estimate the TFP change and its components. Second, a panel data regression model is employed to investigate the determinants of the estimated TFP change and its components.

The remainder of the chapter is organized as follows. Section 6.2 contains the empirical design to be followed for estimation. Section 6.3 discusses the estimation results and interpretations and, finally, Section 6.4 concludes.

6.2 Research design

Since the focus of this chapter is to examine the impact of financial reform policies on productivity changes, the sample banks remain the same as in Chapter 5, i.e., 12 commercial banks in Bangladesh having both pre- and post-reform banking operation history. As noted in Chapter 4, the Färe-Primont TFP index is used to make reliable multi-lateral and multi-temporal comparisons, i.e., comparisons involving many firms and different time periods (O'Donnell, 2012b, Arora and Arora, 2013). Therefore, TFP change can be compared over the three different periods, 1983-1990 as the pre-reform period, 1991-1995 as the transition period and 1996-2012 as the post-reform period, in order to investigate whether banking reform policies have had any impact on bank productivity. The computer program DPIN3.0 developed by O'Donnell (2011a) is used for computing the Färe-Primont TFP index.

6.2.1 TFP change and its components

Recalling the derivation from Chapter 4, the multiplicatively-complete TFP index in period- t relative to period- s can be defined as:

$$TFP_{s,t} = \frac{TFP_t}{TFP_s} = \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{TFPE_t}{TFPE_s} \right) \quad (4.48)$$

where, the first term in parentheses measures the change in the maximum TFP over time and thus is a natural measure of technical change. The second term in parentheses is a measure of overall efficiency change. Therefore, Equation (4.48) can be further extended with different components of efficiency change as noted in Chapter 4, i.e., the output-oriented TFP change and its decomposition:

$$TFP_{s,t} = \frac{TFP_t}{TFP_s} = \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{OTE_t}{OTE_s} \right) \times \left(\frac{OME_t}{OME_s} \right) \times \left(\frac{ROSE_t}{ROSE_s} \right) \quad (4.49)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{OTE_t}{OTE_s} \right) \times \left(\frac{OSE_t}{OSE_s} \right) \times \left(\frac{RME_t}{RME_s} \right) \quad (4.50)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{OTE_t}{OTE_s} \right) \times \left(\frac{OSME_t}{OSME_s} \right) \quad (4.51)$$

where, the first term in the parentheses is a measure of technical change which measures the difference between the maximum TFP possible using the period- t technology and the maximum TFP possible using the period- s technology. The efficiency change components are technical efficiency change (OTE), mix efficiency change (OME), scale efficiency change (OSE), residual mix efficiency change (RME) and scale-mix efficiency change (OSME), where $OSME_t = OME_t \times ROSE_t = OSE_t \times RME_t$.

Similar TFP decompositions can be obtained for input-oriented production technology as noted in Chapter 4:

$$TFP_{s,t} = \frac{TFP_t}{TFP_s} = \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{ITE_t}{ITE_s} \right) \times \left(\frac{IME_t}{IME_s} \right) \times \left(\frac{RISE_t}{RISE_s} \right) \quad (4.52)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{ITE_t}{ITE_s} \right) \times \left(\frac{ISE_t}{ISE_s} \right) \times \left(\frac{RME_t}{RME_s} \right) \quad (4.53)$$

$$= \left(\frac{TFP_t^*}{TFP_s^*} \right) \times \left(\frac{ITE_t}{ITE_s} \right) \times \left(\frac{ISME_t}{ISME_s} \right) \quad (4.54)$$

This chapter estimates both output-oriented and input-oriented TFP measures. The output-oriented decompositions are most meaningful in the empirical context where inputs are held fixed. On the other hand, input-oriented decompositions are relevant where outputs are held fixed and the inputs mix can vary.

6.2.2 Determinants of productivity change

After the Färe-Primont TFP indexes are calculated, panel data regressions are estimated with the TFP change and its components used separately as the dependent variable and various explanatory factors as independent variables. Recalling Equation (4.69) from Chapter 4, the model can be expressed as:

$$FPI_{it}^{s,t} = \alpha_i + \beta X_{it} + \varepsilon_{it} \quad (4.69)$$

where $FPI_{it}^{s,t}$ is a measure of Färe-Primont TFP index for bank i between two consecutive periods s and t . FPI represents the TFP change and its components. The dependent variable X represents bank-specific and environmental variables, α is the constant term, β 's parameters to be estimated and ε denotes the error term.

6.2.3 Data

The sample contains a balanced panel dataset constructed from bank level data of 12 commercial banks in Bangladesh for the period 1983-2012 as in Chapter 5. The number of observations is 360.

6.2.4 Variables

The intermediation approach is followed in determining the input and output variables. Therefore, the same input and output variables are used as in Chapter 5 for productivity estimation. Since cost efficiency increases the productivity (Bauer,

1990a), the same explanatory variables (as in Chapter 5) are employed to regress on TFP change and its components and, thus estimate the intensity of influence.

The input vectors are (1) labour (q_1), the number of full-time employees; (2) physical capital (q_2), the book value of premises and fixed assets; and (3) loanable funds (q_3), the sum of deposit (demand and time) and non-deposit funds (borrowed funds).

The output vectors are: (1) total loans and advances (y_1), which include loans, cash credits and overdrafts and bills discounted and purchased; and (2) other earning assets (y_2) that comprise government securities, treasury bills, shares (fully paid), debentures, bonds and other investments (gross total assets less loans and physical capital/fixed assets).

Apart from input and output variables, bank-specific characteristics and environmental variables may influence the TFP change and its components. However, this is still a judgmental issue what variables should be taken into account (Kumbhakar and Lovell, 2003). Following Chapter 5, the explanatory variables considered are equity capital, bank size, time trend, 3-bank concentration ratio, bank board composition: political and independent director in the bank board and reform period dummy variables. The detailed definition of these variables has been discussed in Chapter 5 and also in Appendix 6.1.

6.3 The empirical results and discussion

This section reports the estimates of productivity change and its components. The estimated Färe-Primont TFP change and its components, technical change and efficiency change are obtained under the assumption that the production technology exhibits variable returns to scale (VRS). It is also assumed that the sample banks experience the same estimated rate of technical change (ΔTC) for a particular year. Since the production possibilities set may expand or contract, technical change may be greater than one (i.e., technical progress) in some periods and technical change

may be less than one in other periods (i.e., technical regress). The technical change can be interpreted as the shift in the production frontier.

Similarly, the efficiency change estimates, for example, a technical efficiency change (ΔOTE) estimate greater than one indicates that the corresponding bank is closer to the frontier. On the other hand, estimates below the unity means that the corresponding bank is moving further from the frontier. Both input- and output-oriented productivity changes are estimated. The estimated results for both orientations are very similar and, therefore, output-oriented estimates are reported in the next sub-section and input-oriented estimates are reported in Appendix 6.2.

6.3.1TFP change: technical change and efficiency change

The estimated average Färe-Primont TFP change and its components, technical and efficiency change are reported in Table 6.1 and 6.2 respectively for public banks and private banks. The individual bank estimates are not presented here due to space limitation. However, they can be provided upon request. Since the Färe-Primont TFP index satisfies the index number axiom of transitivity, the reported estimates can be used to make meaningful comparisons of performance across banks (inter-spatial) and time periods (inter-temporal).

6.3.1.1TFP change and public banks

Table 6.1 presents the average TFP change (ΔTFP) and its components, technical change (ΔTC) and efficiency change (ΔEff) for the sample public banks. All changes are measured in ratio form, as deviations from one. The components of the output-oriented efficiency change are output-oriented technical efficiency change (ΔOTE), residual scale efficiency change ($\Delta ROSE$) and mix efficiency change (ΔOME).

Table 6.1: Output-oriented TFP change for public banks

Period	ΔTFP	ΔTC	ΔEff	ΔOTE	ΔOME	ΔROSE	ΔOSME
Pre-reform period							
1985/ 84	1.235	1.127	1.096	1.001	0.920	1.202	1.090
1986/85	0.993	0.917	1.083	1.008	1.013	1.061	1.074
1987/86	0.879	0.702	1.255	1.000	1.118	1.133	1.253
1988/87	1.012	1.079	0.937	1.000	0.992	0.946	0.937
1989/88	1.048	0.939	1.117	0.984	1.013	1.121	1.135
1990/89	0.947	1.021	0.927	0.983	0.962	0.983	0.943
Transition period							
1991/90	1.012	1.082	0.935	1.008	1.026	0.907	0.928
1992/91	1.025	0.997	1.027	0.986	0.991	1.052	1.042
1993/92	1.107	1.077	1.028	1.044	0.989	0.998	0.987
1994/93	1.082	1.117	0.969	0.958	1.028	0.989	1.019
1995/94	1.066	0.988	1.079	1.006	0.988	1.086	1.074
Post-reform period							
1996/95	1.078	2.721	0.396	0.981	0.840	0.518	0.404
1997/96	1.083	0.369	2.936	1.045	1.269	2.378	2.821
1998/97	1.004	1.085	0.926	0.993	0.988	0.944	0.933
1999/98	1.200	0.982	1.223	0.979	1.025	1.221	1.249
2000/99	1.072	0.977	1.097	1.010	0.990	1.097	1.086
2001/00	1.245	1.007	1.236	1.029	0.983	1.221	1.201
2002/01	1.076	1.059	1.016	0.991	1.021	1.004	1.026
2003/02	0.913	0.978	0.934	1.009	1.022	0.905	0.925
2004/03	1.049	1.064	0.986	0.999	1.005	0.983	0.987

Period	ΔTFP	ΔTC	ΔEff	ΔOTE	ΔOME	ΔROSE	ΔOSME
2005/04	1.079	0.997	1.083	0.999	0.970	1.119	1.089
2006/05	1.035	1.203	0.861	1.017	0.991	0.854	0.846
2007/06	1.019	1.099	0.927	1.000	1.049	0.886	0.927
2008/07	1.010	1.156	0.874	0.969	0.987	0.918	0.904
2009/08	1.028	0.798	1.288	1.022	0.998	1.268	1.263
2010/09	1.183	1.213	0.975	0.982	0.944	1.059	0.994
2011/10	1.001	1.054	0.950	1.025	0.999	0.931	0.927
2012/11	1.021	0.974	1.048	1.002	1.016	1.031	1.046

Source: Author's estimation using DPIN3.0 developed by O'Donnell(2011a)

Alternatively, efficiency change can be expressed in terms of the measures of technical efficiency change (Δ OTE) and scale-mix efficiency change (Δ OSME) since scale-mix efficiency change can be defined as : Δ OSME= Δ OME \times Δ ROSE. The estimated values greater than unity indicate an improvement in the relative performance. Conversely, the estimated values less than unity indicate deterioration.

As shown in Table 6.1, the public banks have been experiencing positive TFP change during the transition and the post-reform period except in 2003-2002. The change in TFP components during these two periods shows that no single component (either Δ TC or Δ Eff) dominates in TFP change. Both technical change and efficiency change contribute in TFP change. The contribution occurs together in the same year or individually in different years. The efficiency change can be associated with technical efficiency change (Δ OTE), mix efficiency change (Δ OME) and residual scale efficiency change (Δ ROSE) or scale-mix efficiency change (Δ OSME). Among the efficiency change components, no single component dominates the efficiency change. However, the technical efficiency change component contributes more compared to other efficiency change components.

The positive technical change (Table 6.1) suggests that the implementation of the reform policies creates a competitive banking environment where public banks attain technological progress, perhaps due to the adoption of advance information and communication technology (ICT) in offering new banking products and services. This is consistent with the findings obtained from the study on Greek banking (Rezitis, 2006).

The TFP change is in part due to technical efficiency change (i.e., ΔOTE). The reason for attaining positive technical efficiency change is perhaps due to following efficient techniques in the production process (O'Donnell, 2012b). Besides, a more appropriate mix of the existing resources may contribute in increasing scale-mix efficiency change ($\Delta OSME$). These suggest a movement towards best-practice banks. However, about 9% deterioration in TFP change was observed in 2003-2002 (post-reform period) as a consequence of deterioration in both technical and efficiency change.

6.3.1.2 TFP change and private banks

The private banks have been experiencing positive TFP change since 1987/86 (i.e., since the pre-reform period). However, change is negative in the initial years of their establishment, i.e., during 1985/1984 and 1986/1985 (Table 6.2)

Table 6.2: Output-oriented TFP change for private banks

Period	ΔTFP	ΔTC	ΔEff	ΔOTE	ΔOME	$\Delta ROSE$	$\Delta OSME$
Pre-reform period							
1985/84	0.990	1.127	0.879	0.972	0.953	0.999	0.924
1986/85	0.996	0.917	1.086	0.983	0.984	1.138	1.113
1987/86	1.049	0.702	1.494	1.095	1.104	1.263	1.364
1988/87	1.025	1.079	0.949	1.017	0.957	0.974	0.934
1989/88	1.008	0.939	1.074	0.996	1.038	1.041	1.079
1990/89	1.008	1.021	0.987	0.985	0.988	1.014	1.001

Period	ΔTFP	ΔTC	ΔEff	ΔOTE	ΔOME	ΔROSE	ΔOSME
Transition period							
1991/90	1.036	1.082	0.957	1.005	1.004	0.949	0.953
1992/91	1.029	0.997	1.032	0.941	1.019	1.107	1.136
1993/92	1.069	1.077	0.993	1.111	1.001	0.929	0.928
1994/93	1.045	1.117	0.936	0.941	0.982	1.014	0.996
1995/94	0.987	0.988	0.999	1.050	0.987	0.972	0.956
Post-reform period							
1996/95	1.794	2.721	0.659	0.921	0.769	0.949	0.706
1997/96	0.993	0.369	2.691	1.104	1.564	1.916	2.551
1998/97	1.032	1.085	0.951	0.999	0.964	0.988	0.952
1999/98	1.197	0.982	1.219	1.051	1.008	1.189	1.167
2000/99	1.124	0.977	1.150	1.021	1.084	1.045	1.126
2001/00	1.075	1.007	1.067	0.984	0.989	1.096	1.084
2002/01	1.052	1.059	0.994	0.983	1.008	1.004	1.011
2003/02	0.982	0.978	1.004	1.047	0.963	0.999	0.965
2004/03	0.988	1.064	0.928	0.991	0.965	0.978	0.937
2005/04	1.091	0.997	1.095	0.997	1.051	1.051	1.100
2006/05	1.087	1.203	0.903	1.000	1.024	0.883	0.903
2007/06	1.072	1.099	0.975	1.007	0.967	1.001	0.969
2008/07	1.071	1.156	0.926	0.992	1.042	0.899	0.936
2009/08	1.036	0.798	1.298	1.019	1.004	1.268	1.274
2010/09	1.131	1.213	0.933	0.979	0.982	0.975	0.955
2011/10	1.051	1.054	0.997	1.020	1.018	0.965	0.982
2012/11	1.017	0.974	1.044	1.003	0.993	1.049	1.041

Source: Author's estimation using DPIN3.0 developed by O'Donnell(2011a)

Unlike the public banks, the TFP for private banks deteriorates for several years during the post-reform period. The technological progress (ΔTC) mainly contributes in achieving the positive TFP change. Lee, Worthington and Leong (2010) find the similar result for Singaporean banking using the non-parametric Malmquist productivity index. The study suggests that banks move toward adopting best-practice. The adoption of new forms of innovation in banking services, such as e-banking, improves efficiency and enhances competition. Park and Weber (2006) also finds that technical progress offsets efficiency declines. The efficiency change components, namely mix efficiency change (ΔOME), scale efficiency change ($\Delta ROSE$) and scale-mix efficiency change ($\Delta OSME$) deteriorate in several years during the sample period. The estimated scores (less than one) for scale and mix efficiency changes indicate that there is still room for gaining from economies of scale and scope in the private sector banking in Bangladesh.

A general comparison of the different indices in Table 6.1 and Table 6.2 reveals that technical change (ΔTC) dominates the TFP change over the years for both public and private sector banks. This is consistent with the findings of Maredza and Ikhide (2013). One possible reason for such technical progress is the adoption of advanced technology in developing banking products and services. These technology based banking services include online banking, mobile phone banking, credit card, debit card and ATM services.

On the other hand, the scale and mix efficiency change estimates deteriorate during the transition and the post-reform period and, therefore, TFP change deteriorates for a few years. These deteriorations can be attributed to the poor performance of the state-owned banks and some private banks because of the sub-optimal usage of inputs by the banks. Similarly, Maredza and Ikhide (2013) observe that deterioration in scale and mix efficiency change estimates contribute to decreasing the TFP change during the post-reform period in South African banking using the Hicks-Moorsteen TFP index.

6.3.2 Periodic average of TFP change and its components

Table 6.3 reports the estimated period averages of TFP change and its components for the three sample periods, the pre-reform period 1984-1990, the transition period 1991-1995 and the post-reform period 1996-2012. Since both input- and output-oriented estimates are very much similar, the output-oriented measures are presented in Table 6.3, while the input-oriented measures are presented in Appendix 6.3.

The estimated period averages in Table 6.3 show that a positive average TFP change is observed in both the transition and the post-reform period compared to the pre-reform period. The increase in average positive TFP change for the sample banks is 3% in transition period and 8% in post-reform period. Mainly technological progress (ΔTC) contributes in gaining positive TFP change in both the periods. The growth in average TFP is higher in public banks in the transition period compared to their private sector counterpart. On the other hand, the growth in average TFP is observed higher in private banks compared to public banks during the post-reform period. Similarly, Casu et al (2004) indicates a change in TFP ascribing it to technical progress in the European banking in the post-deregulation period. The improvement in technical change is attributed to the application of advanced technology, especially ICT in producing cost-effective banking products and services after the implementation of financial reform program.

Table 6.3: Periodic average of TFP change and its components

Banks	ΔTFP	ΔTC	ΔOTE	$\Delta OSME$
Pre-reform Period, 1983-1990				
Public Banks	1.019	0.964	0.996	1.072
Private Banks	1.013	0.964	1.008	1.069
All Banks	1.015	0.964	1.004	1.070

Banks	Δ TFP	Δ TC	Δ OTE	Δ OSME
Transition Period, 1991-1995				
Public Banks	1.058	1.052	1.000	1.009
Private Banks	1.033	1.052	1.009	0.994
All Banks	1.041	1.052	1.006	0.999
Post-reform Period, 1996-2012				
Public Banks	1.064	1.102	1.003	1.095
Private Banks	1.105	1.102	1.007	1.098
All Banks	1.092	1.102	1.006	1.097

Source: Author's calculation

In terms of efficiency gain, Table 6.3 shows that the public banks adopt efficient techniques in production process and, therefore, gain positive change in average technical efficiency (Δ OTE), i.e., move towards best-practice banks during the post-reform period. Both public and private banks attain higher levels of average scale-mix efficiency change (Δ OSME) in the post-reform period compared to both the transition and pre-reform period. One possible reason is that the banks increase the scale of production expanding their branch network and also use input-mix more efficiently and cost-effectively. The efficiency may also increase due to improved managerial practices in banks following the prudential regulations after the financial reform. Empirical studies, such as Isik and Hassan (2003) and Rezitis (2006), find similar results respectively on Turkish and Greek banking.

6.3.3 Determinants of productivity change and its components

This sub-section investigates the drivers and determinants of the computed TFP change and its components. The panel data model developed in Chapter 4 (also mentioned in Section 6.2) is employed for estimation. The estimated TFP change and its various components (Table 6.1 and 6.2) are used as dependent variables. The

explanatory variables that have been used in cost efficiency estimation in Chapter 5 are considered as independent variables. Since there is dual relation between TFP change and cost efficiency (Bauer, 1990a), the rationality of the explanatory variables, as described in Chapter 5, is also applicable for determining the factors of productivity change.

Recalling Equation (4.69) from Chapter 4,

$$FPI_{it}^{s,t} = \alpha_i + \beta X_{it} + \varepsilon_{it} \quad (4.69)$$

where $FPI_{it}^{s,t}$ is a measure of Färe-Primont TFP index for bank i between two consecutive periods s and t . X represents the selected explanatory variables, ε denotes error term, α and β are parameters. Therefore, the empirical models to be estimated are as follows:

$$y_1 = \alpha_0 + \alpha_1 EQ + \alpha_2 ID + \alpha_3 PD + \alpha_4 SIZE + \alpha_5 DTr + \alpha_6 DP_s + \alpha_7 t + \alpha_8 CR3 + e \quad (6.1)$$

$$y_2 = \beta_0 + \beta_1 EQ + \beta_2 DTr + \beta_3 DP_s + \beta_4 t + \beta_5 CR3 + v \quad (6.2)$$

where, y_1 is the measured productivity change, ΔTFP , ΔOTE , ΔOME , $\Delta ROSE$, $\Delta OSME$, and y_2 is technical change, ΔTC . The explanatory variables are equity capital (EQ), independent director in the bank board (ID), political director in the bank board (PD), bank size (SIZE), 3-bank concentration ratio (CR3), time trend (t), dummy variable for transition period (DTr), dummy variable for post-reform period (DPs). The pre-reform period dummy is treated as the base, so the coefficient of DTr (DPs) can be interpreted as the change in productivity and its components from the pre-reform period to the transition (post-reform) period. α and β are parameters and e and v denote error terms.

Both random effect (RE) and fixed effect (FE) models are estimated for Equations (6.1) and (6.2). The Hausman specification test is performed to choose

which of the models is appropriate for representing the sample data. Based on the results of the Hausman tests (the probability for λ^2 -statistic in Appendix 6.4), the RE model is found the appropriate one. Therefore, the estimated parameters for the RE model are reported in Table 6.4. The estimated parameters for FE model are presented in Appendix 6.4.

Table 6.4 reveals that technological progress contributes in gaining positive TFP change since the estimated coefficient for the time trend variable (t) is positive (0.201) and statistically significant at 1% level. This is consistent with the findings of the estimated Färe-Primont TFP indices analysis in Sub-section 6.3.1. The positive (0.219) and highly significant (1% level of significance) relation between time trend and ΔTC indicates technical progress over time.

The estimated positive and highly significant coefficient for 3-bank concentration ratio (7.698) indicates that a more concentrated banking industry has a positive impact on TFP change. In this case, technological progress contributes for attaining higher productivity growth since the coefficient for technical change (ΔTC) is positive (7.01) and highly significant. However, banks may be relatively less efficient in selecting appropriate mix of inputs as the estimated coefficient for mix efficiency change (ΔOME) is found negative (-1.54) and statistically significant.

Table 6.4: Determinants of TFP change and its components

	ΔTFP	ΔTC	ΔOTE	ΔOME	$\Delta ROSE$	$\Delta OSME$
Equity (EQ)	-0.001 (0.038)	-0.029*** (0.009)	0.002 (0.003)	0.009 (0.006)	0.028 (0.029)	0.041 (0.030)
Independent Director (ID)	0.032 (0.283)	-	0.015 (0.025)	0.045 (0.045)	0.212 (0.221)	0.264 (0.225)
Political Director (PD)	-0.063 (0.220)	-	0.004 (0.017)	0.031 (0.031)	-0.063 (0.160)	-0.029 (0.171)

	Δ TFP	Δ TC	Δ OTE	Δ OME	Δ ROSE	Δ OSME
Size (SIZE)	-0.172 (0.301)	-	-0.006 (0.025)	0.009 (0.045)	-0.131 (0.227)	-0.133 (0.236)
Transition (DTr)	-0.646** (0.295)	-0.359*** (0.075)	0.033 (0.027)	0.144*** (0.048)	-0.042 (0.232)	0.169 (0.234)
Post-reform (DPs)	-1.326** (0.591)	-1.763*** (0.149)	0.115** (0.054)	0.529*** (0.096)	0.493 (0.465)	1.169** (0.470)
Time trend (t)	0.201*** (0.073)	0.219*** (0.019)	-0.012* (0.007)	-0.056*** (0.012)	-0.016 (0.058)	-0.089 (0.058)
Concentration (CR3)	7.698*** (2.539)	7.014*** (0.658)	-0.339 (0.231)	-1.541*** (0.414)	0.926 (1.998)	-1.148 (2.021)
R-squared	0.077	0.414	0.019	0.122	0.082	0.107
Wald Chi-square	28.63	240.78	6.74	47.00	30.25	41.07
Total observations	348	348	348	348	348	348

Source: Author's estimation using STATA12. The pre-reform period is treated as the base period. Standard errors are in parentheses;*** denotes statistical significance level at 1%; ** denotes the level of statistical significance at 5%; * denotes statistical significance level at 10%

The estimated positive and highly significant coefficient for 3-bank concentration ratio (7.698) indicates that concentrated banking industry has a positive impact on TFP change. Perhaps three large state-owned banks (Sonali, Janata and Agrani) attain higher productivity growth utilizing greater market power. This indicates that the banking industry in Bangladesh still remains concentrated and, therefore, less competitive even after three decades of financial liberalization. Delis (2012) also argue that financial liberalization policies may not increase competition in relatively underdeveloped countries. The TFP component, technological progress contributes for attaining higher productivity growth since the coefficient for technical change (Δ TC) is positive (7.01) and highly significant. However, banks may be

relatively less efficient in selecting appropriate mix of inputs as the estimated coefficient for mix efficiency change (ΔOME) is found negative (-1.54) and statistically significant.

The estimated negative coefficient for equity capital indicates that an increased equity capital has a negative impact on TFP change. However, the estimated coefficient is not statistically significant. The estimated negative but statistically significant coefficient (at 1% level of significance) for technical change indicates that equity capital may not have positive impact on technical change. One possible reason is that some banks may use equity capital for compliance to the regulatory requirements, e.g., capital adequacy requirement following Basel accords. Therefore, they may be unable to use their capital for the development of their production technology (Boucinha et al., 2013, Das and Ghosh, 2006).

6.4 Conclusion

This chapter measures the productive performance of 12 commercial banks in Bangladesh. Employing an aggregate quantity framework, the Färe-Primont TFP index, the productivity change is computed and decomposed into various components, such as, technical change, technical efficiency change, mix efficiency change, residual scale efficiency change and scale-mix efficiency change.

The measured TFP change indices (Table 6.1 and 6.2) indicate that the sample banks have been experiencing positive TFP change after financial reform. However, a slight deterioration in TFP change is observed for two years, 2003-2004 in the post-reform period. The negative scale and mix efficiency change mainly contribute to the diminishing TFP growth during these two years.

The panel data regression analysis demonstrates that technological progress is a determinant of positive TFP growth for the sample banks. Among the various components of TFP change, technological progress mainly contributes in attaining positive TFP growth. The positive technical change (i.e., technological progress) can

be attributed to the application of advanced technology; especially using ICT in producing technology based cost-effective and competitive banking services. Therefore, it is important for banks to develop adequate capacity to apply advanced technology in providing banking services. Following the performance evaluation in terms of efficiency (Chapter 5) and productivity (Chapter 6), the next empirical chapter evaluates the financial performance of the sample banks as a consequence of financial deregulation.

Chapter 7

Financial deregulation and profitability in the commercial banks in Bangladesh

7.1 Introduction

Bank performance can be measured in a multidimensional way. Two different performance measures, cost efficiency and productivity, are discussed respectively in Chapters 5 and in Chapter 6. Although cost efficiency and productivity are important performance indicators each reflects one dimension of bank's overall performance. Another performance measure, profitability, captures both cost and revenue dimensions of overall performance of banks (Fried et al., 2008a, Berger and Humphrey, 1997). All three performance measures are related; for example, cost efficiency and productivity have dual relationships; an increase in cost efficiency increases productivity (Schmidt and Lovell, 1979, Bauer, 1990a). Similarly, Kwast and Rose (1982) and Bourke (1989) find that cost efficiency is an important factor in achieving higher bank profitability; because reduced expenses improve the efficiency and, hence, raise the profitability of a financial institution. Furthermore, Athanasoglou, Brissimis and Delis (2008) find that productivity growth and profitability are positively related. Again, Miller and Noulas (1996) suggest that more profitable banks have lower pure technical inefficiency. Hence, this chapter analyses the measures of profitability and the determinants of profitability for the 12 commercial banks in Bangladesh for the period 1983-2012. Utilizing the same panel dataset employed in the previous empirical chapters, the study thus contributes to the ongoing discussion (Chapter 5 and Chapter 6) on the effects of financial deregulation on the performance of the banking sector controlling other factors.

A profitable banking sector is necessary in order to withstand negative economic shocks (e.g., financial crisis) and for the stability of the whole financial system. Thus, profitability analysis obviously has important policy implications

especially for the expansion of the sector. The key banking policy decisions, for example, introduction of new banking products and services, innovation of banking services utilizing advanced technology, and new investments in banking business - all depend on the profitability of the industry.

The majority of the studies on bank profitability (e.g., Short, 1979, Bourke, 1989, Goddard et al., 2004) use linear models to estimate the impact of various factors on profitability. However, studies examining the impact of corporate governance and financial reform policies on profitability are very few, especially in developing country perspectives (Bangladesh, for example). Therefore, this study employs a panel regression framework to determine the underlying determinants of the sample banks' financial performance in terms of profitability measures: net interest margin (NIM), return on assets (ROA) and return on equity (ROE). Unlike many other empirical studies on profitability, corporate governance variables and financial reform period dummy variables are included in the regression analysis apart from other bank-specific, industry-related and macroeconomic factors.

The remainder of the chapter is structured as follows. Section 7.2 provides the literature on profitability. Section 7.3 explains the profitability measures and determinants of profitability. Section 7.4 contains empirical design and methodology to be followed for estimation. Section 7.5 discusses the estimation results, and finally, Section 7.6 concludes.

7.2 Literature on profitability

The literature on bank profitability has focused on the key indicators of profitability: net interest margin (NIM), return on assets (ROA), and return on equity (ROE) (Flamini et al., 2009, Naceur and Omran, 2011). Ho and Saunders (1981) seminal paper presents a theoretical framework (dealership model) for the determinants of NIM. The authors find that interest margin depends on both the degree of market competition and interest rate risk. A decrease in NIM indicates an improved

functioning of the banking system (Kasman et al., 2010). However, it may not always reflect improved efficiency rather it may reflect a reduction in bank taxation or higher loan default rate (Demirguc-Kunt and Huizinga, 1999).

Many empirical studies examine the effect of determinants on bank performance (e.g., Bourke, 1989, Molyneux and Thornton, 1992, Athanasoglou et al., 2008, Dietrich and Wanzenried, 2011). The determinants may be internal and external. The internal determinants are related to bank-specific management decisions, for example, level of liquidity, credit exposure, capital ratio, operational efficiency and bank size. The external determinants are industry related, e.g., reform policies or regulations, ownership and concentration and macroeconomic factors, e.g., inflation, GDP growth and broad money growth.

Bank capital plays an important role in determining profitability. Among others, Bourke (1989) and Molyneux and Thornton (1992) find a positive relationship between the level of capital (capital ratio) and profitability. In fact, well-capitalized banks may need less borrowing, and therefore, the cost of fund is low. Moreover, well-capitalized banks may enjoy access to cheaper sources of funds (Berger, 1995b). Similarly, profits may lead to higher capital, if the earned profit is reinvested (Flamini et al., 2009). Another empirical study on 23 Greek banks, utilizing time series data for 1990-2002, reveals that a higher level of ROA is associated with well-capitalized banks and also efficient expense management (Kosmidou, 2008).

Bourke (1989) reports that higher concentration in banking markets encourages banks to hold less risky assets. This indicates that higher level concentration is associated with higher bank profits emanated from low-risk asset portfolio. However, Berger (1995a) argues that profit-concentration relationship is a spurious one since the relationship may be affected by other factors. The author finds a negative relationship between concentration and profitability once the other effects, for example, efficiency and market share are controlled. Kosmidou (2008) also finds a statistically significant negative relationship between bank concentration and ROA

in Greek banking. Pasiours and Kosmidou (2007) find that bank-specific characteristics, financial market structure and macroeconomic conditions have significant impact on profitability. The authors find no significant relationship between profitability and bank concentration for domestic banks, while concentration in domestic market may reduce foreign banks' profit (Williams, 2003).

Profitability may differ with bank size. Bank size has a significant positive impact on interest margin (Demirguc-Kunt and Huizinga, 1999). Larger and more profitable banks may have higher level of technical efficiency. An empirical study on MENA banks suggests a positive correlation between bank size and accounting profitability (Olson and Zoubi, 2011). However, large banks may have experienced poor performance as a consequence of declining quality of asset portfolio. Because high-risk loans generate higher accumulation of default loans and, eventually, lower the profitability (Miller and Noulas, 1997, Miller and Noulas, 1996). Applying the GMM regression technique on a panel of Greek banks for the period 1985-2001, Athanasoglou et al. (2008) provide the evidence that profitability of Greek banks is shaped by bank-specific and macroeconomic factors, however, bank size and other industry structure variables do not have any significant effect on profitability.

The macroeconomic factors e.g., economic growth has a positive effect on profitability (Sufian and Habibullah, 2009a, Kosmidou, 2008). Higher economic growth increases bank credit in the economy and, consequently, increases bank earnings. Inflation is another macroeconomic indicator which may affect bank profitability. Kosmidou (2008) finds that inflation has a significant negative impact on bank profitability while investigating the determinants of profits in Greek banking during EU financial integration. However, Perry (1992) argues that the effect of inflation depends on whether the inflation is anticipated or unanticipated. If inflation is unanticipated, banks may take time to adjust their interest rates, which results a faster increase in bank costs compared to its revenues and, therefore, bank will lose. On the other hand, if inflation is fully anticipated bank interest rates will increase to

include inflation premium while the liabilities of the bank fall in real terms and bank will gain.

The literature on the effect of financial reform policies on bank profitability is limited. Heffernan and Fu (2010) find no significant influence of reform policies on bank performance. Following the GMM approach on a panel of 76 Chinese banks, the study suggests that reform policies have significant effect on NIM but not on ROA or ROE. Naceur and Goaid (2008) find that partial liberalization negatively affect interest margin, whereas complete liberalization strengthens the ability of Tunisian banks to generate profit margins. Similarly, another study on 10 MENA (Middle East and North Africa) countries reveals that regulatory changes and bank-specific characteristics have impact on bank performance (Naceur and Omran, 2011).

There is no comprehensive study investigating the impact of financial deregulation on the profitability of the commercial banks in Bangladesh. However, Sufian and Habibullah (2009b) find a significant relationship between bank-specific characteristics and profitability while investigating the commercial banks in Bangladesh for the period 1997-2004. The study does not consider financial reform periods and corporate governance issues. Furthermore, the study uses one or two years of data for the sample banks and, therefore, lacks data sufficiency. Hence, the estimated results may not be a true reflection of bank profitability, particularly in the context of financial deregulation. In contrast, this chapter provides an analysis of profitability for both the pre- and post-reform periods utilizing banking sector data for 30 years, 1983-2012.

7.3 Profitability measures and determinants

Bank performance evaluation involves assessing the interaction among internal operations, industry characteristics and macroeconomic environment. In the context of increased innovation and deregulation in the financial industry, both internal and external competitiveness have become crucial in evaluating performance. Therefore,

the determinants of bank profitability may be both internal and external. While the internal determinants are related to bank's management decisions and policy objectives, external determinants reflect economic and industry conditions. The next sub-sections discuss about the profitability measures and both internal and external factors that influence profitability measures.

7.3.1 Profitability measures

The profitability measures considered in this chapter are: net interest margin (NIM), return on assets (ROA), and return on equity (ROE). ROA is the net profit expressed as a percentage of average total assets. The bank profitability literature suggests ROA as an appropriate measure of the ability of a bank to generate returns on its asset portfolios (Rivard and Thomas, 1997, Pasiouras and Kosmidou, 2007), while ROE reflects how effectively a bank management is using its equity capital. Bank's ROE may be affected by its ROA and also the degree of financial leverage or equity ratio (equity/asset). A bank with a higher equity ratio will have a higher return on assets and a lower return of equity than with a lower equity ratio while other things remain the same, i.e., *ceteris paribus* (Demirguc-Kunt and Huizinga, 1999). Another profitability measure, NIM is the accounting value of a bank's net interest income (interest income minus interest expense) divided by total assets. Therefore, variation in NIM may reflect changes in net interest income or total asset depending on the quality of assets (i.e., loan default rate) or taxation (Demirguc-Kunt and Huizinga, 1999).

7.3.2 Determinants of profitability: internal and external

Following the literature discussed in Section 7.2, the major internal determinants or bank-specific factors that influence profitability measures are: capital ratio, asset composition, bank size and corporate governance. The external determinants include both industry-related and macroeconomic factors. The industry-related factors are:

ownership structure, concentration and policy reforms. The macroeconomic factors that have been considered are: GDP growth rate and CPI inflation.

The capital ratio indicates the solvency of financial institutions. This reflects bank's capability to absorb losses incurred due to poor asset quality. Poor asset quality is perceived to cause capital erosion and therefore, increases risk. The capital ratio is measured as the total capital divided by total asset. The literature suggests that higher the capital ratio, the lower the need for external funding, and therefore, higher the profitability of banks (Kosmidou, 2008).

The risk-related characteristic specific to each bank is the composition of assets (i.e., asset quality). In general, banks are intermediaries between depositors and borrowers. The more deposits are transformed into loans, the higher the net interest income and profits. A bank with a higher ratio of loans to assets (TL/TA) is expected to be more efficient in earning profits because interest income is the main source of bank revenue, which impact the profit positively (Maudos et al., 2002). However, non-performing loans (NPLs) incur loss to the bank due to the provisioning against the NPLs, which lead to a decrease in profits (Miller and Noulas, 1997). Therefore, the expected sign of the variable (TL/TA) depends on the volume of asset portfolio and associated non-performing loans. For example, if a bank has a large volume of assets with negligible NPLs, the bank's profit will be higher.

Bank size (SIZE) is considered as a relevant determinant of profitability. Bank size can be measured by total assets of a bank. In the banking literature, there is no consensus on the direction of influence of bank size on profitability. On the one hand, large size bank may reduce costs and, thus increase profits due to economies of scale and/or scope. On the other hand, large banks may not be efficient in reducing operational cost and, therefore, less profitable (compared to small size banks) due to complex bureaucratic system, excess staffs, and weak supervision of their large volume of assets. The empirical literature discussed in Section 7.2 shows mixed results regarding the relationship between bank size and profitability.

Following the previous empirical chapters, Chapter 5 and Chapter 6, governance variables, such as, political director and independent director in the bank board, are included in the estimation in order to examine how these variables affect the profitability of banks. Among other empirical studies, Shen and Lin (2012) provide the evidence that political interference deteriorates the financial performance of banks in terms of ROA, ROE and NIM in a cross-country study using bank level data for 65 countries for the period 2003-2007. Alternatively, Pathan et al. (2007) find a statistically significant positive relationship between independent director in the bank board and profitability measures, such as ROA and ROE, employing a panel fixed-effect regression model for Thai commercial banks. Skully (2002) also recommends that the presence of independent directors in the bank board ensures better bank governance. Therefore, as a proxy of governance variable, independent and political dummy variables are included in the model. The variables can be defined as: PD=1 if any politically linked person is in the bank board and zero otherwise. Similarly, ID=1 if any independent director is in the bank board and zero otherwise. The empirical studies suggest for an expected negative sign for the dummy variable for political directors and a positive sign for independent directors in the bank board.

There is still disagreement in the banking literature whether ownership structure has any effect on bank performance. Many empirical studies (e.g., Micco et al., 2007, Iannotta et al., 2007, Short, 1979) provide the evidence that ownership structure does affect bank profitability. In contrast, Dietrich and Wanzenried (2011) and Athanasoglou et al. (2008) argue that bank ownership status (private or state-owned) is irrelevant for explaining profitability. A dummy variable is included to reflect the ownership structure of banks defining OWN=1, if the bank is state-owned and zero, otherwise.

The degree of market concentration (CR) is related to the degree of competition. The structure-conduct-performance (SCP) hypothesis argues for non-competitive pricing behaviour of banks/firms (i.e., earning monopoly profit) in

highly concentrated markets (Short, 1979, Garcia-Herrero et al., 2009). According to the hypothesis, banks are expected to enjoy greater market power, and consequently, become more efficient in earning profits in more concentrated markets. However, banks may feel less pressure to control of their costs and, therefore, become less cost-efficient if there is a high degree of concentration. Thus, the effect of concentration on profitability may be either positive or negative. Following the previous empirical chapters, a 3-bank deposit concentration ratio is constructed as an explanatory variable in the estimation.

Changes in regulatory conditions in financial/banking markets may have impact on profitability. Many developing economies including Bangladesh, have liberalized their banking market through privatization and deregulations. The major reform policies implemented already are as follows: liberalization of interest rates, allowing private banking operation and strengthening prudential regulations. Following the previous empirical chapters, period dummy variables are constructed to indicate the pre-reform (DPr), transition (DTr) and post-reform periods (DPs) to distinguish between regulatory regimes in the sample period and thus evaluate the effect of regulatory changes on bank performance.

Macroeconomic conditions may affect bank performance. Higher economic growth may strengthen the debt servicing capacity of borrowers and, therefore, contribute to lowering the credit risk. However, adverse macroeconomic conditions may increase non-performing loans (NPLs) and eventually reduce bank profit. Among others, Maudos et al. (2002) and Pasiouras and Kosmidou (2007) find a positive correlation between GDP growth rate and profitability.

Following the literature, average CPI inflation is included in the regression analysis as a macroeconomic indicator. A higher level of inflation may increase bank revenue if income increases more than the cost. Perry (1992) suggests that the effect of inflation on bank performance depends on whether the inflation is anticipated or unanticipated. The definition of the variables is provided in Appendix 7.1.

7.4 Research design

Since the focus of this chapter is to examine the impact of financial reform policies on profitability measures, the sample banks and periods remain the same as in Chapters 5 and 6, i.e., 12 commercial banks in Bangladesh having pre- and post-reform banking operation history for the period 1983-2012. As noted in Chapter 4, a panel data regression model is employed to investigate the determinants of bank profitability. Following the literature discussed in Section 7.2, three panel regressions have been estimated with three measures of profitability, NIM, ROA and ROE as dependent variables and a set of explanatory variables, which are bank-specific, industry-related and macroeconomic indicators, as independent variables. The correlation matrix demonstrated in Appendix 7.2 shows the degree of correlation between the dependent and the explanatory variables used in the regression analysis. The matrix shows no strong correlation among the variables.

7.4.1 Data

The sample contains a balanced panel with bank level data from the 12 commercial banks in Bangladesh for the period 1983-2012. The data have been collected from the balance sheets of individual banks. The macro-level data have been collected from Bangladesh Bureau of Statistics (BBS), Central Bank of Bangladesh (Bangladesh Bank), Ministry of Finance, the Government of Bangladesh and World Development Indicator (WDI). The total number of observations is 360.

7.4.2 Model estimation

Recalling Equation (4.48) from Chapter 4, the panel regression model is expressed as:

$$Z_{it} = \beta_i + \gamma Y_{it} + \nu_{it} \quad (4.48)$$

where Z_{it} represents the measures of profitability for banks i . Y_{it} indicates the selected explanatory variables, ν_{it} denotes the error term, β is the constant term and γ is the vector of regression coefficients. The empirical model to be estimated is as follows:

$$z_{it} = \beta_0 + \gamma_1 CAP + \gamma_2 AQ + \gamma_3 SIZE + \gamma_4 OWN + \gamma_5 CR3 + \gamma_6 PD + \gamma_7 ID + \gamma_8 DTr + \gamma_9 DP_s + \gamma_{10} GDPG + \gamma_{11} INF + e_{it} \quad (7.1)$$

where, z_{it} is expressed as the measure of profitability in terms of one of ROA, ROE or NIM. The explanatory variables are capital ratio (CAP), asset quality (AQ), bank size (SIZE), dummy variable for bank ownership (OWN), 3-bank deposit concentration ratio (CR3), dummy variable for political director in the bank board (PD), dummy variable for independent director in the bank board (ID), dummy variable for the transition period of the financial reform program (DTr), dummy variable for the post-reform period (DPs). The pre-reform period dummy is treated as the base, so the coefficient of DTr (DPs) can be interpreted as the change in profitability ratios from the pre-reform period to the transition (post-reform) period. β is the constant term and γ is the vector of coefficients and e denotes the error term.

Both random-effect (RE) and fixed-effect (FE) models are estimated for Equation (7.1). The Hausman specification test is performed to choose which of the models is appropriate for representing the sample data. The result indicates that the RE model is the appropriate one (the probability of χ^2 statistic is given in Appendix 7.3). The estimated results for the RE model are presented in the text (Table 7.1). The regression results for both the FE model and the RE model are presented in Appendix 7.3.

7.5 The estimation results and discussion

This section discusses the regression results. Table 7.1 reports the results for the regressions for each of NIM, ROA and ROE on bank-specific, industry-related and macroeconomic variables. The model seems to fit the panel data reasonably well. The Wald-test indicates fine goodness of fit. The probability values for Wald statistic for all three regressions provide strong significance level as shown in Table 7.1.

The estimated results show a positive relationship between capital ratio and ROA at 1% level of significance. This implies that well-capitalized banks earn more profits. One possible reason is that well-capitalized banks need less external funding and, therefore, cost of funding is low and earns higher profit. This is consistent with other empirical studies (e.g., Berger, 1995b, Kosmidou, 2008, Pasiouras and Kosmidou, 2007, Garcia-Herrero et al., 2009).

The estimated coefficient for asset quality (total loans/total assets) enters all three regression models with a positive sign and statistically significant at 5% and 1% level of significance respectively for ROA and ROE. However, no significance is found for NIM. Banks with higher loan-asset ratio tend to be more profitable due to increased loan portfolio. The finding is consistent with the previous empirical studies, such as Molyneux and Thornton (1992) and Pasiouras and Kosmidou (2007).

The relationship between bank size and profitability ratios is found positive in all three estimated regressions. However, the coefficient is statistically significant only for ROA at 5% level of significance. The empirical studies, for example, Hauner (2005) and Kosmidou (2008) find similar positive relationships between bank size and profitability. Perhaps large size banks have cost advantages associated with product and risk diversification. Besides, the existing increasing returns to scale in the production process of large size banks may increase bank profitability. However, Pasiouras and Kosmidou (2007) find negative relationship between bank size and performance.

Table 7.1: Determinants of profitability: NIM, ROA & ROE

	NIM	ROA	ROE
Capital ratio (TCTA)	0.098 (0.076)	0.171*** (0.021)	-0.967 (0.666)
Asset Quality (TLTA)	0.010 (0.036)	0.024** (0.009)	0.858*** (0.315)
Bank size (SIZE)	0.015 (0.013)	0.007** (0.004)	0.115 (0.115)
Ownership dummy (OWN)	-0.025** (0.012)	-0.008** (0.003)	-0.004 (0.107)
Concentration ratio (CR3)	0.004 (0.034)	0.011 (0.009)	0.665** (0.299)
Political Director dummy (PD)	-0.001 (0.009)	-0.000 (0.002)	0.009 (0.078)
Independent Director dummy (ID)	-0.001 (0.012)	0.004 (0.003)	0.021 (0.107)
Transition Period dummy (DTr)	0.004 (0.010)	-0.006 (0.003)	-0.193** (0.089)
Post-reform period dummy (DPs)	0.025** (0.013)	0.000 (0.003)	-0.061 (0.110)
GDP growth rate (GDPG)	-0.011*** (0.004)	-0.001 (0.000)	0.044 (0.031)
CPI inflation (INF)	0.002* (0.001)	0.000 (0.000)	0.025** (0.011)
R-squared	0.076	0.272	0.108
Wald Chi-square	28.43	130.11	42.13
Probability (Chi-square)	0.003	0.000	0.000
Total Observations	360	360	360

Source: Author's estimation using STATA12. The pre-reform period is treated as the base period. Standard errors are in parentheses;*** denotes statistical significance level at 1%; ** denotes the level of statistical significance at 5%; * denotes statistical significance level at 10%

The estimated negative coefficients for ownership dummy variable in all three regressions indicate an inverse relationship between banks' profitability and government ownership. Micco et al. (2007) finds similar lower profitability for the state-owned banks compared to the private sector banks in developing country perspectives. The result is also consistent with some other empirical studies e.g., Short (1979), Bourke (1989) and Lin and Zhang (2009). In fact, the objective of private banks is profit maximization, while state-owned banks do not necessarily pursue profit maximization rather they follow government demands. In many cases, the government uses public banks to support its political objectives at the expense of depositors' fund (La Porta et al., 2002). Moreover, the public sector banks have a

social role and address market imperfections. Therefore, the public sector banks can be socially profitable but financially unprofitable (Stiglitz, 1993).

Bank concentration enters positively in all three regressions (NIM, ROA and ROE). However, the coefficient is statistically significant only for ROE. The result is consistent with Molyneux and Thornton (1992) and Smirlock (1985), among others, and supports the traditional structure-conduct-performance paradigm. The estimated coefficient indicates that greater market power (i.e., higher concentration) leads to higher bank profit. However, several other studies find inverse relationship between concentration and profitability (Berger, 1995a, Athanasoglou et al., 2008, Garcia-Herrero et al., 2009) .

The estimated negative coefficient for financial reform period dummy variable (transition period) indicates that ROE has been adversely affected during the transition period compared to the pre-reform period. The coefficient is statistically significant at 5% level of significance. Perhaps, as discussed in the previous empirical chapters, banks borrow funds at a higher cost to raise the capital base in order to maintain the required capital adequacy (as a compliance of the Basel recommendation), which lowers the profitability. However, the estimated coefficients for NIM and ROA are not statistically significant. The estimated positive and statistically significant (at 5% level of significance) coefficient for the post-reform period dummy variable on NIM indicates an increased interest income in the post-reform period. Perhaps banks invest their surplus funds (after maintaining the capital requirement) in economically viable and profitable projects and, eventually, earn more interest income. Besides, rising inflation over the years may contribute earning more interest incomes for banks. The estimated coefficients for governance variables, political and independent director in the bank board, in all three regressions are not statistically significant.

Turning to the macroeconomic indicators, the regression results show that GDP growth rate has a significant negative impact on NIM. Although Kosmidou (2008) argues for positive relationship between GDP growth and profitability,

nevertheless, this may not be true for the sample banks in Bangladesh. The GDP growth may have positive impact on the financial strength of the banks resulting enhanced capacity to provide loans at a lower interest rate, which eventually decrease the net interest margin.

Inflation enters the profitability regressions with a positive coefficient. The coefficients for NIM and ROE are statistically significant at 10% and 5% level of significance respectively. However, the magnitude and significance level are not meaningful for ROA. The regression results for NIM and ROE suggest that profitability increases as inflation increases. This is consistent with the Perry's (1992) hypothesis of anticipated inflation and also Demirguc-Kunt and Huizinga (1999) where interest rates are adjusted in such a way that the bank revenue increases faster than the cost.

7.6 Conclusion

This chapter explores how bank-specific characteristics, industry-related and macroeconomic factors affect the profitability of the commercial banks in Bangladesh. The chapter also focuses on investigating the impact of financial reform policies on profitability.

The results also show that large size banks are more profitable, suggesting an increased quality asset size. As suggested by Berger and Humphrey (1997), small banks can enhance asset size through merging. The results demonstrate that greater market power (i.e., higher concentration) leads to higher bank profit. The findings also reveal that GDP growth effect may not pass through to higher banking profitability, while CPI inflation increases the profitability of the sample banks.

The analysis finds that profitability of the sample banks has not improved further after the financial reform except for NIM (in the post-reform period). This is consistent with the findings of the previous empirical chapters; cost efficiency (Chapter 5) improves in the transition period (compared to the pre-reform period) but

shows a declining trend in the post-reform period compared to the transition period. Similarly, productivity (Chapter 6) improves marginally in the post-reform period. The results indicate that corporate governance variables, political director and independent director in the bank board, do not have any significant impact on profitability measures.

The findings indicate that greater capital strength and asset quality may lead to higher profitability. Hence, regulators should insure that banks remain highly capitalized. Banks may increase assets through diversifying loan portfolios. Therefore, appropriate banking policy on raising capital base and quality loan portfolio is vital for ensuring a viable banking sector in Bangladesh.

Chapter 8

Conclusion and policy implications

8.1 Overview

The financial system, predominantly the banking sector in Bangladesh has experienced a series of legal, policy and institutional reforms over the past three decades. The major developments that have been achieved so far: liberalization of interest rates, privatization of state-owned banks, greater freedom for the operation of private sector banks and adoption of prudential regulations in compliance with the Basel accords. There is no comprehensive study evaluating the impact of financial reforms on the banking efficiency and productivity in Bangladesh since the initiation of the reform programs in the late 1980s. Hence, this thesis aims to investigate the banking performance in terms of efficiency, productivity and profitability in the context of financial deregulation.

The thesis provides an empirical analysis using bank level data for 12 commercial banks in Bangladesh, which have both pre- and post-reform operation history for the period 1983-2012. Employing the one-stage stochastic frontier analysis (SFA) technique, suggested by Battese and Coelli (1995), Chapter 5 addresses the research question whether cost efficiency improves after the financial deregulation. The model allows measuring the effect of deregulation and other bank-specific and environmental variables on both the cost function and the inefficiency function in one step. The Färe-Primont TFP index, suggested by O'Donnell (2008, 2011b), is employed to compute and decompose the total factor productivity (TFP) of the sample banks in Chapter 6. In the second step, a panel data regression framework is used to examine the links between the estimated TFP change components and reform period dummy variables controlling for other key determinants of TFP growth. The analysis of profitability identifies the determinants

of profitability measures, such as net interest margin (NIM), return on assets (ROA), and return on equity (ROE) by estimating a panel data regression model in Chapter 7.

The remainder of this final chapter is organized as follows. Section 8.2 summarizes the empirical findings. Policy implications of the empirical analysis are highlighted in Section 8.3, and finally, Section 8.4 concludes including a discussion of limitations of the study and the focus for future research.

8.2 Major empirical findings

The following three sub-sections describe the important results that emerge from the three empirical chapters of the thesis.

8.2.1 Cost frontier analysis

The cost function analysis (Sub-section 5.4.1) finds that bank cost reduces due to financial deregulation. The estimated coefficient for post-reform dummy variable is negative and strongly significant (-0.11). This indicates a downward shift of the cost frontier following the financial reforms. The adoption of prudential banking regulations and policy initiatives in the post-reform period may reduce bank costs. Moreover, cost diminution may occur as banks produce competitive and technology driven cost-effective banking products and services such as mobile banking, on-line banking, and use of ATM due to increased competition in the industry after financial liberalization.

The parameter estimates of the inefficiency function (Sub-section 5.4.2) also reveal that on average the sample banks move towards the frontier, i.e., best-practice banks due to decline in cost inefficiency. The estimated negative and strongly significant coefficient (-0.024) for time trend variable implies that on average banks move towards the frontier over time.

The estimated coefficient for transition period dummy variable (DTr) is negative (-0.065) and significant. This indicates that on average banks have become more cost efficient during the reform policy implementation period compared to the pre-reform period. However, the estimated coefficient for post-reform dummy variable (DPs) is positive (0.269) and significant. This indicates an increased cost inefficiency, which contradicts with the coefficient for the transition period. One possible explanation for such results is that financial liberalization appears to lower the cost frontier but may leave some banks further from it as their adjustment is inadequate. The cost of regulatory measures such as licencing fees, maintaining capital adequacy and provisioning for loan losses may affect different banks (for example, different asset size) to different extents.

The regression estimates also show that state-owned banks exhibit greater efficiency compared to their private sector counterparts. This is consistent with other developing country studies, e.g., Bhattacharrya et al.(1997). Perhaps, initial capital expenditure, borrowings at a higher interest rate, higher salaries, expensive decoration etc. push private banks' cost to a higher level. Similarly, the large size banks are more cost efficient than the banks with small scale of operation. This suggests that large banks have comparative advantages over small banks in terms of delivering banking services through a credible and competent management team and using advanced technology, which have the potential to enhance their relative efficiency.

The thesis finds that political influence adversely affects banking performance in Bangladesh. The estimated positive and statistically significant coefficient (0.094) for the dummy variable for political director (Sub-section 5.4.2) reveals that banks with political person in the board are less cost efficient compared to the banks with no political interference. One possible reason for such inefficiency is politically motivated bank finance, which eventually deteriorates the quality of the bank's asset portfolios. Therefore, bank cost may increase for monitoring and supervision and maintaining the required provisions against such loan losses.

The average cost efficiency analysis (Sub-section 5.4.3) shows that cost efficiency on average increases about 3% in the post-reform period compared to the pre-reform period. The estimated average cost efficiency is 94% in the pre-reform period while the efficiency is 97% in the post-reform period. Therefore, banks can still reduce costs by about 3% in order to become fully efficient, i.e., best-practice banks. These increased average cost efficiency scores are consistent with the estimated coefficient for the transition period dummy variable in the inefficiency function, but a conflict is apparent between these results and the estimated coefficient for the post-reform dummy variable in the inefficiency function in Section 5.4.2. Perhaps, early stages of reform initiatives are associated with greater cost efficiency while the level of efficiency deteriorates in advanced stages. Although the average cost efficiency of public banks is higher than its private sector counterparts during the pre-reform period, the efficiency difference shrinks in the post-reform period. Perhaps private sector banks have adopted reform measures and advanced technology more rapidly and gained efficiency at a faster pace compared to the public banks in the post-reform period.

8.2.2 TFP growth decomposition and determinants

The estimates of productivity change for different bank groups, public and private, reveal that mainly technical change (due to technological progress) contributes in attaining positive TFP growth over the years. One plausible reason for positive technical change is the adoption of advanced technology in developing competitive products and services, for example, online banking, mobile phone banking and ATM services. The growth in average TFP is higher in private banks than their public sector counterparts in the post-reform period (Table 6.3). However, both public and private sector banks attain higher level of average scale-mix efficiency change during the sample period.

The measured TFP change indices (Table 6.1 and 6.2) indicate that the sample banks have been experiencing positive TFP change after financial

deregulation. However, a slight deterioration in TFP change is observed for the years, 2003-2004 in the post-reform period. The negative scale and mix efficiency change mainly contribute to the diminishing TFP growth during these two years.

The panel data regression analysis (Table 6.4) demonstrates that technological progress is a determinant of positive TFP growth for the sample banks. The estimated positive and strongly significant coefficient for time trend variable shows that application of advanced technology for delivering innovative banking products and services contributes in attaining positive TFP growth. This is consistent with the findings from the Färe-Primont TFP indices analysis in Sub-section 6.3.1.

8.2.3 Profitability measures and determinants

The profitability analysis finds that financial reform does not have significant effect on profitability indicators, ROA and ROE (Table 7.1). However, the estimated positive and statistically significant (at 5% level of significance) coefficient for the reform dummy variable in the NIM regression indicates an increased net interest income margin in the post-reform period. The regression results also indicate a positive relation between NIM and CPI inflation. The extent of increased net interest income depends on the anticipated inflation.

The regression results show that greater capital strength and asset quality lead to higher profitability. The well-capitalized banks need less borrowed funds and, therefore, earn higher profits. However, this is not valid for the other indicators of profitability, e.g., ROE, since the more the equity providers to a bank, the higher the denominator of the ROE. Banks with higher loan-asset ratio tend to be more profitable, although with a higher risk profile given the larger loan portfolio.

The analysis demonstrates a positive relationship between bank size and profitability measures. Perhaps large size banks have cost advantages associated with product and risk diversification. This is consistent with the findings in the cost efficiency analysis reported in Sub-section 5.4.2.

The results reveal that public banks are less profitable than their private sector counterparts. The possible reason for such profitability difference is the difference in objective functions of the two types of banks. The private banks' objective is to maximize profit, while the public banks do not necessarily pursue for maximizing profits rather they pursue government agenda. The results also indicate that greater market power (i.e., higher concentration) leads to higher bank profit, which supports the traditional structure-conduct-performance paradigm.

8.3 Policy implications

The empirical findings discussed in Section 8.2, have some implications for the development of an efficient and productive banking sector in Bangladesh in the context of financial reforms. Although financial deregulation contributes in reducing bank costs, however, inefficiency may persist in banks which are different in terms of size, ownership and the capacity to adopt prudential regulations and advanced technology. Therefore, the government should implement reform policies in such a way that banks can strengthen their capacity to achieve the medium- and long-term challenges of the reform measures.

A challenge ahead is to implement the Basel III regulations where the requirements are increased. The implementation of this accord has already been started from January 1, 2013 giving another 7 year-period until 2019 for full implementation (Basel Committee on Banking Supervision, 2011). Kupiec (2013) argues that the complex rules of the new Basel III accord are expensive to enforce; the most obvious cost of Basel III is compliance costs. Hence, the banking policy makers in Bangladesh may re-design the reform policies considering the medium- and long-term targets.

The analysis suggests that large size banks are more cost efficient than the banks with small scale of operation. Therefore, banks may increase their size through merging. In fact, public sector banks have a comparative advantage to attain greater

efficiency utilizing their broader network and large volume of assets. However, public banks are burdened with a large volume of non-performing loans (due to government directed finance), unskilled and excessive staffs. As such, privatization, i.e., removing government control, can be a prudent strategy to increase banking efficiency.

Political influence is another major concern for the banking sector (both public and private) in Bangladesh. The study finds that banks with a political director in the bank board is less cost efficient than the banks with no political person in the board of directors. Therefore, the government should not intervene in appointing directors in the state-owned banks and also give autonomy to the central bank to formulate appropriate guidelines not allowing politically linked personalities in the bank board for both public and private sector banks.

Both the cost frontier and productivity estimates demonstrate that technological progress plays a pivotal role in cost diminution and TFP growth in banks. Avkiran (2000) argues for the adoption of new information and communication technology (ICT) as the most effective ways for the delivery of financial services. The ability of the banks to deliver efficient and competitive services in future will depend on whether they can take full advantage of electronic banking. Therefore, it is important for banks to develop adequate capacity to apply advanced technology in providing competitive banking services. The capacity building of banks, especially for the state-owned banks is vital since they cover most of the country areas through an extensive branch network. Banks may be advised to establish research and development wings for continuous development and innovation of technology driven cost-effective products and services to face the growing industry competition.

The profitability analysis indicates capital strength and quality asset portfolio as the drivers of profitability. Therefore, appropriate banking policy on raising capital base and quality loan portfolio is vital for ensuring a viable banking sector in Bangladesh. Financial reforms have had effect on net interest margin (NIM);

however, the extent of increased net interest income depends on the anticipated inflation. Therefore, a favourable and stable macroeconomic condition is important for a profitable and sustainable banking sector in Bangladesh.

Table 8.1: Summary of major policy implications

<p><u>Cost efficiency Analysis</u></p> <ul style="list-style-type: none"> • Although financial deregulation contributes in reducing bank costs, inefficiency may persist in banks which are different in terms of size, ownership and the capacity to adopt prudential regulations and advanced technology. Therefore, the government should implement reform policies in such a way that banks can strengthen their capacity to achieve the medium- and long-term objectives of the reform measures. • Banks may increase size through merging since the analysis suggests that the large banks are comparatively efficient. • The presence of politically linked directors on the bank board has an adverse effect on efficiency. Therefore, the government should not intervene in appointing directors in the state-owned banks and also give autonomy to the central bank to formulate appropriate guidelines not allowing politically linked personalities in the bank board for both public and private sector banks.
<p><u>Productivity Analysis</u></p> <ul style="list-style-type: none"> • Technological progress plays a pivotal role in attaining higher productivity in banks. Therefore, policy should encourage banks to strengthen their capacity to apply advanced technology in developing technology driven products.
<p><u>Profitability Analysis</u></p> <ul style="list-style-type: none"> • Both capital strength and quality asset portfolio are the main drivers of profitability for the sample banks. Therefore, appropriate banking policy on raising capital base and the quality of loan portfolios is vital for ensuring a viable banking sector in Bangladesh.

8.4 Limitations and the focus for future research

The study has several limitations. On the methodological front, the thesis employs parametric technique, the one-stage stochastic frontier analysis (SFA), which presumes a specific functional form on the technology. The study has not employed other parametric frontier techniques, e.g., distribution free approach and thick frontier approach (as mentioned in Chapter 4) to obtain alternative sets of efficiency estimates. Therefore, further research can be done using alternative techniques to see the sensitivity of the results.

The study models heterogeneity employing the one-stage translog cost frontier framework by incorporating banks-specific variables both in the cost function and in the inefficiency function. It is likely that the heterogeneity variables included in both functions are not complete and, thus the empirical analysis is afflicted by an omitted variable problem. This may create biases in the efficiency estimates. Berger and Humphrey (1997) suggest that explanatory variables can explain a small portion of its total variation because of lack of information on what the main determinants of efficiency are both across banks within the industry and across branches within a single bank. Future research may address this problem using the ‘true effects model’ proposed by Greene (2005b). The model includes an additional stochastic term in the traditional SFA model to distinguish time invariant unobserved heterogeneities from the inefficiency term.

Since the main objective of this thesis is to investigate the impact of the financial reform programs on bank performance, the sample includes all 12 commercial banks, both public and private, that have both pre-and post-reform banking operation history. The remaining banks (all new private banks) of the sector have been allowed to operate in several phases after the implementation of the financial liberalization program in the late 1980s. However, the sample containing data from only 12 banks can be considered as a limitation of the study. Therefore,

future research may focus on post-reform banking performance by accommodating information on all banks when data are available.

Another limitation of the study is not to examine the profit efficiency of the banks though the determinants of the profitability have been investigated in Chapter 7. Therefore, a future research can investigate the profit efficiency of the banking sector in Bangladesh in the context of financial liberalization.

Despite the limitations, this thesis is the benchmark for future research on the banking sector in Bangladesh since there is no comprehensive study on banking efficiency and productivity in Bangladesh in the context of financial deregulation. Therefore, the findings of this study are valuable guides for the researchers and policy makers. Policy makers may re-design reform policies, especially in developing country perspectives, accommodating the long-term challenges including more deregulation, capacity building of the financial institutions, increased supervision, less political influence, compliance with the international banking regulations (e.g., Basel accords), and macro financial stability. Moreover, the approaches applied in this thesis may be of interest to other developing countries which are at similar stage of economic development and have implemented financial reform programs.

Appendices

Appendices to Chapter 2

Appendix 2.1: Banking sector in Bangladesh at a glance by the end of 2013

Banks	No. of Banks	No. of Branches	Total assets (billion Tk)	Industry asset share (%)	Total deposit (billion Tk)	Industry deposit share (%)	NPL to Total Loans (%)	Return on Asset (ROA)	Return on Equity (ROE)	Net Interest Margin (NIM)	Capital adequacy ratio
SCBs	4	3520	2108.5	26.4	1631.2	26.0	19.8	0.6	10.9	-5.4	8.7
DFIs	4	1494	454.8	5.7	343	5.5	26.8	-0.4	5.8	3.8	13.7
PCBs	39	3602	4948.2	61.9	3939.3	62.8	4.5	1.0	9.8	118.2	12.1
FCBs	9	69	488.7	6.1	359.5	5.7	5.5	3.0	16.9	15.8	20.6

Source: Annual Report 2013, Bangladesh Bank; Note: Average Taka (Tk)=US Dollar exchange rate, 2013 was 79.93; SCBs= State-owned commercial banks, DFIs = State-owned development banks, PCBs= Private commercial banks, FCBs= Foreign commercial banks

Appendix 2.2: Policy measures undertaken in the financial sector in Bangladesh during the pre- and post-reform period, 1972-2013

Period	Policy measures on financial Sector	Consequences due to policy measures
<p>1972-1982: Command Economy/pre-reform period</p>	<ul style="list-style-type: none"> • Strictly regulated • Administered interest rate • Directed sectoral lending • Strict control over foreign exchange transaction • Fixed exchange rate • All banks are nationalized • Lack of modern monetary tools 	<ul style="list-style-type: none"> • Inefficiency in resource allocation; credit disbursement was politically motivated or directed by the Central Bank or the Government in state-owned commercial banks; • Poor credit delivery and recovery • Widespread loan defaults and delinquencies; therefore, growing capital shortfall in nationalized banks • Low level of financial intermediation; only about one percent of GDP in 1979 (BBS) • Weak management of foreign exchange system
<p>1983-1988: First phase of the financial deregulation initiatives;</p>	<ul style="list-style-type: none"> • Rationalization of interest rate; • Denationalization of state owned commercial banks • Licensing new private sector banks • Constituted a commission (Money, Banking and Credit) to recommend on remedial measures to make the banking sector more efficient and competitive 	<ul style="list-style-type: none"> • No expected outcome from the partial reform measures during the period, due to inherent structural rigidities • However, FSRP came into reality in 1989 against enormous paper works, recommendations from several committees/commissions during the period
<p>1989-2000: Second phase of the financial deregulation initiatives;</p>	<ul style="list-style-type: none"> • Financial sector reform programme (FSRP) started in 1989 with assistance from USAID and IDA • Introduction of market based interest rate policy • Abolition of directed sectoral lending • Revision of loan classification and provision- 	<ul style="list-style-type: none"> • Market determined interest rate with few exceptions for export oriented sectors • Banks and financial institutions can decide on their sectoral disbursement of credit portfolio • Credit information Bureau (CIB) was set up in BB in 1992 to provide credit information for loan risk assessment • Both on-site and off-site supervision by BB brought financial discipline

	<ul style="list-style-type: none"> ing criteria • Revision of legal provisions and procedures enforcing loan recovery • Shift of exchange rate regime: fixed to flexible (pegging) • Separate department was established at BB to strengthen the bank supervision 	<ul style="list-style-type: none"> in the banking sector • Exchange rate pegging system (flexible within a band) keep the foreign exchange market stable • Current account convertibility in 1994 • Bank Company Act 1991 enacted to give BB more authority to regulate the banking sector
<p>2001-2007: Third phase of the financial deregulation initiatives;</p>	<ul style="list-style-type: none"> • Introduction of modern monetary policy instruments Repo (Repurchase agreement) and reverse Repo • Amendment of Bank company Act 1991 and Bangladesh Bank Order 1972 • Enactment of Financial Institution Act 1993 • Introduction of free floating exchange rate • Introduction of risk-weighted asset based capital adequacy requirement as per the BASEL-1 recommendation • State-owned commercial banks were corporatized • Enactment of Money Laundering and Prevention Act 2002 in order to prevent terrorist financing at the onset of the terrorist attack in USA 	<ul style="list-style-type: none"> • BB can manage day-to-day liquidity in response to temporary and unexpected shocks in the supply and demand for money through Repo and reverse Repo • Market determined exchange rate, though BB does intervene if necessary to keep the value of Taka stable. • Amendment of Bangladesh Bank Order and Bank Company Act empowered the central bank more in pursuing independent monetary policy and regulate and supervise the banking sector. • Enactment of Financial Institution Act entrusted BB the authority to supervise the financial institutions • As per the BASEL recommendation, banks were obliged to keep 8 percent of risk-weighted asset as capital adequacy requirement, which has further been increased to 10 percent. • Three state-owned commercial banks were made limited company in 1997 with a view to ensuring good governance, less influence (from the Government side) on the Board of Directors.
<p>2008-2013:Reform measures after the global financial crisis;</p>	<ul style="list-style-type: none"> • Corporate governance regulations • Risk management system development • Stress testing policies 	<ul style="list-style-type: none"> • Regulation of corporate governance limits the number of the commercial bank board members to 13; besides several committees, e.g., audit committee have been formed to oversee the day-to-day banking activi-

	<ul style="list-style-type: none"> • Automation of • Enhancement of capital adequacy requirement as per the BASEL II recommendations • Foreign exchange Regulations 1947 updated with inclusion of new provisions • On line connectivity of Credit Information Bureau (CIB) • Introduction of net banking (e-banking), mobile banking, and automated clearing of payment instruments 	<ul style="list-style-type: none"> ties; • Submission of compliance report to BB made mandatory on regular basis • Bank balance sheet and other financial statements have to be disclosed in public media in every six months for stakeholders to be aware of the financial condition of the banks. • Capital adequacy requirement increased 10 percent of the total risk-weighted asset to ensure solvency of the bank. • Online CIB report helps banks to make quick and accurate decision on prospective investment, and thus efficient resource allocation • Banks have to efficiently manage core risks: credit risk, market risk, liquidity risk, asset-liability risk, foreign exchange risk, internal audit and compliance risk, money laundering risk • An independent Risk Management Unit (RMU) established in all banks to conduct stress testing for examining the bank's capacity of handling future shocks. • Mobile banking helps banks to take banking services to the remote areas to unbanked people
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Source: Author's compilation based on various issues of annual reports of the Bangladesh Bank.

Appendices to Chapter 5

Appendix 5.1: Definition of the variables

Variables	Definition
Dependent variable	
TC	Total cost: the sum of interest expenses and operating expenses. The variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
Independent variables	
Outputs	
y ₁	Loans and advances: the sum of total loans and bills discounted. The variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
y ₂	Other earning assets: total assets less total loans and advances and fixed assets. The variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
Input prices	
w ₁	Price of labour: total expenditure on employees (salaries and allowances) divided by the total number of employees.
w ₂	Price of physical capital: total expenditure on premises and fixed assets, i.e., other operating expenses (except salary and allowances and charges on loans/investment losses) divided by the book value of physical capital and other fixed assets.
w ₃	Price of loanable funds: total interest expenses divided by total loanable funds (total deposits plus borrowed funds).
Bank specific variables and correlates of inefficiencies	
EQ	Equity: the sum of core capital and supplementary capital: the sum of paid up capital, statutory reserve, general reserves, other reserves and general provisions. The value of the variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
FI	Financial intermediation: the ratio of total loans to total deposit.
t	Time trend: t=1 for 1983, t=2 for 1984.....T=30 for 2012.
DPr	Pre-reform dummy variable for the period, 1983-1990. However, pre-reform period is considered as the base period.
DTr	Transition dummy variable for the period, 1991-1995. DTr=1 if transition period and zero otherwise.
DPs	Post-reform dummy variable for the period, 1996-2012. DPs=1 if post-reform period and zero otherwise.
OWN	Bank ownership: dummy variable for bank ownership. OWN=1 if public bank and zero otherwise.

SIZE	Bank size: natural logarithm of the total assets, as deflated using GDP deflator, base: 1996=100 (WDI, 2013).
CR3	3-bank concentration ratio: an annual index measures the deposit share of three major state-owned banks (Sonali, Janata and Agrani).
ID	Independent director dummy variable; ID=1 if independent director in the bank board and zero, otherwise.
PD	Political director dummy variable; PD=1 if political director in the bank board and zero otherwise.

Appendix 5.2: Parameter estimates of the stochastic cost frontier

Variables	Parameters	Model 1 (Half-normal)	Model 2 (Truncated)	Model 3 (Tech. Eff. effects)
Intercept	α_0	-0.053*** (0.011)	-0.054*** (0.012)	0.250** (0.124)
Lny ₁	α_1	0.541*** (0.021)	0.541*** (0.020)	0.824*** (0.068)
Lny ₂	α_2	0.392*** (0.026)	0.393*** (0.026)	0.348*** (0.077)
Ln(w ₁ /w ₂)	β_1	0.143*** (0.016)	0.142*** (0.016)	0.515*** (0.069)
Ln(w ₃ /w ₂)	β_2	0.819*** (0.016)	0.819*** (0.015)	0.599*** (0.039)
Lny ₁ Lny ₁	α_{11}	-0.314*** (0.042)	-0.315*** (0.042)	0.185*** (0.585)
Lny ₁ Lny ₂	α_{12}	0.766*** (0.097)	0.768*** (0.098)	-0.127 (0.106)
Lny ₂ Lny ₂	α_{22}	-0.459*** (0.055)	-0.459*** (0.055)	-0.080 (0.049)
Ln(w ₁ /w ₂)Ln(w ₁ /w ₂)	β_{11}	0.146*** (0.028)	0.146*** (0.028)	0.368*** (0.053)
Ln(w ₁ /w ₂)Ln(w ₃ /w ₂)	β_{12}	-0.315*** (0.042)	-0.315*** (0.042)	-0.555*** (0.051)
Ln(w ₃ /w ₂)Ln(w ₃ /w ₂)	β_{22}	0.155*** (0.010)	0.155*** (0.010)	0.202*** (0.010)
Lny ₁ Ln(w ₁ /w ₂)	χ_{11}	-0.191*** (0.062)	-0.192*** (0.063)	-0.161** (0.081)
Lny ₁ Ln(w ₃ /w ₂)	χ_{12}	0.557*** (0.059)	0.558*** (0.059)	0.053 (0.078)
Lny ₂ Ln(w ₁ /w ₂)	χ_{21}	0.106* (0.065)	0.107* (0.065)	0.305*** (0.093)
Lny ₂ Ln(w ₃ /w ₂)	χ_{22}	-0.441*** (0.075)	-0.441*** (0.075)	-0.187** (0.088)
Control variables				
t (time trend)	θ_1	-	-	-0.005 (0.007)
t ²	θ_{11}	-	-	0.0003* (0.0001)
Lny ₁ t	ϕ_{1t}	-	-	-0.008* (0.004)
Lny ₂ t	ϕ_{2t}	-	-	-0.005 (0.005)
Ln(w ₁ /w ₂)t	ρ_{1t}	-	-	-0.021*** (0.005)
Ln(w ₃ /w ₂)t	ρ_{2t}	-	-	0.013*** (0.003)

Variables	Parameters	Model 1 (Half-normal)	Model 2 (Truncated)	Model 3 (Tech. Eff. effects)
z ₁ (equity)	τ_1	-	-	0.003** (0.001)
z ₂ (Financial intermediation)	τ_2	-	-	-0.181*** (0.014)
z ₃ (3-bank concentration ratio)	τ_3	-	-	-0.139 (0.139)
DTr (1= transition period, 0=otherwise)	τ_4	-	-	-0.012 (0.022)
DPs (1= post-reform period, 0= otherwise)	τ_5	-	-	-0.107*** (0.037)
Correlates of bank inefficiencies/environmental variables				
Intercept	δ_0	-	-	0.869*** (0.289)
OWN (1=Public, 0=otherwise)	δ_1	-	-	- 0.037** (0.017)
ID (1=Independent director in the bank board, 0=otherwise)	δ_2	-	-	-0.024 (0.081)
PD(1=Political director in the bank board,0=otherwise)	δ_3	-	-	0.094*** (0.014)
SIZE	δ_4	-	-	-0.058** (0.024)
DTr (1= transition period, 0=otherwise)	δ_5	-	-	-0.065* (0.034)
DPs (1= post-reform period, 0= otherwise)	δ_6	-	-	0.269*** (0.058)
t (time trend)	δ_7	-	-	-0.024*** (0.007)
CR3: 3-bank deposit concentration ratio	δ_8	-	-	-0.369 (0.243)
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma_u^2$	0.005*** (0.002)	0.005 (0.003)	0.002*** (0.0003)
Gamma	$\gamma = \frac{\sigma_u^2}{\sigma_s^2}$	0.589*** (0.151)	0.517* (0.312)	0.574*** (0.111)
Log likelihood		576.977	577.004	701.751
Number of observations		360	360	360

Note: Asymptotic standard errors are in parentheses. The pre-reform period (1983-1990) dummy is treated as the base, so the coefficient of DTr (DPs) can be interpreted as the change in cost or

efficiency from the pre-reform period to the transition (post-reform) period.*** denotes statistical significance level at 1%; ** denotes the level of statistical significance at 5%; * denotes statistical significance level at 10%; Source: Author's estimation using the computer programme FRONTIER 4.1, developed by Tim Coelli (1996).

Appendix 5.3: Cost efficiency scores for the sample banks in Bangladesh, 1983-2012

	Agrani	Janata	Rupali	Sonali	AB	National	City	IFIC	UCB	Pubali	Uttara	Islami
1983	0.957	0.897	0.866	0.916	0.931	0.902	0.959	0.865	0.912	0.843	0.952	0.821
1984	0.900	0.911	0.889	0.913	0.946	0.961	0.888	0.967	0.892	0.862	0.939	0.893
1985	0.985	0.926	0.898	0.940	0.936	0.906	0.904	0.951	0.897	0.857	0.954	0.935
1986	0.989	0.932	0.910	0.949	0.963	0.947	0.924	0.956	0.925	0.872	0.909	0.936
1987	0.942	0.933	0.926	0.955	0.929	0.967	0.963	0.947	0.953	0.884	0.940	0.949
1988	0.956	0.955	0.946	0.969	0.948	0.963	0.974	0.978	0.964	0.908	0.954	0.968
1989	0.966	0.969	0.951	0.977	0.969	0.977	0.982	0.981	0.979	0.911	0.965	0.968
1990	0.972	0.973	0.986	0.984	0.982	0.986	0.975	0.986	0.981	0.929	0.976	0.984
1991	0.957	0.953	0.938	0.973	0.974	0.981	0.961	0.979	0.975	0.919	0.962	0.982
1992	0.973	0.966	0.929	0.979	0.982	0.984	0.974	0.984	0.900	0.930	0.971	0.987
1993	0.982	0.978	0.965	0.985	0.986	0.988	0.980	0.989	0.983	0.941	0.974	0.989
1994	0.988	0.980	0.976	0.984	0.987	0.988	0.981	0.992	0.984	0.952	0.987	0.996

	Agrani	Janata	Rupali	Sonali	AB	National	City	IFIC	UCB	Pubali	Uttara	Islami
1995	0.991	0.983	0.980	0.989	0.987	0.989	0.980	0.993	0.985	0.985	0.986	0.993
1996	0.906	0.889	0.879	0.907	0.892	0.919	0.881	0.925	0.835	0.888	0.890	0.907
1997	0.912	0.903	0.894	0.923	0.951	0.924	0.898	0.900	0.904	0.851	0.899	0.945
1998	0.926	0.914	0.912	0.934	0.966	0.938	0.923	0.911	0.918	0.857	0.912	0.954
1999	0.967	0.951	0.916	0.972	0.972	0.956	0.947	0.979	0.931	0.890	0.941	0.971
2000	0.975	0.962	0.929	0.972	0.973	0.986	0.975	0.985	0.951	0.904	0.959	0.964
2001	0.979	0.986	0.964	0.978	0.982	0.983	0.979	0.987	0.971	0.916	0.969	0.970
2002	0.985	0.989	0.973	0.983	0.968	0.985	0.986	0.986	0.979	0.926	0.978	0.979
2003	0.983	0.973	0.969	0.984	0.976	0.988	0.982	0.981	0.982	0.919	0.976	0.984
2004	0.982	0.975	0.977	0.987	0.987	0.985	0.985	0.988	0.985	0.919	0.979	0.988
2005	0.983	0.982	0.979	0.992	0.989	0.979	0.989	0.958	0.984	0.923	0.984	0.988
2006	0.982	0.986	0.984	0.991	0.981	0.984	0.993	0.978	0.991	0.919	0.988	0.990

	Agrani	Janata	Rupali	Sonali	AB	National	City	IFIC	UCB	Pubali	Uttara	Islami
2007	0.988	0.987	0.986	0.993	0.993	0.992	0.993	0.978	0.992	0.931	0.989	0.992
2008	0.989	0.991	0.988	0.987	0.995	0.992	0.992	0.987	0.994	0.964	0.990	0.993
2009	0.990	0.992	0.989	0.989	0.993	0.994	0.994	0.987	0.995	0.979	0.993	0.995
2010	0.991	0.995	0.993	0.994	0.992	0.996	0.992	0.985	0.992	0.975	0.993	0.995
2011	0.992	0.994	0.991	0.995	0.995	0.996	0.994	0.991	0.994	0.990	0.995	0.996
2012	0.992	0.993	0.992	0.992	0.996	0.997	0.995	0.994	0.994	0.993	0.995	0.996

Source: Author's estimation using computer program FRONTIER 4.1(Coelli, 1996)

Appendices to Chapter 6

Appendix 6.1: Definition of the variables

Variables	Definition
Outputs	
y_1	Loans and advances: the sum of total loans and bills discounted. The variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
y_2	Other earning assets: total assets less total loans and advances and fixed assets. The variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
Inputs	
q_1	Labour : number of full-time employees
q_2	Physical capital: the book value of premises and fixed assets. The variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
q_3	Loanable funds: the sum of deposit (demand and time) and non-deposit funds (borrowed fund). The variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
Determinants of TFP change	
EQ	Equity: the sum of core capital and supplementary capital: the sum of paid up capital, statutory reserve, general reserves, other reserves and general provisions. The value of the variable is measured in million Taka (Bangladesh currency), deflated using GDP deflator, base: 1996=100 (WDI, 2013).
t	Time trend: t=1 for 1983, t=2 for 1984.....T=30 for 2012.
DPr	Pre-reform dummy variable for the period, 1983-1990. However, pre-reform period is considered as base period.
DTr	Transition dummy variable for the period, 1991-1995. DTr=1 if transition period and zero otherwise.
DPs	Post-reform dummy variable for the period, 1996-2012. DPs=1 if post-reform period and zero otherwise.
SIZE	Bank size: natural logarithm of the total assets, as deflated using GDP deflator, base: 1996=100 (WDI, 2013).
CR3	3-bank concentration ratio: an annual index measures the deposit share of three major state-owned banks (Sonali, Janata and Agrani).
ID	Independent director: dummy variable; ID=1 if independent directors are in the bank board and zero otherwise.
PD	Political director: dummy variable; PD=1 if political directors are in the bank board and zero otherwise.

Appendix 6.2(a): Input-oriented TFP change for public banks

Period	Δ TFP	Δ T	Δ Eff	Δ ITE	Δ IME	Δ RISE	Δ ISME
Pre-reform period							
1985/84	1.2348	1.1267	1.0964	1.0009	1.0292	1.0579	1.08898
1986/85	0.9934	0.9168	1.0832	1.0098	1.0506	1.0261	1.07244
1987/86	0.8792	0.7018	1.2525	1	1	1.2525	1.2525
1988/87	1.0115	1.0797	0.9374	1	1	0.9374	0.93739
1989/88	1.0482	0.9385	1.1169	0.9825	0.9679	1.1793	1.13696
1990/89	0.9474	1.0211	0.9274	0.9782	1.0365	0.918	0.94841
Transition period							
1991/90	1.0124	1.0824	0.9351	1.0155	0.9445	0.977	0.92143
1992/91	1.0245	0.9973	1.0274	0.9867	0.9653	1.0789	1.0408
1993/92	1.1068	1.0767	1.028	1.0434	1.0324	0.9585	0.98742
1994/93	1.0823	1.1165	0.9693	0.9494	0.9671	1.0828	1.03164
1995/94	1.0659	0.9879	1.0792	1.0039	1.0519	1.0401	1.07524
Post-reform period							
1996/95	1.0781	2.7213	0.396	0.9853	0.9595	0.4206	0.4031
1997/96	1.0832	0.369	2.9357	1.0529	1.0603	2.6521	2.80013
1998/97	1.0044	1.0852	0.9257	0.9904	0.9829	0.9517	0.93495
1999/98	1.2003	0.9819	1.2226	0.9804	0.9823	1.2702	1.24704
2000/99	1.0716	0.9768	1.0967	1.0093	0.9928	1.0963	1.08663
2001/00	1.2448	1.0071	1.2362	1.03	1.0492	1.1372	1.2003
2002/01	1.0755	1.0589	1.0156	0.987	0.9955	1.0343	1.02967
2003/02	0.9131	0.9783	0.9336	1.014	0.9826	0.9368	0.92018

Period	ΔTFP	ΔT	ΔEff	ΔITE	ΔIME	$\Delta RISE$	$\Delta ISME$
2004/03	1.0494	1.064	0.9864	0.998	0.9753	1.0142	0.98886
2005/04	1.0795	0.9967	1.0831	1.0007	1.0626	1.0239	1.08339
2006/05	1.0351	1.2025	0.8607	1.0175	0.9825	0.8674	0.8458
2007/06	1.0188	1.0996	0.9265	1	0.88	1.0701	0.92654
2008/07	1.0101	1.1559	0.874	0.9671	0.9784	0.9254	0.90628
2009/08	1.028	0.7981	1.2878	1.0254	1.0066	1.2505	1.25894
2010/09	1.1825	1.2125	0.9752	0.9807	1.1214	0.8963	0.99636
2011/10	1.0014	1.054	0.9502	1.0254	0.9809	0.9453	0.92642
2012/11	1.0206	0.9738	1.048	1.0027	1.01	1.035	1.04573

Notes: $\Delta TFP = \Delta T \times \Delta Eff$, $\Delta Eff = \Delta ITE \times \Delta IME \times \Delta RISE = \Delta ITE \times \Delta ISME$

Source: Author's estimation

Appendix 6.2(b): Input-oriented TFP change for private banks

Period	ΔTFP	ΔTC	ΔEff	ΔITE	ΔIME	ΔRISE	ΔISME
Pre-reform period							
1985/84	0.9904	1.1267	0.8792	0.9397	0.9443	1.025	0.96627
1986/85	0.9961	0.9168	1.0864	1.0403	1.1439	0.9524	1.04725
1987/86	1.0487	0.7018	1.4944	1.0512	1.0749	1.3677	1.42353
1988/87	1.0245	1.0797	0.949	1.0162	1.0509	0.8958	0.93442
1989/88	1.0083	0.9385	1.0742	0.9961	0.9088	1.2107	1.07871
1990/89	1.0079	1.0211	0.9869	0.9909	1.0078	0.9883	0.99554
Transition period							
1991/90	1.0359	1.0824	0.9572	0.9976	0.9869	0.9784	0.95987
1992/91	1.029	0.9973	1.0318	0.9565	1.0375	1.0563	1.09504
1993/92	1.0697	1.0767	0.9934	1.0717	0.9719	0.9789	0.94166
1994/93	1.0451	1.1165	0.936	0.9439	1.0101	0.9931	0.99535
1995/94	0.9873	0.9879	0.9996	1.0578	1.1176	0.8725	0.94766
Post-reform period							
1996/95	1.7943	2.7213	0.6593	0.9854	1.0793	0.5788	0.66624
1997/96	0.9932	0.369	2.6911	0.9681	0.9359	3.0131	2.78788
1998/97	1.0317	1.0852	0.951	1.0032	1.0042	0.9445	0.94848
1999/98	1.1969	0.9819	1.2189	1.0511	0.997	1.1727	1.16973
2000/99	1.1235	0.9768	1.1502	1.0297	1.0508	1.0624	1.11749
2001/00	1.0747	1.0071	1.0671	0.9793	1.0011	1.0893	1.09036
2002/01	1.0524	1.0589	0.9938	0.9783	1.0001	1.0175	1.01635
2003/02	0.9819	0.9783	1.0038	1.0609	0.982	0.975	0.95485

Period	ΔTFP	ΔTC	ΔEff	ΔITE	ΔIME	$\Delta RISE$	$\Delta ISME$
2004/03	0.9877	1.064	0.9284	0.9899	1.0267	0.9141	0.93821
2005/04	1.0913	0.9967	1.095	1.0047	0.9718	1.1301	1.09087
2006/05	1.0865	1.2025	0.9034	0.993	0.934	0.9856	0.90968
2007/06	1.0722	1.0996	0.9752	1.006	1.0266	0.9504	0.96954
2008/07	1.0707	1.1559	0.9263	0.9977	0.9761	0.9529	0.92945
2009/08	1.0357	0.7981	1.2978	1.0129	1.11	1.1602	1.28117
2010/09	1.131	1.2125	0.9328	0.9839	1.0152	0.9368	0.94925
2011/10	1.0507	1.054	0.9969	1.0139	0.9736	1.014	0.98607
2012/11	1.0165	0.9738	1.0438	1.0027	1.0432	1.0013	1.04098

Notes: $\Delta TFP = \Delta T \times \Delta Eff$; $\Delta Eff = \Delta ITE \times \Delta IME \times \Delta RISE = \Delta ITE \times \Delta ISME$

Source: Author's estimation

Appendix 6.3: Periodic average of input-oriented TFP change

	ΔTFP	ΔTC	ΔITE	$\Delta ISME$
Pre-reform period				
Public Banks	1.019	0.964	0.995	1.073
Private Banks	1.013	0.964	1.006	1.074
All Banks	1.015	0.964	1.002	1.074
Transition period				
	ΔTFP	ΔTC	ΔITE	$\Delta ISME$
Public Banks	1.058	1.052	0.999	1.011
Private Banks	1.033	1.052	1.006	0.988
All Banks	1.042	1.052	1.004	0.996
Post-reform period				
	ΔTFP	ΔTC	ΔITE	$\Delta ISME$
Public Banks	1.065	1.102	1.004	1.094
Private Banks	1.105	1.102	1.004	1.109
All Banks	1.092	1.102	1.004	1.1094

Source: Author's calculation

Appendix 6.4: Sources of TFP change and its components

	Δ TFP		Δ T		Δ OTE		Δ OME		Δ ROSE		Δ OSME	
	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
Equity (EQ)	-0.003 (0.039)	-0.001 (0.038)	-0.034*** (0.010)	-0.029*** (0.009)	0.002 (0.004)	0.002 (0.003)	0.011 (0.0060)	0.009 (0.006)	0.028 (0.031)	0.028 (0.029)	0.421 (0.031)	0.041 (0.030)
Independent Director (ID)	0.644*** (0.215)	0.032 (0.283)	-	-	0.015 (0.027)	0.015 (0.025)	0.038 (0.048)	0.045 (0.045)	0.242 (0.232)	0.212 (0.221)	0.286 (0.235)	0.264 (0.225)
Political Director (PD)	0.072 (0.387)	-0.063 (0.220)	-	-	-0.004 (0.035)	0.004 (0.017)	0.015 (0.063)	0.031 (0.031)	0.042 (0.304)	-0.063 (0.160)	0.062 (0.308)	-0.029 (0.171)
Size (SIZE)	-0.317 (0.383)	-0.172 (0.301)	-	-	-0.013 (0.035)	-0.006 (0.025)	0.069 (0.063)	0.009 (0.045)	-0.247 (0.301)	-0.131 (0.227)	-0.193 (0.305)	-0.133 (0.236)
Transition (DTr)	-0.627** (0.297)	-0.646** (0.295)	-0.368*** (0.076)	-0.359*** (0.075)	0.033 (0.027)	0.033 (0.027)	0.141*** (0.049)	0.144*** (0.048)	-0.021 (0.233)	-0.042 (0.232)	0.185 (0.236)	0.169 (0.234)
Post-reform (DPs)	-1.296** (0.596)	-1.326** (0.591)	-1.782*** (0.153)	-1.763*** (0.149)	0.115** (0.055)	0.115** (0.054)	0.527*** (0.098)	0.529*** (0.096)	0.532 (0.468)	0.493 (0.465)	1.202** (0.474)	1.169** (0.470)
Time trend (t)	0.202*** (0.074)	0.201*** (0.073)	0.221*** (0.019)	0.219*** (0.019)	-0.012* (0.007)	-0.012* (0.007)	-0.058*** (0.012)	-0.056*** (0.012)	-0.017 (0.058)	-0.016 (0.058)	-0.091 (0.059)	-0.089 (0.058)
Concentration (CR3)	7.573*** (2.557)	7.698*** (2.539)	7.066*** (0.669)	7.014*** (0.658)	-0.344 (0.234)	-0.339 (0.231)	-1.514*** (0.419)	-1.541*** (0.414)	0.791 (2.011)	0.926 (1.998)	-1.250 (2.035)	-1.148 (2.021)
R-squared	0.0749	0.077	0.413	0.414	0.018	0.019	0.090	0.122	0.079	0.082	0.106	0.107
Hausman test	Prob $\chi^2=0.999$:RE		Prob $\chi^2=0.963$:RE		Prob $\chi^2=1.00$:RE		Prob $\chi^2=0.966$:RE		Prob $\chi^2=0.994$:RE		Prob $\chi^2=0.999$:RE	
Total observations	348		348		348		348		348		348	

Source: Author's estimation using STATA12. FE stands for fixed-effect model and RE is random-effect model. Pre-reform period is treated as base period. Standard errors are in parentheses;*** denotes statistical significance level at 1%; ** denotes the level of statistical significance at 5%; * denotes statistical significance level at 10%

Appendices to Chapter 7

Appendix 7.1: Definition of the variables

Variables	Definition
Dependent variables	
NIM	Net interest margin: interest income-interest expense divided by total assets.
ROA	Return on Asset: net profit divided by total assets
ROE	Return on Equity: net profit divided by total equity
Explanatory variables	
Bank-specific characteristics	
TCTA	Capital ratio : total capital divided by total assets
TLTA	Asset quality: total loan divided by total assets
SIZE	Bank size: natural logarithm of the total assets, as deflated using GDP deflator, base: 1996=100 (WDI, 2013).
Industry-specific characteristics	
CR3	3-bank concentration ratio: an annual index measures the deposit share of three major state-owned banks (Sonali, Janata and Agrani).
DPr	Pre-reform dummy variable for the period, 1983-1990. However, pre-reform period is considered as base period.
DTr	Transition dummy variable for the period, 1991-1995. DTr=1 if transition period and zero otherwise.
DPs	Post-reform dummy variable for the period, 1996-2012. DPs=1 if post-reform period and zero otherwise.
Corporate Governance variables	
ID	Independent director: dummy variable; ID=1 if independent directors are in the bank board and zero otherwise.
PD	Political director: dummy variable; PD=1 if political directors are in the bank board and zero otherwise.
Macroeconomic factors/indicators	
GDPG	GDP growth rate: real GDP growth rate, base: 1996=100
INF	CPI inflation, base : 1996=100

Appendix 7.2: Correlation matrix

	NIM	ROE	ROA	DPs	OWN	DTr	PD	SIZE	ID	CR3	TCTA	TLTA	GDPG	INF
NIM	1.000													
ROE	0.189	1.000												
ROA	0.230	-0.023	1.000											
DPs	0.094	-0.029	0.103	1.000										
OWN	-0.169	0.084	-0.266	0.000	1.000									
DTr	-0.074	-0.146	-0.156	-0.511	0.000	1.000								
PD	-0.124	0.087	-0.198	0.063	0.777	-0.032	1.000							
SIZE	-0.031	0.059	-0.065	0.526	0.630	-0.129	0.598	1.000						
ID	0.061	-0.009	0.184	0.238	-0.147	-0.122	-0.051	0.177	1.000					
CR3	-0.074	0.071	-0.110	-0.744	-0.000	0.216	-0.085	-0.612	-0.424	1.000				
TCTA	0.123	-0.131	0.441	0.069	-0.339	-0.041	-0.298	-0.208	0.197	-0.140	1.000			
TLTA	0.067	0.152	0.119	0.190	-0.156	-0.065	-0.070	0.244	0.139	-0.278	-0.164	1.000		
GDPG	-0.024	0.005	0.056	0.691	-0.000	-0.235	0.069	0.452	0.291	-0.711	0.132	-0.166	1.000	
INFL	0.049	0.162	0.111	-0.261	0.000	-0.182	0.027	-0.135	0.119	0.082	0.171	-0.057	-0.026	1.000

Source: Author's calculation

Appendix 7.3: Determinants of profitability measures: NIM, ROA & ROE

	NIM		ROA		ROE	
	FE	RE	FE	RE	FE	RE
Capital ratio (TCTA)	0.152* (0.079)	0.098 (0.076)	0.179*** (0.022)	0.171*** (0.021)	-0.718 (0.678)	-0.967 (0.666)
Asset Quality (TLTA)	0.055 (0.041)	0.010 (0.036)	0.023* (0.011)	0.024** (0.009)	0.511 (0.357)	0.858*** (0.315)
Bank size (SIZE)	- 0.011 (0.019)	0.015 (0.013)	0.009* (0.005)	0.007** (0.004)	0.245 (0.167)	0.115 (0.115)
Ownership dummy (OWN)	-	-0.025** (0.012)	-	-0.008** (0.003)	-	-0.004 (0.107)
Concentration ratio (CR3)	-0.022 (0.038)	0.004 (0.034)	0.015 (0.010)	0.011 (0.009)	0.794** (0.329)	0.665** (0.299)
Political Director dummy (PD)	-0.003 (0.018)	-0.001 (0.009)	0.000 (0.005)	-0.000 (0.002)	0.022 (0.151)	0.009 (0.078)
Independent Director dummy (ID)	0.002 (0.013)	-0.001 (0.012)	0.004 (0.004)	0.004 (0.003)	0.015 (0.111)	0.021 (0.107)
	NIM		ROA		ROE	
	FE	RE	FE	RE	FE	RE
Transition Period dummy (DTr)	0.007	0.004	-0.006**	-0.006	-0.212**	-0.193**

	(0.010)	(0.010)	(0.003)	(0.003)	(0.089)	(0.089)
Post-reform period dummy (DPs)	0.031** (0.013)	0.025** (0.013)	-0.000 (0.004)	0.000 (0.003)	-0.096 (0.112)	-0.061 (0.110)
GDP growth rate (GDPG)	-0.011*** (0.004)	-0.011*** (0.004)	-0.001 (0.001)	-0.001 (0.000)	0.043 (0.031)	0.044 (0.031)
CPI inflation (INFL)	0.002* (0.001)	0.002* (0.001)	0.000 (0.000)	0.000 (0.000)	0.024** (0.011)	0.025** (0.011)
R-squared	0.062	0.076	0.194	0.272	0.094	0.108
Hausman test	Prob $\chi^2=0.29$:RE		Prob $\chi^2=0.842$:RE		Prob $\chi^2=0.000$:RE	
Total observations	360		360		360	

Source: Author's estimation using STATA12. FE stands for fixed-effect model and RE is random-effect model. Pre-reform period is treated as base period. Standard errors are in parentheses;*** denotes statistical significance level at 1%; ** denotes the level of statistical significance at 5%; * denotes statistical significance level at 10%

References

- ABRAMOVITZ, M. 1956. Resource and output trends in the United States since 1870. *American Economic Review*, 46, 5-23.
- ADB 2012. *Asian Development Bank Outlook*. Manila: Asian Development Bank.
- ADDISON, T., CHOWDHURY, A. R. & MURSHED, S. M. 2002. By how much does conflict reduce financial development. *Discussion Paper*. World Institute for Development Economics Research.
- AFRIAT, S. N. 1972. Efficiency estimation of production function. *International Economic Review*, 13, 568-598.
- AHMAD, A. U. F. & HASSAN, M. K. 2007. Regulation and performance of islamic banking in Bangladesh. *Thunderbird International Business Review*, 49, 251-277.
- AIGNER, D., LOVELL, C. A. K. & SCHMIDT, P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6, 21-37.
- AKTHER, S., FUKUYAMA, H. & WEBER, W. L. 2012. Estimating two-stage network slacks-based inefficiency: an application to Bangladesh banking. *Omega*, 41, 88-96.
- AL-MUHARRAMI, S., MATTHEWS, K. & KHABARI, Y. 2006. Market structure and competitive conditions in the Arab GCC banking system. *Journal of Banking & Finance*, 30, 3487-3501.
- ALTMAN, E. I. & SAUNDERS, A. 2001. An analysis and critique of the BIS proposal on capital adequacy and ratings. *Journal of Banking & Finance*, 25, 25-46.
- ALTUNBAS, Y., LIU, M.-H., MOLYNEUX, P. & SETH, R. 2000. Efficiency and risk in Japanese banking. *Journal of Banking & Finance*, 24, 1605-1628.
- ANDRES, P. D. & VALLELADO, E. 2008. Corporate governance in banking: the role of the board of directors. *Journal of Banking & Finance*, 32, 2570-2580.
- ARIFF, M. & CAN, L. 2008. Cost and profit efficiency of Chinese banks: a non-parametric analysis. *China Economic Review*, 19, 260-273.
- ARJOMANDI, A., HARVIE, C. & VALADKHANI, A. 2012. An empirical analysis of Iran's banking performance. *Studies in Economics and Finance*, 29, 287-300.
- ARJOMANDI, A., VALADKHANI, A. & HARVIE, C. 2011. Analysing productivity changes using the bootstrapped Malmquist approach: the case of the Iranian banking industry. *Australasian Accounting, Business and Finance Journal* 5, 35-56.
- ARJOMANDI, A., VALADKHANI, A. & O'BRIEN, M. 2014. Analysing banks' intermediation and operational performance using the Hicks-Moorsteen TFP Index: The case of Iran. *Research in International Business and Finance*, 30, 111-125.
- ARORA, H. & ARORA, P. 2013. Measuring and decomposing productivity change using Hicks-Moorsteen index numbers:evidence from Indian banks. *International Journal of Productivity and Quality Management*, 11, 73-95.

- ATHANASOGLU, P. P., BRISSIMIS, S. N. & DELIS, M. D. 2008. Bank-specific, industry-specific and macroeconomic determinants of bank profitability. *Journal of International Financial Markets, Institutions & Money*, 18, 121-136.
- AVKIRAN, N. 2000. Rising productivity of Australian trading banks under deregulation 1986-1995. *Journal of Economics and Finance*, 24, 122-140.
- AVKIRAN, N. K. 1999. The evidence on efficiency gains: the role of mergers and the benefits to the public. *Journal of Banking & Finance*, 23, 991-1013.
- BALK, B. M. 2001. Scale efficiency and productivity change. *Journal of Productivity Analysis*, 15, 159-183.
- BALTAGI, B. H. & GRIFFIN, J. M. 1988. A general index of technical change. *Journal of Political Economy*, 96, 20-41.
- BANGLADESH BANK 2006. *Financial Sector Review*. Dhaka: Bangladesh Bank.
- BANGLADESH BANK 2011a. *Annual Report*. Dhaka: Bangladesh Bank.
- BANGLADESH BANK 2011b. *Prudential Regulations for Banks: Selected Issues*. Dhaka: Bangladesh Bank.
- BANGLADESH BANK 2012. *Risk Management Guidelines for Banks*. Dhaka: Bangladesh Bank.
- BANGLADESH BANK 2014a. *Annual Report*. Dhaka: Bangladesh Bank.
- BANGLADESH BANK 2014b. *Bangladesh Bank Quarterly*. Dhaka: Bangladesh Bank.
- BANGLADESH BANK 2014c. *Schedule Bank Statistics*. Dhaka: Bangladesh Bank.
- BANGLADESH BANK 2015. *Monthly Economic Trends*. Dhaka: Bangladesh Bank.
- BANGLADESH BUREAU OF STATISTICS 2013. *National Income Accounting*. Dhaka: Government of Bangladesh.
- BANKER, R. D., CHANG, H. & LEE, S.-Y. 2010. Differential impact of Korean banking system reforms on bank productivity. *Journal of Banking & Finance*, 34, 1450-1460.
- BANKER, R. D., CHARNES, A. & COOPER, W. W. 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30, 1078-1092.
- BASEL COMMITTEE ON BANKING SUPERVISION 2011. Basel III : a global regulatory framework for more resilient banks and banking systems. *Basel III* Basel: Bank for International Settlements.
- BATTESE, G. E. & COELLI, T. J. 1992. Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India. *Journal of Productivity Analysis*, 3, 153-169.
- BATTESE, G. E. & COELLI, T. J. 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20, 325-332.
- BAUER, P. W. 1990a. Decomposing TFP growth in the presence of cost inefficiency, nonconstant returns to scale and technological progress. *Journal of Productivity Analysis*, 1, 287-299.

- BAUER, P. W. 1990b. Recent developments in the econometric estimation of frontiers. *Journal of Econometrics*, 46, 39-56.
- BAUER, P. W., BERGER, A. N., FERRIER, G. D. & HUMPHREY, D. B. 1998. Consistency conditions for regulatory analysis of financial institutions: a comparison of frontier efficiency methods. *Journal of Economics and Business*, 50, 85-114.
- BAUER, P. W., BERGER, A. N. & HUMPHREY, D. B. 1993. Efficiency and productivity growth in U.S. banking. In: FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, S. S. (eds.) *The Measurement of Productive Efficiency: Techniques and Applications*. New York: Oxford University Press.
- BBS 2014. *Bangladesh National Accounts Statistics : Sources and Methods*. Dhaka: Bangladesh Bureau of Statistics.
- BENSTON, G. J. 1965. Branch banking and economies of scale. *Journal of Finance*, 20, 312-331.
- BERG, S. A., FORSUND, F. R. & JANSEN, E. S. 1992. Malmquist indices of productivity growth during the deregulation of Norwegian banking. *Scandinavian Journal of Economics*, 94, 211-228.
- BERGER, A. N. 1993. Distribution-free estimates of efficiency in the U.S. banking industry and tests of the standard distributional assumptions. *Journal of Productivity Analysis*, 4, 261-292.
- BERGER, A. N. 1995a. The profit-structure relationship in Banking-tests of market-power and efficient-structure hypothesis. *Journal of Money, Credit and Banking*, 27, 404-431.
- BERGER, A. N. 1995b. The relationship between captial and earnings in Banking. *Journal of Money, Credit and Banking*, 27, 432-456.
- BERGER, A. N., CLARKE, G. R. G., CULL, R., KLAPPER, L. & UDELL, G. F. 2005. Corporate governance and bank performance: a joint analysis of the static, selection, and dynamic effects of domestic, foreign, and state ownership. *Journal of Banking & Finance*, 29, 2179-2221.
- BERGER, A. N. & DEYOUNG, R. 1997. Problem loans and cost efficiency in commercial banks. *Journal of Banking & Finance*, 21, 849-870.
- BERGER, A. N., HASAN, I. & ZHOU, M. 2009. Bank ownership and efficiency in China: what will happen in the world's largest nation? *Journal of Banking & Finance*, 33, 113-130.
- BERGER, A. N. & HUMPHREY, D. B. 1991. The dominance of inefficiencies over scale, product mix economies in banking. *Journal of Monetary Economics*, 28, 117-148.
- BERGER, A. N. & HUMPHREY, D. B. 1992. Measurement and efficiency issues in commercial banking. In: GRILLICHES, Z. (ed.) *Output Measurement in the Service Sector*. Chicago: University of Chicago.
- BERGER, A. N. & HUMPHREY, D. B. 1997. Efficiency of financial institutions: international survey and directions for future research. *European Journal of Operational Research*, 98, 175-212.
- BERGER, A. N., KICK, T. & SCHAECK, K. 2012. Executive board composition and bank risk taking. Bangor: Bangor Business School.

- BERGER, A. N. & MESTER, L. J. 1997. Inside the black box: what explains differences in the efficiencies of financial institutions? *Journal of Banking & Finance*, 21, 895-947.
- BERGER, A. N. & MESTER, L. J. 2001. Explaining the dramatic changes in performance of U.S. banks: technological change, deregulation, and dynamic changes in competition. *Working Paper*. University of Pennsylvania.
- BHATTACHARYYA, A., LOVELL, C. A. K. & SAHAY, P. 1997. The impact of liberalization on the productive efficiency of Indian commercial banks. *European Journal of Operational Research*, 98, 332-345.
- BJUREK, H. 1996. The Malmquist total factor productivity index. *Scandinavian Journal of Economics*, 98, 303-313.
- BONIN, J. P., HASAN, I. & WACHTEL, P. 2005. Bank performance, efficiency and ownership in transition countries. *Journal of Banking & Finance*, 29, 31-53.
- BOUCINHA, M., RIBEIRO, N. & WEYMAN-JONES, T. 2013. An assessment of Portuguese banks' efficiency and productivity towards euro area participation. *Journal of Productivity Analysis*, 39, 177-190.
- BOURKE, P. 1989. Concentration and other determinants of bank profitability in Europe, North America and Australia. *Journal of Banking & Finance*, 13, 65-79.
- BOYCKO, M., SHLEIFER, A. & VISHNY, R. W. 1996. A theory of privatization. *Economic Journal*, 106, 309-319.
- BURKI, A. A. & NIAZI, G. S. K. 2010. Impact of financial reforms on efficiency of state-owned, private and foreign banks in Pakistan. *Applied Economics*, 42, 3147-3160.
- CARRETTA, A., FARINA, V., GON, A. & PARISI, A. 2012. Politicians 'on board': do political connections affect banking activities in Italy? *European Management Review*, 9, 75-83.
- CASU, B., GIRARDONE, C. & MOLYNEUX, P. 2004. Productivity change in European banking: a comparison of parametric and non-parametric approaches. *Journal of Banking & Finance*, 28, 2521-2540.
- CAVES, D. W., CHRISTENSEN, L. R. & DIEWERT, W. E. 1982. The economic theory of index numbers and the measurement of input, output and productivity. *Econometrica*, 50, 1393-1414.
- CHANG, T.-P., HU, J.-L., CHOU, R. Y. & SUN, L. 2012. The sources of bank productivity growth in China during 2002-2009: a disaggregation view. *Journal of Banking & Finance*, 36, 1997-2006.
- CHARNES, A., COOPER, W. W. & RHODES, E. 1978. Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2, 429-444.
- CHEN, X., SKULLY, M. & BROWN, K. 2005. Banking efficiency in China: application of DEA to pre- and post-deregulation eras: 1993-2000. *China Economic Review*, 16, 229-245.
- CHOI, S. & HASAN, I. 2005. Ownership, governance, and bank performance: Korean experience. *Financial Markets, Institutions & Instruments*, 14, 215-242.

- CHOWDHURY, A. R. 2001. The impact of financial reform on private savings in Bangladesh. *Discussion Paper*. World Institute for Development Economics Research.
- CHRISTENSEN, L. R., JORGENSON, D. W. & LAU, L. J. 1973. Transcendental logarithmic production frontiers. *Review of Economic and Statistics*, 55, 28-45.
- CLARK, J. A. 1996. Economic cost, scale efficiency and competitive viability in banking. *Journal of Money, Credit and Banking*, 28, 342-364.
- COELLI, T. J. 1995. Recent developments in frontier modelling and efficiency measurement. *Australian Journal of Agricultural Economics*, 39, 219-245.
- COELLI, T. J. 1996. A guide to FRONTIER version 4.1: a computer program for stochastic frontier production and cost function estimation. *CEPA Working Paper* Armidale: University of New England.
- COELLI, T. J. & PERELMAN, S. 1999. A comparison of parametric and non-parametric distance functions: with application to European Railways. *European Journal of Operational Research*, 117, 326-339.
- COELLI, T. J., RAO, D. S. P., O' DONNELL, C. J. & BATTESE, G. E. 2005. *An Introduction to Efficiency and Productivity Analysis*, New York, Springer.
- COLWELL, R. J. & DAVIS, E. P. 1992. Output and Productivity in Banking. *Scandinavian Journal of Economics*, 94, 111-129.
- CORNWELL, C., SCHMIDT, P. & SICKLES, R. C. 1990. Production frontiers with cross-sectional and time-series variation in efficiency levels. *Journal of Econometrics*, 46, 185-200.
- COWING, T. G. & STEVENSON, R. E. 1981. Introduction: productivity measurement and regulated industries. In: COWING, T. G. & STEVENSON, R. E. (eds.) *Productivity Measurement in Regulated Industries*. New York: Academic Press.
- DAS, A. & GHOSH, S. 2004. Corporate governance in banking system: an empirical investigation. *Economic and Political Weekly*, 39, 1263-1266.
- DAS, A. & GHOSH, S. 2006. Financial deregulation and efficiency: an empirical analysis of Indian banks during the post reform period. *Review of Financial Economics*, 15, 193-221.
- DAS, A. & KUMBHAKAR, S. C. 2012. Productivity and efficiency dynamics in Indian banking: an input distance function approach incorporating quality of inputs and outputs. *Journal of Applied Econometrics*, 27, 205-234.
- DE YOUNG, R. 1997. A diagnostic test for the distribution-free efficiency estimator: an example using U.S. commercial bank data. *European Journal of Operational Research*, 98, 243-249.
- DEBREU, G. 1951. The coefficient of resource utilization. *Econometrica*, 19, 273-292.
- DELIS, M. D. 2012. Bank competition, financial reform, and institutions: the importance of being developed. *Journal of Development Economics*, 97, 450-465.
- DELIS, M. D., MOLYNEUX, P. & PASIOURAS, F. 2011. Regulations and productivity growth in banking: evidence from transition economies. *Journal of Money, Credit and Banking*, 43, 735-764.

- DEMIRGUC-KUNT, A. & HUIZINGA, H. 1999. Determinants of commercial bank interest margins and profitability: some international evidence. *World Bank Economic Review*, 13, 379-408.
- DEMSETZ, H. 1973. Industry structure, market rivalry, and public policy. *Journal of Law and Economics*, 16, 1-9.
- DENIZER, C. A., DINC, M. & TARIMCILAR, M. 2007. Financial liberalization and banking efficiency: evidence from Turkey. *Journal of Productivity Analysis*, 27, 177-195.
- DEPRINS, D., SIMAR, L. & TULKENS, H. 1984. Measuring labour efficiency in post offices. In: MARCHAND, M., PESTIEAU, P. & TULKENS, H. (eds.) *The Performance of Public Enterprises: Concepts and Measurement*. Amsterdam: North-Holland.
- DEYOUNG, R. & NOLLE, D. E. 1996. Foreign-owned banks in the United States: earning market share or buying it? *Journal of Money, Credit and Banking*, 28, 622-636.
- DIETRICH, A. & WANZENRIED, G. 2011. Determinants of bank profitability before and during the crisis : evidence from Switzerland. *Journal of International Financial Markets, Institutions & Money*, 21, 307-327.
- DIETSCH, M. & LOZANO-VIVAS, A. 2000. How the environment determines banking efficiency: a comparison between French and Spanish industries. *Journal of Banking & Finance*, 24, 985-1004.
- DONG, Y. 2009. *Cost efficiency in the Chinese banking sector: a comparison of parametric and non-parametric methodologies*. Ph.D thesis, Loughborough University.
- DRAKE, L. & HALL, M. J. B. 2003. Efficiency in Japanese banking: an empirical analysis. *Journal of Banking & Finance*, 27, 891-917.
- DRAKE, L., HALL, M. J. B. & SIMPER, R. 2006. The impact of macroeconomic and regulatory factors on bank efficiency: a non-parametric analysis of Hong Kong's banking system. *Journal of Banking & Finance*, 30, 1443-1466.
- DU, J. & GIRMA, S. 2011. Cost economies, efficiency and productivity growth in the Chinese banking industry: evidence from a quarterly panel dataset. *Empirical Economics*, 41, 199-226.
- EDIRISURIYA, P. 2007. Effects of financial sector reforms in Sri Lanka: evidence from the banking sector. *Asia Pacific Journal of Finance and Banking Research*, 1, 45-63.
- EDIRISURIYA, P. & O' BRIEN, G. C. 2001. Financial deregulation and economies of scale and scope: evidence from the major Australian banks. *Asia-Pacific Financial Markets*, 8, 197-214.
- EISENBEIS, R. A., FERRIER, G. D. & H, K. S. 1996. An empirical analysis of the informativeness of programming and SFA efficiency scores: efficiency and bank performance. *Working paper*. Chapel Hill NC: University of North Carolina.
- ELYASIANI, E. & MEHDIAN, S. 1995. The comparative efficiency performance of small and large U.S. commercial banks in the pre and post deregulation eras. *Applied Economics*, 27, 1069-1079.
- FÄRE, R., GROSSKOPF, S. & LOGAN, J. 1983. The relative efficiency of Illinois electric utilities. *Resources and Energy*, 5, 349-367.

- FÄRE, R., GROSSKOPF, S. & MARGARITIS, D. 2008. Efficiency and productivity: Malmquist and more. In: FRIED, H. O., LOVELL, C. A. K. & S.SCHMIDT, S. (eds.) *The Measurement of Productive Efficiency and Productivity Growth*. Oxford: Oxford University Press.
- FÄRE, R. & LOVELL, C. A. K. 1978. Measuring the technical efficiency of production. *Journal of Economic Theory*, 19, 150-162.
- FÄRE, R. & PRIMONT, D. 1995. *Multi-output Production and Duality: Theory and Applications*, Boston, Kluwer Academic Publishers.
- FARRELL, M. 1957. The measurement of productivity efficiency. *Journal of the Royal Statistical Society* 120, 253-281.
- FAVERO, C. A. & PAPI, L. 1995. Technical efficiency and scale efficiency in the Italian banking sector: a non-parametric approach. *Applied Economics*, 27, 385-396.
- FENG, G. & SERLETIS, A. 2009. Efficiency and productivity of the US banking industry, 1998-2005: evidence from the fourier cost function satisfying global regularity conditions. *Journal of Applied Econometrics*, 24, 105-138.
- FENG, G. & SERLETIS, A. 2010. Efficiency, technical change and returns to scale in large US banks: panel data evidence from an output distance function satisfying theoretical regularity. *Journal of Banking & Finance*, 34, 127-138.
- FENG, G. & ZHANG, X. 2012. Productivity and efficiency at large and community banks in the US: a Bayesian true random effects stochastic distance frontier analysis. *Journal of Banking & Finance*, 36, 1883-1895.
- FERRIER, G. D. & LOVELL, C. A. K. 1990. Measuring cost efficiency in banking: econometric and linear programming evidence. *Journal of Econometrics*, 46, 229-245.
- FIORDELISI, F., MARQUES-IBANEZ, D. & MOLYNEUX, P. 2011. Efficiency and risk in European banking. *Journal of Banking & Finance*, 35, 1315-1326.
- FISHER, I. 1922. *The making of index numbers*, Boston, Houghton Mifflin.
- FLAMINI, V., MCDONALD, C. & SCHUMACHER, L. 2009. The determinants of commercial bank profitability in Sub-Saharan Africa. *IMF Working Paper*. International Monetary Fund.
- FRERIER, G. D. & LOVELL, C. A. K. 1990. Measuring cost efficiency in banking: econometric and linear programming evidence. *Journal of Econometrics*, 46, 229-245.
- FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, P. 2008a. Efficiency and productivity. In: FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, P. (eds.) *The Measurement of Productive Efficiency and Productivity Growth*. New York: Oxford University Press.
- FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, S. S. 2008b. Efficiency and productivity. In: O.FRIED, H., LOVELL, C. A. K. & S.SCHMIDT, S. (eds.) *The Measurement of Productive Efficiency and Productivity Growth*. Oxford: Oxford University Press.
- FRIES, S. & TACI, A. 2005. Cost efficiency of banks in transition: evidence from 289 banks in 15 post-communist countries. *Journal of Banking & Finance*, 29, 55-81.

- FRY, M. J. 1995. *Money, Interest and Banking in Economic Development*, London, The Johns Hopkins University Press.
- FÄRE, R., GROSSKOPF, S. & LOVELL, C. A. K. 1994. *Production Frontiers*, New York, Cambridge University Press.
- GARCIA-HERRERO, A., GAVILA, S. & SANTABARBARA, D. 2009. What explains the low profitability of Chinese banks? *Journal of Banking & Finance*, 33, 2080-2092.
- GIRARDONE, C., MOLYNEUX, P. & GARDENER, E. P. M. 2004. Analysing the determinants of bank efficiency: the case of Italian banks. *Applied Economics*, 36, 215-227.
- GOB 1986. *Report of The National Commission on Money, Banking and Credit*. Dhaka: Government of Bangladesh.
- GODDARD, J., MOLYNEUX, P. & WILSON, J. O. S. 2004. Dynamics of growth and profitability in Banking. *Journal of Money, Credit and Banking*, 36, 1069-1090.
- GREENE, H. W. 1993. The econometric approach to efficiency analysis: techniques and applications. In: FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, S. S. (eds.) *The Measurement of Productive Efficiency*. New York: Oxford University Press.
- GREENE, H. W. 1997. Frontier production functions. In: PESARAN, H. & SCHMIDT, P. (eds.) *Handbook of Applied Econometrics*. Oxford: Oxford University Press.
- GREENE, H. W. 2008. The econometric approach to efficiency analysis. In: FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, P. (eds.) *The Measurement of Productive Efficiency and Productivity Growth*. Oxford: Oxford University Press.
- GREENE, W. 2005a. Reconsidering heterogeneity in panel data estimators of the stochastic frontier model. *Journal of Econometrics*, 126, 269-303.
- GREENE, W. H. 1980. On the estimation of a flexible frontier production model. *Journal of Econometrics*, 13, 101-115.
- GREENE, W. H. 1990. A gamma-distributed stochastic frontier model. *Journal of Econometrics*, 46, 141-163.
- GREENE, W. H. 2005b. Fixed and random effects in stochastic frontier models. *Journal of Productivity Analysis*, 23, 7-32.
- GREENE, W. H. 2012. *Econometric Analysis*, Boston, Prentice Hall.
- GRIFELL-TATJE, E. & LOVELL, C. A. K. 1999. Profit and productivity. *Management Science*, 45, 1177-1193.
- GROSSKOPF, S. 1993. Efficiency and productivity. In: FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, S. S. (eds.) *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford: Oxford University Press.
- GROSSKOPF, S. 1996. Statistical-inference and nonparametric efficiency - a selective survey. *Journal of Productivity Analysis*, 7, 161-176.
- GUP, B. E. 2007. Corporate governance in banks: does the board structure matter? In: GUP, B. E. (ed.) *Corporate Governance in Banking: A Global Perspective*. Cheltenham: Edward Elgar Publishing Limited.

- HAO, J., HUNTER, W. C. & YANG, W. K. 2001. Deregulation and efficiency: the case of private Korean banks. *Journal of Economics and Business*, 53, 237-254.
- HASAN, I. & MARTON, K. 2003. Development and efficiency of the banking sector in a transitional economy: Hungarian experience. *Journal of Banking & Finance*, 27, 2249-2271.
- HASSAN, M. K. 1999. Islamic banking in theory and practice: the experience of Bangladesh. *Managerial Finance*, 25, 60-113.
- HASSAN, M. K. & TUFTE, D. R. 2001. The X-efficiency of a group-based lending institution: the case of the Grameen Bank. *World Development*, 29, 1071-1082.
- HAUNER, D. 2005. Explaining efficiency differences among large German and Austrian banks. *Applied Economics*, 37, 969-980.
- HAUSMAN, J. A. 1978. Specification tests in econometrics. *Econometrica*, 46, 1251-1272.
- HAUSMAN, J. A. & TAYLOR, W. E. 1981. Panel data and unobservable individual effects. *Econometrica*, 49, 1377-1398.
- HEFFERNAN, S. A. & FU, X. 2010. Determinants of financial performance in Chinese banking. *Applied Financial Economics*, 20, 1585-1600.
- HELLMANN, T. & MURDOCK, K. 1997. Financial sector development policy: the importance of reputational capital and governance. In: SZEKELY, I. P. & SABAT, R. (eds.) *Development Strategy and Management of the Market Economy*. Oxford: Endom Press.
- HERMALIN, B. E. & WEISBACH, M. S. 1991. The effects of board composition and direct incentives on firm performance. *Financial Management*, 20, 101-112.
- HESHMATI, A. 2003. Productivity growth, efficiency and outsourcing in manufacturing and service industries. *Journal of Economic Surveys*, 17, 79-112.
- HO, T. S. Y. & SAUNDERS, A. 1981. The determinants of bank interest margins: theory and empirical evidence. *Journal of Financial and Quantitative Analysis*, XVI, 581-600.
- HUMPHREY, D. B. 1993. Cost and technical change: effects from bank deregulation. *Journal of Productivity Analysis*, 4, 9-34.
- HUNTER, W. C., TIMME, S. G. & YANG, W. K. 1990. An examination of cost subadditivity and multiproduct production in large U.S. banks. *Journal of Money, Credit and Banking*, 22, 504-525.
- IANNOTTA, G., NOCERA, G. & SIRONI, A. 2007. Ownership structure, risk and performance in the European banking industry. *Journal of Banking & Finance*, 31, 2127-2149.
- IMAI, M. 2009. Political determinants of government loans in Japan. *Journal of Law and Economics*, 52, 41-70.
- ISIK, I. & HASSAN, M. K. 2002. Technical, scale and allocative efficiencies of Turkish banking industry. *Journal of Banking & Finance*, 26, 719-766.
- ISIK, I. & HASSAN, M. K. 2003. Financial deregulation and total factor productivity change: an empirical study of Turkish commercial banks. *Journal of Banking & Finance*, 27, 1455-1485.

- JHA, R., MURTY, M. N. & PAUL, S. 1991. Technological change, factor substitution and economies of scale in selected manufacturing industries in India *Journal of Quantitative Economics*, 7, 165-178.
- JONDROW, J., LOVELL, C. A. K., MATEROV, I. S. & SCHMIDT, P. 1982. On the estimation of technical inefficiency in the stochastic frontier production function model *Journal of Econometrics*, 19, 233-238.
- JORGENSON, D. W. & GRILICHES, Z. 1967. The explanation of productivity change. *Review of Economic Studies*, 34, 249-283.
- KABIR, S. H. 2004. Is financial liberalization a vehicle for economic sector efficiency of Bangladesh. *Bank Parkrama*, XXVIII & XXIX, 147-169.
- KALIRAJAN, K. P. & OBWONA, M. B. 1994. Frontier production function: the stochastic coefficients approach. *Oxford Bulletin of Economics and Statistics*, 56, 87-96.
- KALIRAJAN, K. P. & SHAND, R. T. 1999. Frontier production functions and technical efficiency measures. *Journal of Economic Surveys*, 13, 149-172.
- KARAS, A., SCHOORS, K. & WEILL, L. 2010. Are private banks more efficient than public banks? *Economics of Transition*, 18, 209-244.
- KASMAN, A., TUNC, G., VARDAR, G. & OKAN, B. 2010. Consolidation and commercial bank net interest margins: evidence from the old and new European Union members and candidate countries. *Economic Modelling*, 27, 648-655.
- KAZEMI, M. A. M. 1998. Financial Sector Reforms: The Bangladesh Experience. *ESCAP Seminar on Improved Management of the Financial Sector*. Manila.
- KHANAM, M. D. & KHANDOKER, M. S. H. 2005. X-efficiency analysis of problem banks of Bangladesh. *Pakistan Journal of Social Sciences*, 3, 521-525.
- KHWAJA, A. I. & MIAN, A. 2005. Do lenders favor politically connected firms? rent provision in an emerging financial market. *Quarterly Journal of Economics*, 120, 1371-1411.
- KODDE, D. A. & PALM, F. C. 1986. Wald criteria for jointly testing equality and inequality restrictions. *Econometrica*, 54, 1243-1248.
- KOOPMANS, T. C. 1951. An analysis of production as an efficient combination of activities. In: T.C.KOOPMANS (ed.) *Activity Analysis of Production and Allocation*. New York: Wiley.
- KOSMIDOU, K. 2008. The determinants of banks' profits in Greece during the period of EU financial integration. *Managerial Finance*, 34, 146-159.
- KRUEGER, A. O. & TUNCER, B. 1982. Growth of factor productivity in Turkish manufacturing industries. *Journal of Development Economics*, 11, 307-325.
- KUMBHAKAR, S. C. 1990. Production frontiers, panel data, and time-varying technical inefficiency. *Journal of Econometrics*, 46, 201-211.
- KUMBHAKAR, S. C. & HESHMATI, A. 1996. Technical change and total factor productivity growth in Swedish manufacturing industries. *Econometric Reviews*, 15, 275-298.
- KUMBHAKAR, S. C. & LOVELL, C. A. K. 2000. *Stochastic Frontier Analysis*, Cambridge, Cambridge University Press.

- KUMBHAKAR, S. C. & LOVELL, C. A. K. 2003. *Stochastic Frontier Analysis*, Cambridge, Cambridge University Press.
- KUMBHAKAR, S. C. & LOZANO-VIVAS, A. 2005. Deregulation and productivity: the case of Spanish banks. *Journal of Regulatory Economics*, 27, 331-351.
- KUMBHAKAR, S. C. & WANG, D. 2005. Economic Reforms, Efficiency, and Productivity in Chinese banking. *Working Paper*. Binghamton: State University of New York.
- KUMBHAKAR, S. C. & WANG, D. 2007. Economic reforms, efficiency and productivity in Chinese banking. *Journal of Regulatory Economics*, 32, 105-129.
- KUPIEC, P. H. 2013. Basel III : some costs will outweigh the benefits. American Enterprise Institute.
- KWAST, M. L. & ROSE, J. T. 1982. Pricing, operating efficiency, and profitability among large commercial banks. *Journal of Banking & Finance*, 6, 233-254.
- LA PORTA, R., LOPEZ-DE-SILANES, F. & SHLEIFER, A. 2002. Government ownership of banks. *Journal of Finance*, 57, 265-301.
- LEE, B. L., WORTHINGTON, A. C. & LEONG, W. H. 2010. Malmquist indices of pre- and post-deregulation productivity, efficiency and technological change in the Singaporean banking sector. *Singapore Economic Review*, 55, 599-618.
- LEFORT, F. & URZUA 2008. Board independence, firm performance and ownership concentration:evidence from Chile. *Journal of Business Research*, 61, 615-622.
- LEIGHTNER, J. E. & LOVELL, C. A. K. 1998. The impact of financial liberalization on the performance of Thai banks. *Journal of Economics and Business*, 50, 115-131.
- LEVINE, R. 1997. Financial development and economic growth: views and agenda. *Journal of Economic Literature*, 35, 688-726.
- LIN, X. & ZHANG, Y. 2009. Bank ownership reform and bank performance in China. *Journal of Banking & Finance*, 33, 20-29.
- LOVELL, C. A. K. 2003. The decomposition of Malmquist productivity indexes. *Journal of Productivity Analysis*, 20, 437-458.
- LOZANO-VIVAS, A. & PASIOURAS, F. 2010. The impact of non-traditional activities on the estimation of bank efficiency: international evidence. *Journal of Banking & Finance*, 34, 1436-1449.
- MAHADEVAN, R. 2004. *The economics of productivity in Asia and Australia*, Northampton, Edward Elgar.
- MAHADEVAN, R. & KALIRAJAN, K. P. 1999. On measuring total factor productivity growth in Singapore's manufacturing industries. *Applied Economics Letters*, 6, 295-298.
- MAHESH, H. P. & BHIDE, S. 2008. Do financial sector reforms make commercial banks more efficient? a parametric exploration of the Indian case. *Journal of Applied Economic Research*, 2, 415-441.
- MANLAGÑIT, M. C. V. 2011. Cost efficiency, determinants, and risk preferences in banking: A case of stochastic frontier analysis in the Philippines. *Journal of Asian Economics*, 22, 23-35.

- MAREDZA, A. & IKHIDE, S. 2013. Measuring the impact of the global financial crisis on efficiency and productivity of the banking system in South Africa. *Mediterranean Journal of Social Sciences*, 4, 553-568.
- MAUDOS, J., PASTOR, J. M., PEREZ, F. & QUESADA, J. 2002. Cost and profit efficiency in European banks. *Journal of International Financial Markets, Institutions & Money*, 12, 33-58.
- MCKINNON, R. I. 1973. *Money and Capital in Economic Development*, Washington DC, The Brookings Institutions.
- MEEUSEN, W. & BROECK, V. D. 1977. Efficiency estimation from Cobb-Douglas production function with composed error. *International Economic Review*, 18, 435-444.
- MESTER, L. J. 1996. A study of bank efficiency taking into account risk-preferences. *Journal of Banking & Finance*, 20, 1025-1045.
- MICCO, A., PANIZZA, U. & YANEZ, M. 2007. Bank ownership and performance: does politics matter. *Journal of Banking & Finance*, 31, 2019-241.
- MILLER, S. M. & NOULAS, A. G. 1996. The technical efficiency of large bank production. *Journal of Banking & Finance*, 20, 495-509.
- MILLER, S. M. & NOULAS, A. G. 1997. Portfoli mix and large-bank profitability in the USA. *Applied Economics*, 29, 505-512.
- MISHKIN, F. S. 2007. *The Economics of Money, Banking and Financial Markets*, New York, Wesley.
- MOLYNEUX, P. & THORNTON, J. 1992. Determinants of European bank profitability : a note. *Journal of Banking & Finance*, 16, 1173-1178.
- MRA 2014. NGO-MFIs in Bangladesh. *NGO-MFIs in Bangladesh*. Dhaka: Microcredit Regulatory Authority.
- MUJERI, M. K. 2004. Changes in policy framework and total Factor productivity growth in Bangladesh. *Bangladesh Development Studies*, 30, 1-29.
- NACEUR, S. B. & GOAIED, M. 2008. The determinants of commercial bank interest margin and profitability: evidence from Tunisia. *Frontiers in Finance and Economics* 5, 106-130.
- NACEUR, S. B. & OMRAN, M. 2011. The effects of bank regulations, competition, and financial reforms on banks' performance. *Emerging Markets Review*, 12, 1-20.
- NISHIMIZU, M. & PAGE, J. M. 1982. Total factor productivity growth, technological progress and technical efficiency change: dimensions of productivity change in Yugoslavia, 1965-78. *Economic Journal*, 92, 920-936.
- NISHIMIZU, M. & ROBINSON, S. 1984. Trade policies and productivity change in semi-industrialized countries. *Journal of Development Economics*, 16, 177-206.
- O'DONNELL, C. J. 2008. An aggregate quantity-price framework for measuring and Decomposing productiivty and profitability change. *Working Paper*. Brisbane: University of Queensland.

- O'DONNELL, C. J. 2010. Measuring and decomposing agricultural productivity and profitability change. *Australian Journal of Agricultural and Resource Economics*, 54, 527-560.
- O'DONNELL, C. J. 2011a. DPIN 3.0 a program for decomposing productivity index numbers. *Working Paper*. Brisbane: The University of Queensland.
- O'DONNELL, C. J. 2011b. Econometric estimation of distance functions and associated measures of productivity and efficiency change. *CEPA Working Paper*. Brisbane: University of Queensland.
- O'DONNELL, C. J. 2011c. The sources of productivity change in the manufacturing sectors of the U.S. economy. *Working Paper*. Brisbane: University of Queensland.
- O'DONNELL, C. J. 2012a. An aggregate quantity framework for measuring and decomposing productivity change. *Journal of Productivity Analysis*, 38, 255-272.
- O'DONNELL, C. J. 2012b. Nonparametric estimates of the components of productivity and profitability change in U.S. agriculture. *American Journal of Agricultural Economics*, 94, 873-890.
- O'DONNELL, C. J. 2013. An econometric approach to estimating support prices and measures of productivity change in public hospitals. *Journal of Productivity Analysis*, 40, 323-335.
- O'DONNELL, C. J. 2014a. An econometric approach to identifying the drivers of productivity change in the market sectors of the Australian economy. *CEPA Working Paper*. Brisbane: University of Queensland.
- O'DONNELL, C. J. 2014b. Econometric estimation of distance function and associated measures of productivity and efficiency change. *Journal of Productivity Analysis*, 41, 187-200.
- OLSON, D. & ZOUBI, T. 2011. Efficiency and bank profitability in MENA countries. *Emerging Markets Review*, 12, 94-110.
- ONDER, Z. & OZYILDIRIM, S. 2011. Political connection, bank credits and growth: evidence from Turkey. *World Economy*, 34, 1042-1065.
- OREA, L. 2002. Parametric decomposition of a generalized Malmquist productivity index. *Journal of Productivity Analysis*, 18, 5-22.
- OREA, L. & KUMBHAKAR, S. C. 2004. Efficiency measurement using a latent class stochastic frontier model. *Empirical Economics*, 29, 169-183.
- PARK, K. H. & WEBER, W. L. 2006. A note on efficiency and productivity growth in the Korean banking industry, 1992-2002. *Journal of Banking & Finance*, 30, 2371-2386.
- PASIOURAS, F. & KOSMIDOU, K. 2007. Factors influencing the profitability of domestic and foreign commercial banks in the European Union. *Research in International Business and Finance*, 21, 222-237.
- PATHAN, S., SKULLY, M. & WICKRAMANAYAKE, J. 2007. Board size, independence and performance: an analysis of Thai banks. *Asia-Pacific Financial Markets* 14, 211-227.

- PATTI, E. B. D. & HARDY, D. C. 2005. Financial sector liberalization, bank privatization, and efficiency : evidence from Pakistan. *Journal of Banking & Finance*, 29, 2381-2406.
- PAUL, C. J. M. 1999. *Cost Structure and the Measurement of Economic Performance :Productivity, Utilization, Cost economies and related Performance Indicators*, Amsterdam, Kluwer Academic Press.
- PERERA, S., SKULLY, M. & NGUYEN, M. 2012. Market concentration and pricing behaviour of Sri Lankan banks. *South Asian Journal of Global Business Research*, 1, 63-78.
- PERERA, S., SKULLY, M. & WICKRAMANAYAKE, J. 2007. Cost efficiency in South Asian banking: the impact of bank size, state ownership and stock exchange Listings. *International Review of Finance*, 7, 35-60.
- PERKINS, F. C. 1996. Productivity performance and priorities for the reform of China's state-owned enterprises. *Journal of Development Studies*, 32, 414-44.
- PERRY, P. 1992. Do banks gain or lose from inflation? *Journal of Retail Banking*, 14, 25-30.
- PI, L. & TIMME, S. G. 1993. Corporate control and bank efficiency. *Journal of Banking & Finance*, 17, 515-530.
- PITT, M. M. & LEE, L.-F. 1981. The measurement and sources of technical inefficiency in the Indonesian weaving industry. *Journal of Development Economics*, 9, 43-64.
- REAZ, M. & ARUN, T. 2006. Corporate governance in developing economies: perspective from the banking sector in Bangladesh. *Journal of Banking Regulation*, 7, 94-105.
- RESTI, A. 1997. Evaluating the cost-efficiency of the Italian banking system: what can be learned from the joint application of parametric and non-parametric techniques. *Journal of Banking & Finance*, 21, 221-250.
- REZITIS 2006. Productivity growth in the Greek banking industry : a non-parametric approach *Journal of Applied Economics*, 9, 119-138.
- REZVANIAN, R., ARISS, R. T. & MEHDIAN, S. M. 2011. Cost efficiency, technological progress and productivity growth of Chinese banking pre- and post- WTO accession. *Applied Financial Economics*, 21, 437-454.
- REZVANIAN, R. & MEHDIAN, S. 2002. An examination of cost structure and production performance of commercial banks in Singapore. *Journal of Banking & Finance*, 26, 79-98.
- RIVARD, R. J. & THOMAS, C. R. 1997. The effect of interstate banking on large bank holding company profitability and risk. *Journal of Economics and Business*, 49, 61-76.
- SALIM, R. A. 1999. *Capacity Realization and Productivity Growth in a Developing Country: Has economic reform had impact?*, Singapore, Ashgate.
- SALIM, R. A., HOQUE, M. Z. & SUYANTO 2010. The role of governance, ICT and badloans in Australian bank efficiency: an empirical study. *Asia Pacific Journal of Economics and Business*, 14, 18-36.

- SAPIENZA, P. 2004. The effects of government ownership on bank lending. *Journal of Financial Economics*, 72, 357-384.
- SATHYE, M. 2001. X-efficiency in Australian banking: an empirical investigation. *Journal of Banking & Finance*, 25, 613-630.
- SAUNDERS, A. E., STROCK, E. & TRAVLOS, N. 1990. Ownership structure, deregulations, and bank risk taking. *Journal of Finance*, 45, 643-54.
- SCHMIDT, P. 1985. Frontier production functions. *Econometric Reviews*, 4, 289-328.
- SCHMIDT, P. & LOVELL, C. A. K. 1979. Estimating technical and allocative inefficiency relative to stochastic production and cost frontiers *Journal of Econometrics*, 9, 343-366.
- SCHMIDT, P. & SICKLES, R. C. 1984. Production frontiers and panel data. *Journal of Business and Economic Statistics*, 2, 367-374.
- SEALEY, C. & LINDLEY, J. T. 1977. Inputs, outputs and a theory of production and cost at depository financial institution. *Journal of Finance*, 32, 1251-1266.
- SEN, K. & VAIDYA, R. R. 1997. *The Process of Financial Liberalization in India*, Delhi, Oxford University Press.
- SENSARMA, R. 2005. Cost and profit efficiency of Indian banks during 1986-2003: a stochastic frontier analysis. *Economic and Political Weekly*, 40, 1198-1209.
- SHAH, S. A.-M. H. 2009. Bangladesh Financial Sector :An agenda for further reforms. Manila: Asian Development Bank.
- SHAW, E. 1973. *Financial Deepening in Economic Development* New York, Oxford University Press.
- SHEN, C.-H. & LIN, C.-Y. 2012. Why government banks underperform: A political interference view. *Journal of Financial Intermediation*, 21, 181-202.
- SHEPHARD, R. W. 1953. *Cost and Production Functions*, Princeton, Princeton University Press.
- SHEPHARD, R. W. 1970. *Theory of Cost and Production functions*, Princeton, Princeton University Press.
- SHIN, D. J. & KIM, B. H. S. 2011. Efficiency of the banking industry structure in Korea. *Asian Economic Journal*, 25, 355-373.
- SHLEIFER, A. & VISHNY, R. 1997. A survey of corporate governance. *Journal of Finance*, 52, 737-783.
- SHLEIFER, A. & VISHNY, R. W. 1994. Politicians and firms. *The Quarterly Journal of Economics*, 109, 995-1025.
- SHORT, B. K. 1979. The relation between commercial bank profit rates and banking concentration in Canada, Western Europe and Japan. *Journal of Banking and Finance*, 3, 209-219.
- SICKLES, R. C., GOOD, D. & JOHNSON, R. L. 1986. Allocative distortions and the regulatory transition of the U.S. airline industry. *Journal of Econometrics*, 33, 143-163.

- SIMAR, L. 1992. Estimating efficiencies from frontier models with panel data: a comparison of parametric, non-parametric and semi-parametric methods with bootstrapping. *Journal of Productivity Analysis*, 3, 171-203.
- SIMAR, L. & WILSON, P. W. 2000. A general methodology for bootstrapping in non-parametric frontier models. *Journal of Applied Statistics*, 27, 779-802.
- SKULLY, M. T. 2002. Banking and corporate governance : some prudential issues. *Second International Conference on Banking and Finance*. Greece.
- SMIRLOCK, M. 1985. Evidence on the (non) relationship between concentration and profitability in banking. *Journal of Money, Credit and Banking*, 17, 69-83.
- SMITH, R. T. 1998. Banking competition and macroeconomic performance. *Journal of Money, Credit and Banking*, 30, 793-815.
- SOLOW, R. M. 1957. Technical change and the aggregate production function. *Review of Economics and Statistics*, 39, 312-320.
- SOPHASTIENPHONG, K. & KULATHUNGA, A. 2010. Getting Finance in South Asia. Washington D.C.: World Bank.
- SPONG, K. & SULLIVAN, R. J. 2007. Corporate governance and bank performance. In: GUP, B. E. (ed.) *Corporate Governance in Banking : A Global Perspective* Cheltenham: Edward Elgar Publishing Limited.
- STEVENSON, R. E. 1980. Likelihood functions for generalized stochastic frontier estimation. *Journal of Econometrics*, 13, 57-66.
- STIGLITZ, J. E. 1993. The role of the state in financial markets. *World Bank Economic Review*. Washington: World Bank.
- STIGLITZ, J. E. & WEISS, A. 1981. Credit rationing in markets with imperfect information. *American Economic Review*, 71, 393-410.
- STURM, J. & WILLIAMS, B. 2004. Foreign bank entry, deregulation and bank efficiency: lessons from the Australian experience. *Journal of Banking & Finance*, 28, 1775-1799.
- SUFIAN, F. & HABIBULLAH, M. S. 2009a. Bank specific and macroeconomic determinants of bank profitability : empirical evidence from the China banking sector. *Frontiers of Economics in China*, 4, 274-291.
- SUFIAN, F. & HABIBULLAH, M. S. 2009b. Determinants of bank profitability in a developing economy : empirical evidence from Bangladesh. *Journal of Business and Economic Statistics*, 10, 207-217.
- SUN, L. & CHANG, T.-P. 2011. A comprehensive analysis of the effects of risk measures on bank efficiency: evidence from emerging Asian countries. *Journal of Banking & Finance*, 35, 1727-1735.
- SUYANTO, BLOCH, H. & SALIM, R. A. 2012. Foreign direct investment spillovers and productivity growth in Indonesian garment and electronic manufacturing. *Journal of Development Studies*, 48, 1397-1411.
- SUYANTO, SALIM, R. A. & BLOCH, H. 2009. Does foreign direct investment lead to productivity spillovers? firm level evidence from Indonesia. *World Development*, 37, 1861-1876.

- SWAMY, P. A. V. B. 1970. Efficient inference in a random coefficient regression model. *Econometrica*, 38, 311-323.
- TALUKDAR, M. B. U. 2007. Corporate governance: an essential mechanism to curb malpractices by organizations. *Policy Notes*. Dhaka: Bangladesh Bank.
- TASLIM, M. A. 2001. Monetary policy and monetary programming in Bangladesh. *Bangladesh Development Studies*, 27, 81-99.
- THADDEN, E.-L. V. 2004. Bank capital adequacy regulation under the new Basel accord. *Journal of Financial Intermediation*, 13, 90-95.
- THANASSOULIS, E., PORTELA, M. C. S. & DESPIC, O. 2008. Data envelopment analysis : the mathematical programming approach to efficiency analysis. In: FRIED, H. O., LOVELL, C. A. K. & SCHMIDT, P. (eds.) *The Measurement of Productive Efficiency and Productivity Growth*. Oxford: Oxford University Press.
- TİRTİROĞLU, D., DANIELS, K. N. & TİRTİROĞLU, E. 1998. Total factor productivity growth and regulation in U.S. commercial banking during 1946-1995: an empirical investigation. *Journal of Economics and Business*, 50, 171-189.
- TULKENS, H. 1993. On FDH efficiency analysis: some methodological issues and applications to retail banking, courts and urban transit. *Journal of Productivity Analysis*, 4, 183-210.
- UYEMURA, D. G. & VAN DEVENTER, D. R. 1993. *Financial Risk Management in Banking*, Illinois, Bankers Publishing Company.
- VAN DEN BROECK, J., KOOP, G., OSIEWALSKI, J. & STEEL, M. F. J. 1994. Stochastic frontier models: A Bayesian perspective. *Journal of Econometrics*, 61, 273-303.
- WAHID, A. N. M. 1986. Expansion and organization of monetary sector: the case of Bangladesh. In: VIVEKANANDA, F. (ed.) *Bangladesh Economy : Some Selected Issues*. Stockholm: Writers Book Machine.
- WANG, D. & KUMBHAKAR, S. C. 2007. Economic reforms, efficiency and productivity in Chinese banking. *Journal of Regulatory Economics*, 32, 105-129.
- WANG, D. & KUMBHAKAR, S. C. 2009. Strategic groups and heterogeneous technologies: an application to the US banking industry. *Macroeconomics and Finance in Emerging Market Economics*, 2, 31-57.
- WANG, H.-J. & SCHMIDT, P. 2002. One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis*, 18, 129-144.
- WEI, Z., VARELA, O. & HASSAN, M. K. 2002. Ownership and performance in Chinese manufacturing industry. *Journal of Multinational Financial Management*, 12, 61-78.
- WESTMAN, H. 2011. The impact of management and board ownership on profitability in banks with different strategies. *Journal of Banking & Finance*, 35, 3300-3318.
- WHEELOCK, D. C. & WILSON, P. W. 1999. Technical progress, inefficiency, and productivity change in U.S. banking, 1984-1993. *Journal of Money, Credit and Banking*, 31, 212-234.
- WILLIAMS, B. 2003. Domestic and international determinants of bank profits: foreign banks in Australia. *Journal of Banking & Finance*, 27, 1185-1210.

- WILLIAMS, J. & NGUYEN, N. 2005. Financial liberalisation, crisis, and restructuring: A comparative study of bank performance and bank governance in South East Asia. *Journal of Banking & Finance*, 29, 2119-2154.
- WORLD BANK 2013. *World Development Indicator*. World Bank.
- WORLD BANK. 2014. *World Development Indicators* [Online]. The World Bank. Available: <http://data.worldbank.org/products/wdi>.
- ZHAO, T., CASU, B. & FERRARI, A. 2010. The impact of regulatory reforms on cost structure, ownership and competition in Indian banking. *Journal of Banking & Finance*, 34, 246-254.
- ZHENG, S. & BLOCH, H. 2014. Australia's mining productivity decline: implications for MFP measurement. *Journal of Productivity Analysis*, 41, 201-212.

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