EFFICIENCY, PRODUCTIVITY CHANGE AND MARKET STRUCTURE OF THE BANKING INDUSTRY IN SRI LANKA

A dissertation submitted by

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ABSTRACT

During the last 27 years, the banking industry in Sri Lanka has undergone a series of changes through financial reforms, advancement of communication and information technologies, globalisation of financial services, and economic development. Those changes should have had a considerable effect on efficiency, productivity change, market structure and performance in the banking industry. The motivation of this study is to investigate empirically the impact of those changes on the banking industry. Thus, this study aims to address three main research issues related to the banking industry in Sri Lanka, namely:

1. Whether deregulation of the financial services sector has led to improvement in efficiency and productivity gains.
2. Whether banks' inefficiency in the banking industry in Sri Lanka is determined by a set of microeconomic and macroeconomic variables.
3. Whether the changes in efficiency or changes in market structure have influenced the overall operational performance of banks in Sri Lanka.

This study adopts a non-parametric Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) to measure efficiency and productivity gains of banks in Sri Lanka using financial and other information representing all local banks over a sixteen year period from 1989 to 2004. Input and output variables are refined to represent the intermediation and assets transformation roles of banks. Window analysis of mean estimated efficiency scores in both aspects indicates a negative trend in estimated efficiency during the study period. However, the analysis of efficiency scores (intermediation) of different forms of banks shows a negative trend during the first half of the study period and a slight positive trend during the end of the second half. These results imply that deregulation may have failed to improve the efficiency of the Sri Lankan banking industry in the short-term. However, the expected benefits of deregulation can be achieved in the long-term. Interestingly, the two state-owned banks have responded poorly to the initial phase of Sri Lankan

financial reforms. However, the improved autonomy given to boards of management under the commercialisation process has led not only to improved efficiency, but also to the reduction of the efficiency gap between the state-owned banks and privately-owned banks. The analysis of efficiency scores (asset transformation) of different forms of banks records a stable trend in estimated efficiency. On the other hand, estimated MPIs show that Sri Lankan banks have focused on improving productivity in the asset transformation process rather than the intermediation process.

Analysis of determinants of technical efficiency shows that technical efficiency in intermediation has positive relationships with variables such as profitability, operational risk, purchased funds, liquidity and stock market capitalization; and negative relationships with variables such as product quality and line of business (commercial bank). Further, results show that efficiency in the asset transformation process has positive relationships with capital strength, operational risk, and market capitalisation; and negative relationships with line of business ownership (privately-owned banks) and old banks. The investigation of influence of market structure and efficiency on operational performance finds that banks' relative market power and technical efficiency have a significant influence on their return on assets (ROA). No evidence supports any relationship of net interest margin with variables such as market power, concentration and efficiency.

CERTIFICATION OF DISSERTATION

I certify that the work contained in this dissertation is entirely my own effort, except where otherwise acknowledged. I also certified that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

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Signature of Candidature

Date…….

ENDORSEMENT

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Signature of the Supervisor

Date…….

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ADA	-	Allocative data envelopment analysis
ADI	-	Authorised depository institutions
ASP	-	All share price index
ATM	-	Automatic teller machine
BCC	-	Banker, Charnes, and Cooper
CAMEL	-	Capital adequacy, assets quality, management quality, earnings ability and liquidity of banks
CAR	-	Capital-adequacy ratio
CAT	-	Productivity gain on catch-up
CBSL	-	Central Bank of Sri Lanka
CCR	-	Charnes, Cooper and Rhodes (1978) formulation
CD	-	Certificate of deposits
CIB	-	Credit information bureau
CLT	-	Central limit theory
COLS	-	Corrected ordinary least square method
CR	-	Concentration ratio
CRS	-	Constant return to scale
CSE	-	Colombo Stock Exchange
DEA	-	Data envelopment analysis
DFA	-	Distribution free approach
DMU	-	Decisions making units
DRS	-	Decreasing return to scale
EMU	-	European Monetary Union
EFS	-	Efficient structure hypothesis
FDH	-	Free disposal hull method
FRN	-	Productivity gain on frontier shift
GDP	-	Gross domestic product
GIM	-	Gross interest margin
GOBU	-	Government-owned-business-undertakings
HHI	-	Herfendathal Hix index
ICT	-	Information and communication technologies
IMF	-	International Monetary Fund

IRTS	-	Increasing return to scale
JB	-	Jarque-Bera test
M1	-	Narrow money
M2	-	Time and saving deposits plus the M1
M3	-	Broad money supply
MPI	-	Malmquist productivity index
NIM	-	Net interest margin
NSB	-	National Savings Bank
PERC	-	Public Enterprise Reform Commission
PFA	-	Production frontier analysis
PLC	-	Public limited company
PTE	-	Pure-technical efficiency
PTE(A)	-	PTE in assets transformation
PTE(I)	-	PTE in intermediations
REPO	-	Market for repurchasing treasury bills
RMP	-	Relative market power
RRDB	-	Regional rural development banks
RTS	-	Return to scale
SCP	-	Structure conduct performance
SE	-	Scale efficiency
SE(A)	-	SE in asset transformation
SE(I)	-	SE in intermediations
SFA	-	Stochastic frontier approach
SRR	-	Statutory reserve requirements
TB	-	Treasury bill
TE	-	Technical efficiency
TE(A)	-	TE in assets transformation
TE(I)	-	TE in intermediations
TFA	-	Thick frontier approach
TFP	-	Total factor productivity
UK	-	United Kingdom
USA	-	United State of America
VRS	-	Variable return to scale

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Efficient intermediation of funds from savers to borrowers enables the allocation of resources to their most productive uses. The more efficient a financial system is in such resource generation and in its allocation, the greater its contribution to productivity and economic growth (McKinnon 1973). Hence, an efficient financial intermediation system is a prime requirement for a country's economic development. Consequently, improvement in real returns in the economy may result in higher savings which would presumably, in turn, produce higher resource generation. Thus, development of the financial system is essential for the general enhancement of productivity and economic growth of a country.

This thesis will focus on the banking industry in Sri Lanka. The banking industry in Sri Lanka, which holds approximately 60% of the total financial assets of the country (World Bank 2003), is the main intermediary in the financial services sector in Sri Lanka. Therefore, efficiency and productivity of the banking industry is an important requirement for the development of the financial services sector. Prior to 1977, Sri Lankan policy makers relied on a planned economic system in which the markets were dominated by government institutions (Dunham & Kelegama 1996). After nearly 30 years of inward-looking economic policies and financial repression, the newly-elected Sri Lankan government (elected in 1977) introduced an economic-policy reforms package that paved the way for structural transformation of the overall economy (Dunham & Kelegama 1996). The reform package included

some drastic policy changes in relation to deregulation of the financial services sector, together with other economic reforms.

In response to the reforms, the financial services sector in Sri Lanka and the banking sector, in particular, have undergone substantial changes which may have impacted on efficiency and productivity change[1], and competition and market structure. The main driving forces behind these changes were financial deregulation, development in information and communication technologies and the globalization of the financial services industry in general. The consequent changes were observable in areas such as the scope of banking operations, number of banks and bank branches, technologies used and quality of human resources in the banking industry. These changes might ultimately be reflected in efficiency and productivity gains. Even though there is a growing body of literature that focuses on efficiency and productivity gains, market structure and the performance of banking industries in other countries (see Casu & Molyneux 2003; Chakrabarti & Chawla 2002; Girardone, Molyneux & Gardener 1997; Hondroyiannis, Lolos & Papapetrou 1999; Maudos & Pastor 2002), no major study has been conducted in Sri Lanka. This study empirically explores the impact of all these forces described above on efficiency and productivity gains, and market structure and operational performance of the banking industry in Sri Lanka.

1.2 Conceptual Framework

As mentioned previously, the banking industry in Sri Lanka has been influenced by the deregulation of the financial services sector, development in information and communication technologies (ICT) and globalisation of financial services industries. Figure 1.1 illustrates the way these forces have influenced the performance of the banking industry. The deregulation process, which began in 1977, is aimed at making structural changes in the financial services industries to enhance

[1] Productivity is defined as a ratio of output to input in a given production situation. However, efficiency relates the input and output in a given decision making unit with the best practice in the industry.

competition. Structural changes in the overall financial services sector have affected the banking industry greatly.

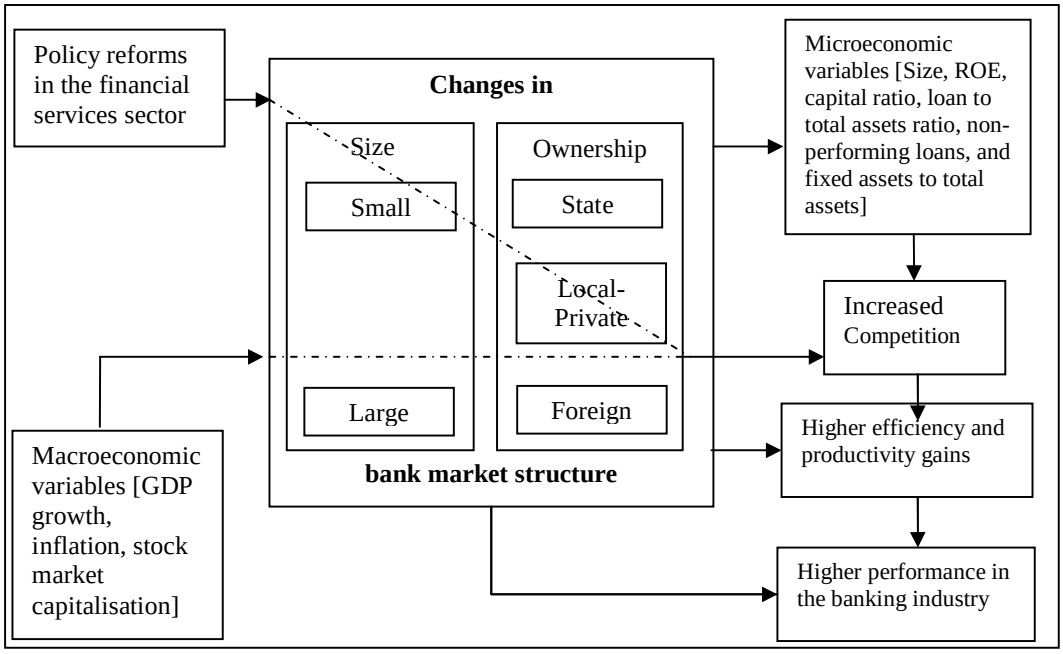


Figure 1.1: Financial reform, market structure, efficiency and productivity gains of the banking industry in Sri Lanka

The entry of new banks, as well as an expansion of branch networks in both privately-owned and state-owned banks, appeared to have increased the degree of competition in the market. Further, globalisation of the sector, together with developments in ICT, has improved the quality and quantity of products and services which are offered by banks. On the other hand, the changes in overall economic policies have improved microeconomic variables which may be directly or indirectly related to bank performance. Therefore, this study predicts that the recorded changes in the financial services industry may have affected overall bank performance through improved efficiency, productivity gains and structural changes in the banking market which enhanced the degree of competition. Based on this background, the study identifies three research issues.

1. Whether deregulation of the financial services sector has affected efficiency and productivity gains in the banking industry in Sri Lanka.

2. Whether inefficiency in the banking industry in Sri Lanka is determined by a set of microeconomic and macroeconomic variables.
3. Whether the changes in efficiency or changes in market structure have influenced the overall performance of the banks in Sri Lanka and, if so, how.

1.3 Rationale for the Research

As explained above, efficiency and productivity gains of the banks, as well as market structure of the banking industry, have been regarded as crucial areas in contemporary public policy concerned with a country's economic development. Empirical analysis of efficiency, productivity change, and market structure is a vital requirement for further policy changes. Accordingly, studies in these areas are important in the following aspects.

First, improvements in efficiency and productivity gains in financial institutions are a vital requirement for providing a more efficient system of asset allocation in the financial services sector. Since Sri Lanka has a bank-led financial services sector, efficiency and productivity gains in firms in the banking industry are more important for providing supportive financial infrastructure for economic development. Improvements in efficiency and productivity gains may reduce the cost of intermediation, which directly affects the intermediation margin in the market.

Secondly, this study addresses a contemporary policy issue in relation to market structure. It examines how the banking structure, improvement in efficiency and productivity change affect bank performance (measured by profitability and net interest margins). This type of analysis is essential in providing evidence for policy changes related to market competition.

It should be noted that there are large numbers of studies of economic liberalisation in Sri Lanka. However, only a few studies have focused on financial liberalisation in Sri Lanka. To the best of the author's knowledge, no in-depth study has been conducted to investigate the impact of financial deregulation on efficiency and productivity changes in the banking industry in Sri Lanka. Thus, this research

intends to fill a gap in research as the first in-depth study in to efficiency, productivity, and market structure of the banking industry in Sri Lanka.

1.4 Objectives of the Research

The main objective of the research is to examine how changes which occurred in the financial services sector during the 16 year period (1989-2004) affected the efficiency, productivity change, and market structure of the banking industry in Sri Lanka. Furthermore, this research is aimed at achieving the following specific objectives:

1. To investigate the banks' efficiency and productivity improvements gained during the post-liberalisation era by focusing on efficiency and productivity gains as a primary method for creating a more economical and efficient banking industry in Sri Lanka.
2. To undertake a comprehensive review of financial reforms and their impact on the banking industry.
3. To investigate determinants of efficiency of banks in Sri Lanka and their significance.
4. To conduct a complementary analysis using the structure-conduct-performance literature to understand the interaction of market structure, efficiency and banks' operational performance.

1.5 Propositions and Hypotheses

Since 1977, the banking industry in Sri Lanka has undergone a transition period in response to the regulatory reforms introduced and resultant changes in the operational environment of the industry[2]. The regulatory reforms aimed at enhancing the efficiency and productivity gains of the industry. Those reforms also led to changes in the structure of the banking industry. Together with financial reforms, globalisation and developments in ICT have also led to changes in the operational

[2] More detailed discussion on regulatory and environmental changes in the financial services sector is presented in Chapter Two.

environment of the banking industry in Sri Lanka. These changes have been used as the rationale for the development of the following three propositions.

Proposition I. Financial reforms have improved the efficiency and productivity gains of the banking industry in Sri Lanka.

Proposition II. The efficiency of banks in Sri Lanka is affected by a range of microeconomic and macroeconomic factors, together with financial deregulation.

Proposition III. Improvements in efficiency have influenced the banks' operational performance than changes in the structure of the market.

The study hypothesises that financial reforms have improved the banks' efficiency in Sri Lanka. The above mentioned proposition are analysed in Chapter Four to Five. Chapter Four addresses the first proposition through assessing and analysing banks' efficiency and productivity change. Chapter Five addresses the second proposition. A range of macroeconomic and microeconomic factors has been traced as factors which may influence bank efficiency. The hypothesised relationships for each factor, with estimated efficiency scores and evidence found in the study, have been recorded in the chapter. Chapter Six addresses the third proposition using four joint hypotheses. These hypotheses investigate the influence of market structure and technical efficiency on banks' operational performance (measured in profitability and net interest margin).

1.6 Methodology

The study uses a research framework which comprises three phases to examine three research propositions. Methodologies, results and discussion in each phase are separately presented in three of the following chapters.

The first phase—Estimation and decomposition of bank efficiency (Chapter 4): The first study phase examines Proposition I. For that, efficiency of individual banks for each year during the sample period is estimated using a non-parametric frontier approach called data envelopment analysis (DEA). Using constant and variable

return to scale DEA models, technical efficiency, scale efficiency and pure technical efficiency are estimated. Furthermore, descriptive statistics, together with Mann-Whitney test scores, are used to identify the efficiency differences in different forms of banks. In addition, Malmquist productivity indices (MPI) are used to examine the productivity improvements recorded from different sources during the study period.

The second phase—Determinants of bank efficiency in Sri Lanka (Chapter 5): The second phase is used to empirically investigate determinants of technical efficiency (Proposition II). Since dependent variables are estimated and limited this phase uses a truncated Tobit regression model.

The third phase—Market structure and efficiency (Chapter 6): This phase is based on Proposition III. It investigates the influence of market structure and efficiency on banks' operational performance measured by return on total assets and net interest margin. The research framework proposed by Berger and Hannan (1993) has been used as an appropriate empirical framework to test influences of the market structure and the estimated efficiency on banks' operational performance.

1.7 Contribution of the Study

There are studies of financial reforms and their influence on banks' efficiency and productivity change which have been conducted in the banking industries in other countries. However, despite financial services sector reforms first being introduced almost 27 years ago, no such study has been conducted in the banking industry in Sri Lanka. Thus, this study attempts to fill the gap in literature by providing empirical evidence to the existing body of knowledge in efficiency and productivity change, market structure and performance in the banking industry in a developing country.

Accordingly, the research contributes to knowledge of reforms in the financial services sector and their influence on the banking industry in Sri Lanka in four respects. Firstly, the study contributes to government policy with an empirical evaluation of the impact of deregulation and subsequent changes in the financial services sector and their influences on the banking industry. Secondly, it contributes

to the existing literature on banking efficiency and productivity change by providing evidence from the banking industry in Sri Lanka. Thirdly, the study contributes to the existing literature in 'structure conduct performance' by empirically investigating the influence of market structure and efficiency on banks' operational performance from a developing country perspective. Further, the findings of this study may assist policy makers and bankers in understanding the way the regulatory changes might affect banks' efficiency, productivity change, market structure and operational performance.

1.8 Organisation of the Thesis

This dissertation contains seven chapters, of which three chapters are empirical by design. The first chapter presents an introduction to the study and provides the background, rationale, objectives, hypotheses, methodology and study outline.

Chapter Two reviews literature related to the financial reforms. The aim of this chapter is to highlight the operational environment of the banking industry of Sri Lanka during the pre and post-deregulation period. The issues highlighted in this chapter are used to explain the trends in estimated efficiency scores in Chapter Four. Chapter Two contains three sections which cover literature related to motives, modes and outcomes of financial deregulation processes, financial reforms in Sri Lanka and the impact of financial reforms on the banking industry in Sri Lanka.

Chapter Three reviews literature on efficiency and productivity change and their application in the banking industry. The aim of this particular chapter is to form a theoretical framework for assessment of efficiency and productivity chanage of the banking industry in Sri Lanka. Findings in this chapter have been used to formulate the analytical framework for Chapter Four.

The next three chapters of this dissertation are used to present the details of the empirical analyses conducted in the study. The study comprises three stages, as explained in section 1.6 of this chapter. Methodologies used in empirical analyses, results, discussions and conclusions in each phase are presented in these chapters.

Accordingly, the Chapter Four presents an analysis of efficiency and productivity change of the banking industry in Sri Lanka. It investigates the trends in estimated efficiency scores and the possible reasons for them. Based on the findings of that chapter, Chapter Five investigates the impact of the other macroeconomic and microeconomic factors on banks' efficiency.

The aim of Chapter Six is to investigate the relationship between market structure and the bank efficiency. It uses structure-conduct-performance (SCP) literature to investigate the influence of efficiency and market structure on the operational performance of banks.

The seventh and final chapter presents overall findings and policy implications of the study. It also discusses limitations faced in the study and makes recommendations for further research.

CHAPTER TWO

DEREGULATION, MARKET STRUCTURE AND THE BANKING INDUSTRY IN SRI LANKA

2.1 Introduction

Currently, and in the recent past, the private-sector in Sri Lanka has been seen as vital to economic development. Governments throughout advanced nations have introduced economic policies to promote private-sector involvement in economic decision making (Fu and Heffernan, 2005; Harper and Leslie, 1993; Hogan, 1992; Maghyereh, 2004). Following the global trend, Sri Lanka also commenced economic reforms in 1977. These reforms have changed market structures and the degree of market competition in the banking industry. This chapter aims to present a comprehensive review of financial reforms and their influences on the banking industry in Sri Lanka.

The chapter consists of four sections. The next section introduces means and modes of financial sector deregulation in general. The third section presents the sequence of financial services sector reforms in Sri Lanka. The fourth section evaluates how the reforms in the financial services sector have influenced the banking industry. The last section summarises the findings of initial analysis of financial reforms and their influence on the banking industry.

2.2 Deregulation in the Financial Services Sector

This section reviews the available literature that considers deregulation and related issues. The processes, modes and influences of deregulation are discussed. Evidence and accompanying analyses from previous empirical studies of Sri Lanka's and other nations' deregulation processes and their evident consequences are outlined and briefly compared.

2.2.1 Deregulation

The financial services sector's circumstances influence a nation's capital accumulation and allocation processes throughout an economy (McKinnon, 1973). These circumstances fundamentally influence the nation's social, economic and political environments. Since a nation's financial sector is the major source of capital accumulation, both the government and the private-sectors play a significant role. However, economists typically have emphasised the necessity of reducing government intervention in the financial services sector through deregulation. By this political process, policy makers have focussed on improving the private-sector operations throughout their nation's financial services industry.

Deregulation does not merely mean removing all legal restrictions imposed on the market. The existence of a comprehensive and stable set of laws and procedures is necessary for more secure, stable and efficient financial markets. Pertinent legislation allows parties to undertake financial transactions with a degree of certainty (Hogan, 1992). Pertinent and well defined regulations are 'legislative and administrative arrangements where the activities of market participants are subject to the direction of and scrutiny by various authorities' (Hogan 1992, p1). Appropriate regulation should specify both the qualitative circumstances of business activities conducted by banks and the quantitative considerations of asset portfolios (Hogan, 1992). Hence, the term deregulation should be interpreted strictly in terms of the context of the social environment previously fostered by the prior regulation of the qualitative and quantitative aspects of banking and financial activities.

Dunham and Kelegama (1996, p. 254) defined economic liberalisation as a 'process of transition from an inward looking, heavily protected and highly regulated economic regime toward an open economy that strives for efficiency through competition in the market'. Accordingly, liberalisation of financial sectors aimed to improve the allocation of resources to lead to greater efficiency, to expand output and to accelerate growth.

McKinnon (1973) and Shaw (1973) advocate financial deregulation to free banking from financial repression, to increase deposit rates and to enhance financial deepening. Their analyses inferred that financial liberalisation may encourage greater competition among financial institutions while enhancing the efficiency and productivity gains of the sector's financial institutions. McKinnon (1973) and Shaw (1973) also noted that removal of interest rate ceilings may encourage savings in the household sector. In their view, liberalisation of a nation's financial services sector may lead to an increase in the volume and the quality of overall national investment (McKinnon, 1973; Shaw, 1973). However, many of the countries that deregulated their financial services industries were unable to reap the anticipated benefits because of other fundamental factors such as the prevailing social, political and economic environments (Arestis, Nissanke and Stein, 2003).

2.2.2 Reasons for the regulation of the financial services industry

Stigler (1971) noted that the need for regulation in a particular industry may stem from different sources. In some industries, regulation may be formulated and implemented primarily for the industries' benefit. In some other industries, regulation has been enforced for some other reasons (Stigler, 1971). Moreover, Stigler (1971) showed that private interest theory and public interest theory can be used to explain motives of regulation. The 'private interest theory' proposes that well organized groups use the coercive power of the state to capture rents at the expense of less privileged groups. Consequently, regulation is instituted for the protection of these groups (Stigler, 1971). The 'public interest theory' posits that government intervention is necessary to avert market failures and maximise social

welfare (Kroszner and Strahan, 1999). The public interest theory sees need for welfare-enhancing regulation but not for regulation that reduces competition (Kroszner and Strahan, 1999).

Many studies have supported the private interest theory as the theory which best describes regulation of the financial services industry. Using the event of the elimination of restrictions on bank branching in different states in the USA, Kroszner and Strahan (1999) examined the explanatory power of these two theories. Their study noted that the beneficiaries of the branching regulation had supported a coalition favouring geographical restrictions despite its cost to consumers in terms of financial services.

La-Porta, Lopez-de-Silanes and Shleifer (2002) provided two competing views regarding government intervention in the banking industry. The 'development view' emphasises the necessity of government intervention in financial development for economic growth. It notes that privately-owned commercial banks were the key institutions for channelling savings into industries in industrial countries in the nineteenth century. Since privately-owned banks in less-developed countries were not able to provide the basic borrowing needs of the society, governments actively intervened in the banking sector (La-Porta, Lopez-de-Silanes and Shleifer, 2002). The second view, the 'political view', argues that government intervention in the banking industry has resulted from the determination of politicians to control investment.

This viewpoint is best illustrated by the financial environments in developing countries (especially in Sri Lanka). In such countries, governments intervene in the banking industry in different ways, for example, by creating subsidiaries, imposing regulations, and by owning banking firms. Incorporating information from 92 countries, La-Porta, Lopez-de-Silanes and Shleifer (2002) concluded that government ownership in banking is commonplace and pervasive throughout the world. Government ownership of banks is greater in countries with low per-capita incomes, under-developed financial systems, interventionist and inefficient

governments and poor protection of property rights. Their research revealed the countries that have higher government intervention have characteristically relatively low economic growth.

2.2.3 Modes of deregulation

As explained by Dunham and Kelegama (1996), modes of deregulation cover three aspects; (1) the speed of deregulation, (2) the stages of deregulation and (3) the order of deregulation of various segments in the market. The first, speed of deregulation, considers whether the process of deregulation should be gradual or 'all at once'. Dunham and Kelegama (1996) pointed out that if deregulation led to a regime with a more superior, less distorted market system, it is preferable to introduce new policies as rapidly as possible. However, in reality, factors such as the social cost of adjustment which may create political consequences, microeconomic situations, income distributions and protection of local industries may limit the speed of reforms. The second, stages of deregulation, implied that an economic system may progress into a fully liberalised economic system based on a few stages, depending on the structure of the economy. The third indicates the order of liberalising different markets such as commodity, labour and financial markets.

Different financial reform measures have been implemented in different countries. Hogan (1992) identified three main areas of financial reform: namely, relaxation of operating constraints; lifting barriers to entry of foreign banks; and strengthening of prudential standards. Abiad and Mody (2000) identified six modes of financial reforms: namely, policies related to credit control, interest rate controls, entry norms, prudential regulations and security markets, as well as policies relating to privatization and international financial transactions. Their research noted that the nature, extent and timing of financial reforms differ from country to country. Different countries have used different approaches for financial reforms, ranging from minor modification to complete overhauls. Abiad and Mody's (2000) findings suggested that:

- countries whose financial sectors are fully repressed are the ones with the strongest tendency to maintain their policy stance and hence to stay fully repressed;
- the direction of the chosen actions is not predetermined;
- different types of crises have systematically different effects on financial sector policy;
- political cycles and political orientation matter and external influence has a moderate, but not statistically significant, effect on reform.

However, reforms need not be all-or-nothing. If political conditions are such that large-scale reforms are not feasible, then it may still be worth implementing the few readily-feasible reforms (Abiad and Mody, 2000). Since the reform process tends to create its own momentum, even a small reform may potentially constitute a considerable victory for the policy makers. Secondly, there is scope for taking advantage of certain circumstances in which policy changes become more acceptable:

- Big economic crises are generally found to have led to facilitate reforms. For example, governments have used currency crises, in particular, to push through reforms (Abiad and Mody, 2000; Hoj et al., 2006).
- Reforms in trading partners tend to go along with stronger domestic product market reforms (whereas the association with labour market reforms is more ambiguous) (Abiad and Mody, 2000; Hoj et al., 2006).
- The longer the period that the governments in office contributed to further reforms but, on average, left -of- centre governments tend to undertake less reform (Hoj et al., 2006).
- The beginning of a new political term is a circumstance where policy changes are more acceptable (Abiad and Mody, 2000).

Various countries have experienced different outcomes as a consequence of the introduction of financial services sector reforms. Financial reforms in Spain started with the removal of interest rate ceilings in 1970. However, the banking crises

during 1978-1984 reduced the momentum of deregulation (Grifell-Tatje and Lovell, 1996). It was not until 25 years later that branching restrictions on saving banks were removed in 1995. In 1997, investment and reserve requirements were relaxed. Deregulation in the Australian context has involved a controlled removal of restrictions on the quantity, quality and pricing standards of financial services offered by banks (Hogan, 1992). To harmonise banking regulation with the European Monetary Union (EMU) the Turkish government imposed structural changes in the financial services sector (Isik and Hassan, 2003). Those changes focussed on freeing foreign exchange and interest rates from government intervention, thereby allowing foreign exchange deposits for residents and non-residents; permitting new forms of financial institutions; and granting more freedom for operational activities.

In the United Kingdom (UK), deregulation enhanced diversification and merger activities and the de-mutualization of segments of both life assurance companies and the building society industry (Drake, 2001). Deregulation and its consequences in Greece were similar to those of Spain - both were aimed at harmonising the regulatory system with the EMU by freeing interest rates; abolition of various credit controls; development of capital market; enhancement of competition from non-bank institutions; and relaxation of entry-exit norms. These examples demonstrate that the expectation, nature and extent of deregulation have differed significantly from country to country.

2.2.4 Impact of deregulation

The impact of deregulation is highly dependent on prevailing social factors, such as economic freedom and 'property rights' protection (Demirguc-Kunt, Laeven and Levine, 2003). The regulatory system in a well-established economic system, which provides adequate economic freedom, facilitates a harmonious operation of a nation's banking activities. Demirguc-Kunt, Laeven and Levine (2003) examined the consequences of bank regulation, bank concentration and institutional setting on bank margins. Their extensive research incorporated data from 1,400 banks across

72 countries. Their findings were that tighter regulations on bank entry and bank activities, together with the rate of inflation, increased net interest margins. Banks in countries which have strict entry controls, operational barriers on off-balance-sheet activities, high reserve requirements and greater operational restrictions have a relatively high interest rate margin. They also reported that greater economic freedom had reduced the unfavourable consequences of bank regulation.

Regulation by the government can restrict operational activities in the commercial banking sector. There are two types of entry restrictions, namely, expansion restrictions on existing banks' branch networks and the prevention or limiting of the entry of new banks. Restricting bank branching limits a bank's ability to diversify its portfolio risk. Both restrictions may adversely affect the free entry to and exit from the banking industry and thereby diminish market competition. Jayeratne and Strahan (1996) examined the outcomes of the removal of entry restrictions on banking efficiency in the United States of America (USA). Their research identified a sharp reduction in banks' operating costs and loan losses after states removed the bank branching restriction within and between states. They concluded that branching restrictions reduced the performance of typical banking activities by passing economic rents to bank borrowers.

The preceding section presented a brief discussion of the meaning of deregulation, reasons for regulating the financial services sector, mode of reforms and expected outcome of financial reforms. The main objective of deregulation is enhancing efficiency and productivity gains by reinforcing competitiveness in the financial services sector. There are a limited number of studies which evaluate the financial reforms and their influence. These studies focus on different issues related to deregulation, for example, improvement in efficiency and productivity gains and the changes in market competition; only a few studies have focused on less-developed countries such as Sri Lanka.

2.3 Financial Reforms in Sri Lanka

This section presents a review of the banking industry and its significance in the financial system in Sri Lanka. It begins by presenting a brief review of the historical background and follows with the deregulation process and its influences on the banking industry in Sri Lanka. The reforms and their expected consequences are discussed. The institutional structure of Sri Lanka's financial services industry and the significance of the banking industry in the financial system are outlined. This section also shows that the microeconomic environment directly influences the performance of the financial system. It ends with a discussion of the impact of financial reforms on the banking industry in Sri Lanka.

2.3.1 Historical background

Banking in Sri Lanka was introduced by British planters in the country's Central Province at the beginning of the nineteenth century. Sri Lanka had a liberal economic system with little direct government involvement in economic activities until the early 1950s. For example, there was neither government intervention in international trade nor exchange controls (Karunasena, 1999). Subsidiaries of foreign banks dominated the banking sector which mainly met the financial requirements of international trade and the working capital requirements of Sri Lanka's plantation sector.

Direct intervention by the government in the banking industry began after the country gained its independence from Britain in 1948. The goal of a self-sufficient economic system led the government to set priority areas for development, namely to control the allocation of loan funds; to intervene in setting interest rates; and to introduce strict foreign exchange regulations. The government resolved to use banks as the main vehicles for mobilizing financial resources in the process of economic development and for providing the most fundamental financial intermediary and payment functions.

The government of Sri Lanka legislated to develop and to expand financial services to remote areas by setting up the Central Bank of Sri Lanka (CBSL) in 1950 (Fernando, 1991). In 1961, the Bank of Ceylon[1] was nationalised and the Peoples' Bank was established, thus increasing the government's position in the financial services sector (Fernando, 1991). The state banks were allowed to increase their share of the banking sector gradually. This was achieved by legislating to allow these banks to expand their services into new areas such as specialized lending facilities, international trade finance and as the sole bankers for the government (Karunasena, 1999). The private-sector was not allowed to establish new banks or to expand existing operations. Thus, as with many other countries, the banking sector in Sri Lanka is led by the state banks, which have taken the role of assigning funds from savers to borrowers. Today, the banking sector is the main provider of the funding needs of both the corporate sector as well as the household sector.

2.3.2 Objectives of deregulation[2]

In 1977, the newly-elected government introduced open economic policies to encourage the private-sector to lead economic decision-making in the country (Karunasena, 1999). At the beginning, economic reforms mainly targeted trade liberalisation. Jayesundara and Indrarathna (1991) outlined five main issues which the financial reforms in Sri Lanka were intended to address:

1. Development of an effective financial system composed of efficient banking and financial institutions for the mobilisation of domestic resources;
2. Elimination of institutional barriers and removal of other policy-imposed distortions to encourage competition in the financial sector and thereby reduce intermediation costs;
3. Strengthening of the regulatory environment in the financial services sector;
4. Introduction of a market-based interest rates structure; and
5. Liberalisation of financial transactions.

[1] Bank of Ceylon commenced its operations in 1931 as a private bank. Currently, both the Bank of Ceylon and the Peoples' Bank are functioning as state-owned banks.

[2] Discussion in this section is mainly based on Central Bank of Sri Lanka (CBSL) annual reports in various years.

Financial reforms in Sri Lanka were designed to establish a finance environment favourable to rapid and sustainable economic growth through greater savings and investment. Specific government legislation focused on the private-sector, while coordinating monetary and financial policies for the development of the financial sector. As an example, CBSL (1999) identified 12 major areas to be considered in future economic reforms in Sri Lanka. Among them, four areas[3] are directly related to the financial services sector.

However, the Sri Lankan government relied on 'gradual reforms' rather than 'all at once reforms'. This seemed appropriate because of the lack of experience in open economic policies and a lack of the skilled human resources required. The circumstances dictated the legislation that slowed down the reform process.

2.3.3 Main phases in deregulation

Three phases are evident in the deregulation of the financial services sector in Sri Lanka (i.e. 1977-1988; 1988-1995 and after 1995 to date). The sequence of the reform process is outlined in Table 2.1. Initial reforms from 1977 to 1988 were intended to expand the institutional structure of the financial services sector. The financial reforms introduced since then focused on two main issues: promotion of financial intermediation through the establishment and promotion of sound financial infrastructure and the deregulation of interest rates. The remaining part of this section highlights the major reform measures introduced in each phase.

[3] The CBSL Annual Report (1999) recognised 12 issues to be included in the future economic reform agendas in Sri Lanka. Among them, there were four issues which may be directly or indirectly related to the financial services sector. They are (1) improvement of efficiency of the state banks, (2) further development of the domestic debt and capital market by permitting foreign investor participation, (3) gradual relaxation of all exchange controls and (4) gradual move towards a complete free float of the exchange rate system.

Table 2.1: Financial services sector reforms from 1977-2003[4]

Year	Action
1977	• Abandonment of the former exchange control regulation by introducing a unified exchange system under a floating exchange rate regime
1979	• Relaxation of operational restrictions by: – Opening the banking market to foreign participants – Granting new banking licences to the private-sector – Allowing existing banks to expand their branch networks • National Development Bank was incorporated to provide long-term funds for the development of industrial, agricultural and commercial activities • Banks were allowed to establish foreign currency banking units to promote offshore banking services and international money market transactions
1980	• M_2[5] and broad monetary aggregate was introduced to monitor money supply in the economy • The export credit refinance facility was increased by 15% to Rs.30 million • The bank rate was increased from 10% to 12% • Commercial banks' lending and savings ratios were increased
1981	• Statutory reserve requirements (SRR) were increased with respect to: – demand deposit from 12% to14% – savings deposit from 5% to 6% • For the first time, CBSL used quantitative measures such as open market operations and the variation of SRR to control money supply • The American Express Bank introduced CDs to the local market. CBSL encouraged other institutions to use such instruments to attract black money to the market. • CBSL incorporated a secondary market for treasury bills (TB) and offered TBs at discounted rates between 15% to 16% • Government incorporated the Employee Trust Funds and National Insurance Corporations • CBSL granted licences to establish several new finance companies
1982	• Two merchant banks were established by Bank of Ceylon and Peoples' Bank • Credit ceilings on bank credit to residents or companies registered in Sri Lanka for the purchase of estates or immovable property were withdrawn • Colombo Stock Exchange Ltd was established
1983	• Credit ceilings on selected non-priority sectors were removed
1984	• National Saving Bank (NSB) was allowed to set its own deposit rates • State Mortgage and Investment Bank was reorganised as a specialised housing bank and was authorised to accept deposits
1985	• CBSL established 17 regional rural development banks (RRDB) to enhance savings mobilisation in rural areas
1987	• Securities Council was established for regulating the Colombo stock market • Two new private-sector commercial banks (Sampath Bank and Seylan Bank) were incorporated and commenced business • CBSL removed the limits placed on commercial banks re the issue of CDs

[4] This table was compiled using information in Ariyarathna (1993), Athukorala and Rajapatirana (2000), Bandara (1998), Cooray (2000), Dunham and Kelegama (1997), Fernando (1991), Karunasena (1999) Karunasena and Jayatissa (1987), Karunatilaka (1986; 1988), Yapa (2003) and various issues of CBSL annual reports.

[5] M_2 includes currency in use and time and savings deposits.

Table 2.1: Financial services sector reforms from 1977-2003 (Continued)

Year	Action
1988	• The Banking Act 1988 gave more power to the CBSL for regulation and control of banking in Sri Lanka
1990	• CBSL established the Credit Information Bureau (CIB) to function as a resources base for banks in screening borrowers to avoid loan defaults
1991	• Two state-owned commercial banks have asked to make sufficient provisions for non-performed loans
1992	• Disclosure requirements and loan recovery mechanisms were introduced
1993	• CBSL established a market (REPO-market) for repurchasing treasury bills with a view to establishing the lower end of the call money market • The private-sector started to issue commercial paper for covering short-term funding needs
1994	• Acceptance of article VIII of the International Monetary Fund (IMF) agreement allowed external 'liberalisation' • Commercial banks started to issue international credit cards
1998	• CBSL introduced bidding through electronic means in government bond market
1999	• The CBSL: – further strengthened its supervising role by imposing 10% minimum capital requirements, specific areas which should be covered in auditors' reports and measures which were to be taken on non-performing loans – introduced specified disclosure requirements to all banks as a means of promoting a sound and efficient banking system – set the single borrower limits to 30% of the capital of the banks as of the end of its preceding financial year • The CBSL started to publish Sri Lanka's inter bank offer rate (SLIBOR) from June • The stock market was opened to foreign individual and institutional investors
2000	• Limits on foreign ownership of local commercial banks and insurance companies were raised to 60% and 90% respectively • CBSL allowed independent floating of the exchange rate
2002	• The financial sector reform committee was established • The lower limit on Statutory Reserve Requirements was removed • Minimum required maturity period of deposits in finance companies was reduced to one month from three months • Prudential norms applicable to the domestic banking units were extended to the offshore banking units • Stamp duty and the national security levy on financial transactions were removed • Debit tax on all withdrawals from checking accounts was introduced
2003	• CBSL reduced the 'repurchase rate' and the 'reserve repurchase rate' by 225 basis points • Daily determination of SRR on commercial banks' deposits was introduced • The risk-weighted capital-adequacy ratio (CAR) for banks was raised by 10%

During the first phase of reforms, the banking industry was opened to new entrants, having been closed for more than 30 years. The private-sector was allowed to establish new banks subject to minimum capital requirements. At the same time, the banking industry was opened to foreign banks. For all practical purposes, domestic banks were permitted to open new branches after gaining permission from the CBSL. Accordingly, the government was directly involved in expanding branch networks of state-owned banks throughout the country. However, the expansion of the branch networks of state-owned banks was aimed at enhancing the popularity of the governing political party. (Moreover, the government used state banks to provide employment opportunities to political supporters resulting in excess employment in the banks).

Initial steps to let market forces determine interest rates were taken by creating an open market for government treasury bills and bonds in 1993. Restrictions on the foreign exchange market were relaxed. Banks were allowed to open foreign currency banking units. However, a reversal of economic reforms occurred in the middle of the 1980s. During the initial period, Sri Lanka's foreign exchange rate appreciated noticeably due to the huge foreign currency inflow for three major foreign-funded development projects (Dunham and Kelegama, 1997). This had the effect of decreasing the export income of the country and increasing the trade account deficit. Hence, in the mid 1980s, the government reintroduced preferential credit facilities for some sectors. On the other hand, the reform process was further undermined by the escalated ethnic crises after 1983 and the insurgencies during the 1987-1989 periods. Furthermore, as indicated by Dunham and Kelegama, (1996), consequent high interest rates, high inflation and the greater expense of welfare and defence reduced the speed of reform processes.

The second phase of deregulation commenced after the re-election of the ruling party for the third term, though under a new leadership. The new leadership managed to crush the insurgents in the south in 1989 and earned an opportunity for accelerating the economic reforms (Yapa, 2003). As explained by Dunham and Kelegama (1996), the second stage of liberalisation reforms was aimed at

stabilisation of the economy and further liberalisation to promote the private-sector as an effective 'engine of growth'. Accordingly, the government's fiscal policy aimed to reduce the budget deficit. The privatisation process was expedited using a popular term 'Peoplisation' (Salih,1999). During this period many of the government corporations were privatised. The government made some unsuccessful attempts to privatise the two state banks which led to frequent work stoppages in the banking sector (CBSL, 2000).

In 1994, a third regime of reforms commenced after a left-wing alliance came into power. The alliance did not approve the economic deregulation mechanism of the previous government. However, in the political campaign, they pledged to continue economic reforms even though they believed that the state should intervene in priority sectors to provide better services. Political lobbying against the privatisation of state banks by the strong labour unions in the banking sector also affected the reforms. In 1996, the government created the Public Enterprise Reform Commission (PERC). PERC was entrusted to find alternative ways to enhance the performance of government-owned-business-undertakings (GOBU) and to stem growing public criticism.

As an alternative to the privatisation of state banks, the government decided to reorganize two state-owned banks using a process called commercialization. State-owned banks were converted into limited public companies giving some freedom to bank management to take radical decisions on the banks' operations. Further, the government forced a write-off of non-performing assets in state-owned banks (Bank of Ceylon, 1999; People's Bank, 1999). The state banks' management were given authority to recruit consultants with international reputations for the reorganization. The main aim of these initiatives was to improve the banking services offered by the state banks.

During the last three decades, various governments in Sri Lanka have introduced different policies to liberalise the financial services sector. The major reforms (see

Table 2.1) in the financial services sector were in the following areas (Karunasena and Jayatissa, 1987):

- Deregulation of the financial industry (relaxation of entry/exit norms, reduction in public ownership in banking industry);
- Reforms of institutions and instruments;
- Allowing interest rates to respond to market forces;
- Allowing credit to be allocated according to market dictates;
- Reducing the cost of financial intermediation;
- Strengthening the legal, accounting and regulatory frameworks for financial institutions;
- Development of money, capital and debt markets; and
- Giving operational flexibility to banks in the management of their assets and liabilities.

These reforms, which were very similar to those made in Australia, facilitated the entry of new financial services providers including unit trusts, funds managers, venture capitalists and investment bankers. Removal of entry restrictions also allowed the entry of foreign banks and the expansion of the activities of the existing foreign banks. The government privatised the two major development banks, the National Development Bank and the Development Finance Corporation. Commercial banks were encouraged to offer new forms of financial products and facilities such as credit cards, automatic teller machines (ATM), non-residence foreign-currency accounts and branded deposits schemes. In 1987, Sampath Bank and Seylan Bank entered the market as privately-owned commercial banks. However, the government continued to function as the major participant in the commercial banking industry by retaining the two large commercial banks, namely the Bank of Ceylon and the Peoples' Bank.

The previous section summarised the major reform measures introduced during the last 23-year period. As explained above, Sri Lanka has opted to use gradual reforms rather than 'all at once'. However, measures have been taken for liberalising the

financial services sector at the initial stage of economic deregulation. Moreover, the reform process has taken a relatively long time. However, even today, policy makers are not able to introduce sufficient measures to deregulate the banking industry from government intervention. Previous researchers have suggested that introduction of economic reforms at the most appropriate time is a major factor underlying the success of deregulation.

2.3.4 Setbacks to deregulation

As explained previously, beginning in 1977, the government introduced various measures to deregulate the financial services sector. However, some measures have given greater freedom to the market forces and some have not. Some reforms have been reversed in subsequent policy changes. As a consequence, not all the expected benefits from economic reform have been realised after 27 years of reforms. As pointed out by Dunham and Kelegama (1997), initial conditions, economic circumstances, and the nature of the political system adversely affected the government's attempts at reform. Further, the policy formulation conflict in stabilization and adjustment slowed the speed of the economic reform process. Similarly, Karunatilaka (1986) indicated that short-term political objectives also undermined the economic reforms.

The World Bank (2003) indicated that the state commercial banks accounted for 49% of banking sector assets, while the private domestic banks accounted for 39% of the assets (with the rest apparently held by foreign banks) in Sri Lanka. This indicates that two state banks have a significant influence on the financial system. The government mainly uses domestic loans to finance budget deficits (CBSL, 2002). The use of commercial banks to fund government deficits at high short-term interest rates leads to high windfall profits which may mask inefficiency in the banking system. Bandara (1998) stated that the government intervenes in fixing the nominal rate of interest on treasury bills. It also encourages deposits with the National Savings Bank which ultimately determines bank deposit and lending rates. Politically-driven lending decisions in the state banks have increased intermediation

costs as a consequence of non-performing loans (Bandara, 1998). Further, the under-developed financial system and the rigid financial institutional structure have constrained the speed and effectiveness of financial reform (Karunasena and Jayatissa, 1987).

2.4 Impact of Financial Reforms on the Banking Industry

The previous section of this chapter briefly discussed the major financial reforms implemented after 1977 and the consequent structure of the banking industry in Sri Lanka. These reforms have affected the financial services sector in different ways. Edey and Gray (1996) identified three areas which reforms can influence. These are: (1) the role of financial regulatory policies, (2) improvements in technology used in institutions and (3) changes in the cost and pricing structures of the intermediation process. In the Sri Lankan context, the reforms further changed the institutional structure of the financial services sector in general.

Financial deregulation in Sri Lanka began in the late 1970s and is still being undertaken to this date. One of the main goals of the policy makers was to increase the efficiency and productivity gains of the entire financial services sector by promoting competition among the different forms of financial intermediaries. The Sri Lankan financial services sector is still dominated by the banking industry. The deregulation process which commenced in 1977 allowed more freedom to local banks. Foreign banks were encouraged to enter and to expand banking operations in Sri Lanka. From 1977 to today, the government of Sri Lanka has introduced different measures to free the market from government intervention. Table 2.1 highlighted major reform measures introduced. The remaining part of this chapter discusses how those reforms affected the banking market in general.

2.4.1 Organization of the financial services sector in Sri Lanka after reforms

Figure 2.1 and Table 2.2 illustrate the composition of the financial services industry in Sri Lanka. It is composed of the organised sector and an unorganised sector. The organised sector includes a diverse institutional system. In contrast, the unorganised sector does not have a formal institutional framework and is based on short-term, small-scale lending markets. Even after the reforms, the banking sector dominates the financial services sector in Sri Lanka. The capital market was not able to reach the anticipated level of development. As a consequence, the debt and the stock markets have made a very low contribution to the capital accumulation process in the corporate sector.

The banking sector in Sri Lanka comprises fully-licensed banks and specialised banks. Fully-licensed banks, which are also called commercial banks, have been permitted to provide all of the banking services. There are different types of specialised banks which provide specific services to industry. These specialised banks are also allowed limited freedom to accept deposits. There are three savings banks, namely, National Savings Bank (NSB)[6], Sanasa Bank and Seylan Saving Bank. NSB leads the deposits market in Sri Lanka. Savings banks can accept both long-term and short-term deposits. However, these banks are not allowed to accept demand deposits. Before 1997, NSB invested its savings mainly in government treasury bills and it had very limited autonomy to set interest rates. However, financial reforms have permitted NSB to set interest rates and to determine its lending portfolio. There are two main development banks which are authorised to accept long-term deposits and to grant long-term and medium-term loans to entrepreneurs. By divesting, the government, in effect, gave full control of the development banks to the private-sector in the late 1980s.

Financial reforms also increased the number of finance companies in the sector at the beginning. However, the formalisation of the regulatory structure of financial

[6] NSB is legally required to invest 60% of its deposits in government securities.

companies has reduced the number of finance companies. Currently there are 25 finance companies registered with the CBSL. The increase in finance companies may enhance the competition for medium- and long-term savings in the market.

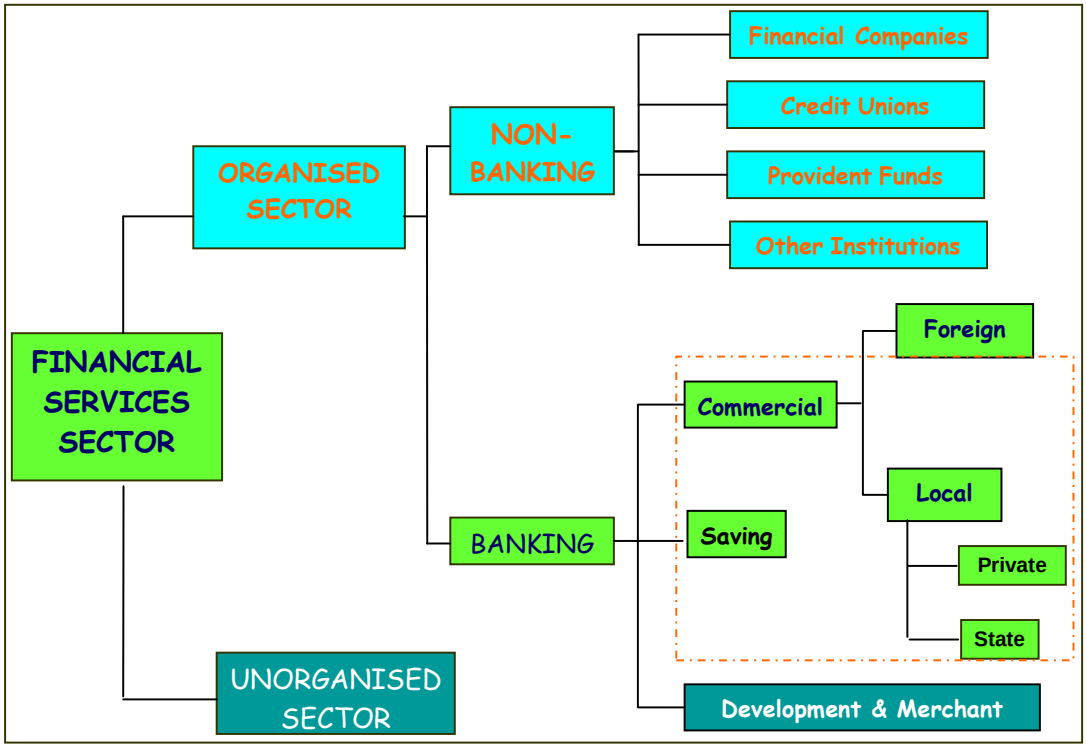


Figure 2.1: Composition of the financial services sector in Sri Lanka

The reforms introduced new forms of financial institutions. In the 1980s, three merchant banks were incorporated by the leading commercial banks to satisfy demands of entrepreneurs and to deal with capital markets. Providing consultancies, underwriting of share issues and helping to find sources of capital are the main tasks of the merchant banks. CBSL promotes venture capital institutions as a medium of providing seed capital for emerging entrepreneurs. Further, to enhance capital market operations, CBSL promoted the creation of mutual funds. Consequently, a number of fund management companies have entered the market during the last two decades. These fund management firms have established 14 unit trusts so far. Those unit trusts significantly contributed to changing the way savings are mobilised in the capital market.

Table 2.2: Infrastructural developments in deposit-taking institutions in Sri Lanka

Year	Local Commercial Banks	Foreign Commercial Banks	Regional Development Bank -Branches	Savings Banks	Rural Bank Branches	Licensed Specialised Banks	Unit Trusts	Finance Companies
1977	4 [298]	7	-	1 [25]	544	Na	-	29
1980	4 [486]	17	-	1 [42]	641	Na	-	27
1985	4 [600]	21	-	1 [57]	914	Na	-	56
1986	4 [604]	21	-	1 [60]	932	Na	-	56
1987	4 [608]	21	-	1 [62]	955	Na	-	53
1988	6 [678]	19	80	1 [64]	Na	Na	-	54
1989	6 [690]	18 [21]	89	1 [69]	Na	Na	-	60
1990	6 [719]	18 [23]	100	1 [76]	Na	Na	2	40
1991	6 [737]	18 [25]	124	1 [81]	Na	Na	2	24
1992	6 [781]	17 [29]	156	1 [84]	Na	Na	2	27
1993	6 [845]	23 [33]	163	1 [85]	Na	Na	2	26
1994	6[876]	23 [36]	169	1 [90]	1216	Na	2	26
1995	6 [876]	26 [37]	171	1 [96]	1251	Na	4	24
1996	7 [906]	26 [37]	175	1 [99]	1293	Na	5	24
1997	8 [949]	18 [38]	176	1 [101]	1329	6	10	25
1998	8 [988]	18 [40]	176	1 [102]	1351	8	10	25
1999	9 [1009]	17 [38]	177	1 [101]	1418	12	12	25
2000	10 [1042]	16 [38]	181	2 [101]	1476	12	12	25
2001	11 [1080]	14 [37]	188	2 [101]	1507	12	12	25
2002	11 [1185]	12 [31]	190	2 [103]	1554	14	13	26
2003	11 [1285]	12 [40]	194	2 [112]	1594	14	13	26
2004	11 [1342]	11 [38]	196	2 [112]	1594	14	14	27

[Number of commercial banks' and savings banks' branches are in parentheses; Na = data are not available]
[Sources: various issues of CBCL annual reports]

Table 2.2 shows the expansion of the deposit-taking institutions in Sri Lanka during the period 1977 to 2004. In 1977, Sri Lanka had only four local commercial (fully licensed) banks with 298 branches. Reforms aimed to expand the commercial banking operations throughout Sri Lanka. In 2004, there were 12 local commercial banks with 1342 branches. There were also 11 foreign banks that have established 38 branches in the country. As a consequence of the collapse of a private savings bank in 2000, the government introduced further regulatory changes to strengthen the supervisory role of the CBSL. In the deregulated environment, the rapid growth in the financial services sector blurred the differences between fully-licensed banks and the specialised financial institutions. This led to the introduction of innovative financial products by the banking institutions.

Financial reforms have reduced the monopoly of commercial banks in the financial services sector. In the early stage of the financial reforms, newly-established specialised non-bank financial institutions have taken over some traditional commercial banking functions such as granting project finance and accepting long-term deposits. Moreover, financial reforms have allowed capital markets to emerge as the main avenue of private-sector direct financing in Sri Lanka.

Fully-licensed banks have to compete with other financial institutions in lending markets as well as in the deposit markets. Most other financial institutions can offer long-term and medium-term deposit instruments to attract savers. Other financial institutions such as development banks, venture capitalist and mortgage institutions operate in the lending markets more assertively than the fully-licensed banks. On the other hand, foreign banks have emerged as main players in the domestic banking market with greater freedom in both deposit and lending markets. Those banks were allowed to offer similar banking products (both deposits and lending) to the local banks. As a consequence, fully-licensed banks are forced to diversify their product lines and to find new fee-based services instead of interest-based products.

The scope of the Sri Lanka's financial services industry has been widened. Particularly, operations of the banking industry have expanded both in the number of

banks and the number of branches. New financial instruments have been introduced to the market. The financial reforms allowed more freedom to open up different forms of financial intermediaries. However, the banking industry is the main intermediary in the financial services sector in Sri Lanka. Prevailing market-based interest rates offer a positive real interest rate for savers and consequently enhance domestic savings. On the other hand, trade liberalisation has increased the demand for funds. Concomitantly, the new forms of financial intermediaries have increased competition in the financial services market.

2.4.2 Operational environment of banks

Along with the structural changes, widening of operational activities of other forms of financial institutions such as insurance, leasing, unit trust and superannuation funds has increased competition in the financial services sector. The new banks have started to use ICT as part of their strategy to provide customer-friendly banking services. Consequently, those banks were able to achieve better competitive positions than the old commercial banks. Accordingly, old banks also commenced gradually to transform their out-dated manual-based banking systems to ICT-based modern automated banking systems. However, a premeditated (less aggressive) approach followed by existing banks did not allow them to reap the full benefits of automation. Local banks tended to introduce new products and improve their existing facilities and delivery channels. This strategy was needed to attract new customers and to retain their existing customers in a competitive environment. During the period, some banks introduced entirely new banking facilities such as internet banking and phone banking, which added new features to their automatic teller machine (ATM) facilities.

The number of ATMs operated and the number of credit cards issued has significantly increased during the period (see Table 2.3). With the increasing number of bank branches operating, the bank density ratio[7] has significantly improved from 0.58 in 1998 to 0.71 in 2004 as shown in Table 2.3. During the

[7] Number of bank branches available for 10,000 people

1970s, private-sector and foreign banks were not allowed to expand their bank branch networks. Deregulation measures introduced in the early stage of financial reforms removed this restriction. As a result, the total number of bank branches has increased from 298 branches in 1977 to 1342 branches and 1109 business centres[8] in 2004 (see Table 2.2).

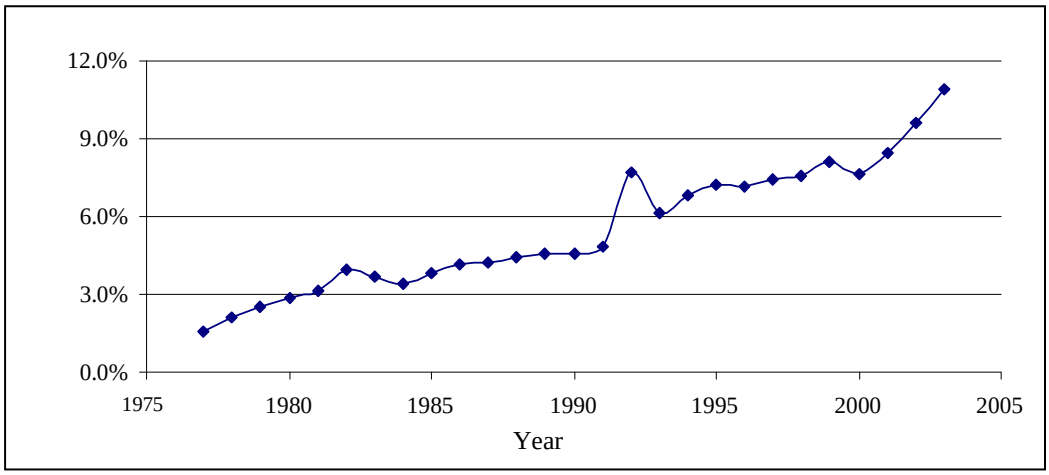
Table 2.3: Development in banking facilities in Sri Lanka

Year	Banking Density	Number of ATMs	Number of credit cards issued
1998	0.58	270	85,964
1999	0.58	316	161,079
2000	0.59	379	205,324
2001	0.60	466	253,258
2002	0.61	635	349,524
2003	0.69	710	393,854
2004	0.71	810	507,591

[Source: Various issues of CBSL Annual Reports]

Another objective of the financial reforms in Sri Lanka is to deepen the financial services sector. In particular, changes in the institutional structure and the regulatory environment have helped to deepen the financial services sector activities. Consequently, the sector contribution in the gross domestic product (GDP) improved during the period from 1977 to 2004. As exhibited in Figure 2.2, the contribution increased from 1.6% of GDP in 1977 to 12.2% of GDP in 2004 indicating a clear upward trend in the sector's contribution after 1990, which commenced the second phase of the reforms. This improvement in the sector coincided with a widening of economic activities in the country with open economic policies. This substantial growth has verified that the financial services sector has played a notable role in Sri Lanka's economic development, confirming McKinnon's (1973) and Shaw's (1973) arguments.

[8] A business centre is a banking unit which provides limited banking services such as accepting deposits, collecting loan repayments and providing consumer loans by mortgaging.

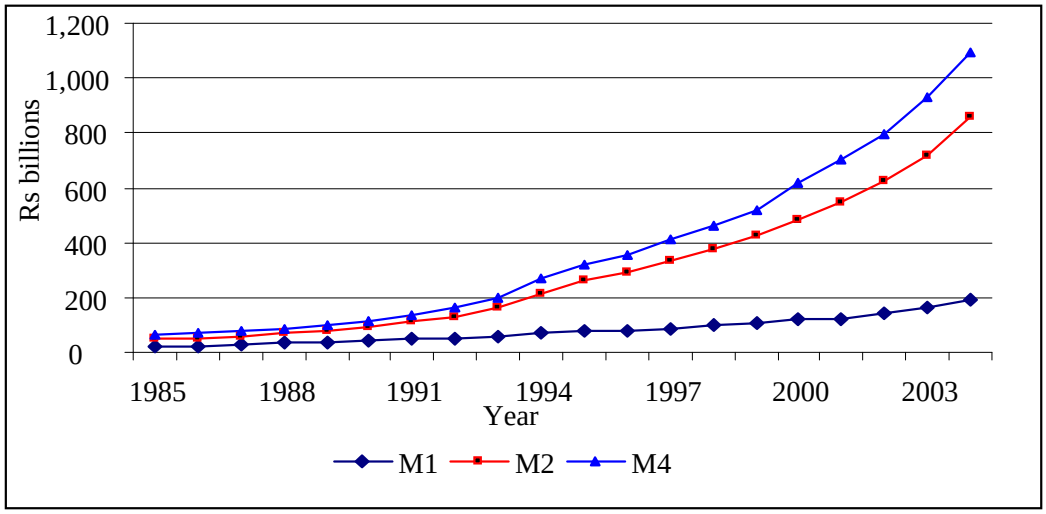


[Source: Various issues of CBSL Annual Reports]

Figure 2.2: Financial services sector contribution to the GDP

The changes in aggregate money supply in the economy during the last 27 year period reflect how the reform process has deepened the financial system. CBSL annually provides statistics for three different measures of monetary aggregates. These annual aggregate sums incorporate currency, commercial banks' demand deposits, time and savings deposits and deposits with finance companies. Narrow money (M1) supply comprises currency and commercial banks' demand deposits. M2 adds time and saving deposits to the M1. Broad Money supply (M4) takes in all currencies and savings including deposits with finance companies.

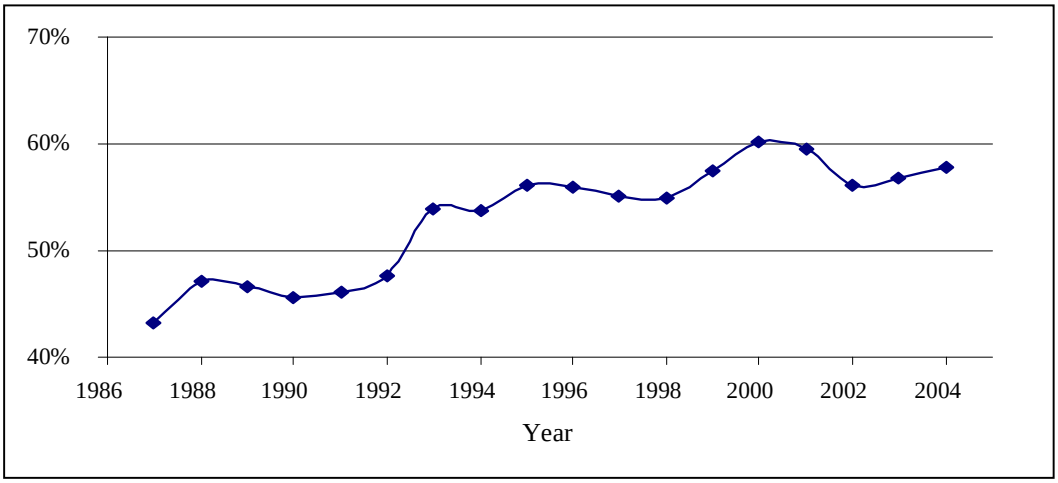
Figure 2.3 outlines the behaviour of money supply during the period. The graph indicates the gradual expansion of Sri Lanka's money supply. The rapid increase in M2 identifies the expansion of commercial banking activities in the financial services sector. In 1985, commercial banks' contribution to broad money supply was relatively insignificant. However, by 1990 it had become a significant portion of broad money supply. Accordingly, developments in the financial services sector have widened the market for deposits.



[Sources: Various issues of CBSL Annual Reports]

Figure 2.3: Monetary aggregates

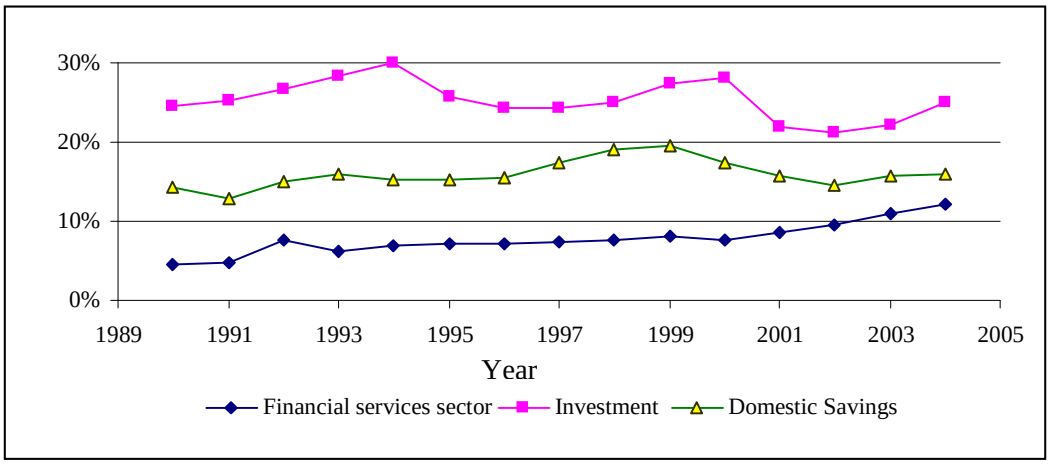
Figure 2.4 shows how the total assets base of commercial banks has been widened during the period 1987 to 2004. The evolution of the financial services sector has increased the assets base of the commercial banks. The percentage of the commercial banks' assets to GDP grew from 43% in 1987 to 58% in 2004 (CBSL, 2004). In rupee terms, the assets base of the commercial banks has significantly increased from Rs.76.8 billion in 1987 to Rs.1028 billion in 2004 (CBSL, 2004).



[Sources: Various issues of CBSL Annual Reports]

Figure 2.4: Banks' assets as proportion of GDP

However, the financial services sector was unable to attract all of the domestic savings in the economy. In 2004, the financial services sectors total contribution to the GDP was 12.2% while the total domestic savings was 16%. In the same year, the total investment was 25% of GDP. This indicates that a significant portion of financial assets is flowing through institutional systems other than the financial services sector. However, Figure 2.5 shows that the financial services sector was able to improve its intake during the last 16 year period.



[Sources: Various issues of CBSL Annual Reports]

Figure 2.5: Domestic savings, investment and financial services sector contribution to GDP

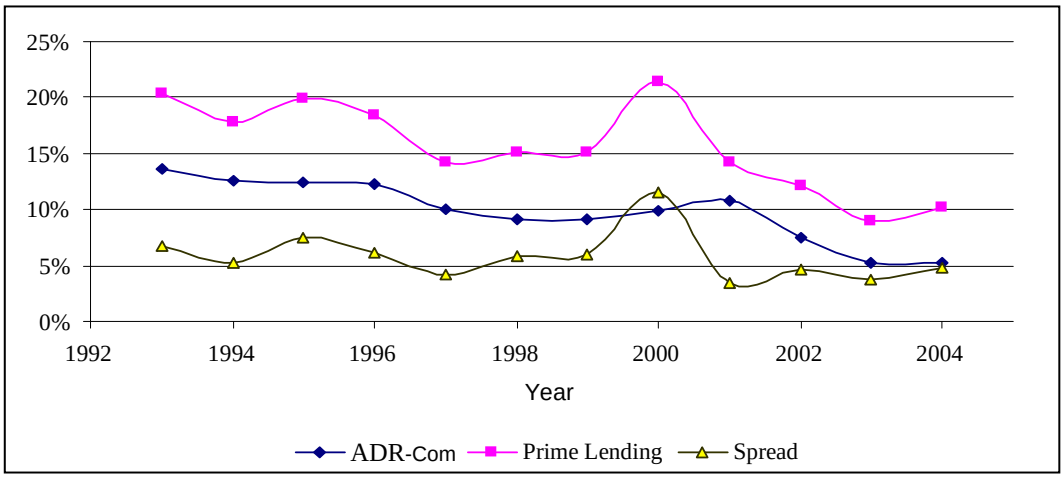
2.4.3 Deposit and lending interest rates

Deregulation gave more freedom to market forces in determining interest rates by removing preferential credit schemes and by establishing a market for government debt instruments. CBSL uses two key policy interest rates, repurchase (repo),[9] and reverse repurchase (reverse repo)[10] to guide the market interest rates. NSB (a state-owned savings bank) is given latitude in determining its deposit rates. These policy rates and the NSB deposit rates are the main factors in determining the market rates. Market interest rates are sensitive to both local rates and international interest rates.

[9] The rate at which commercial banks and primary dealers invest their surplus funds in government securities sold by the CBSL under short-term repurchase agreements.

[10] The rate at which commercial banks and primary dealers can obtain funds from the CBSL by selling government securities to CBSL under short-term repurchase agreements.

The economic recession in the industrialised countries in the late 1990s occasioned a reduction in both the levels of deposits and a reduction in the interest rates in the international markets.



[Sources: Various issues of CBSL Annual Reports]

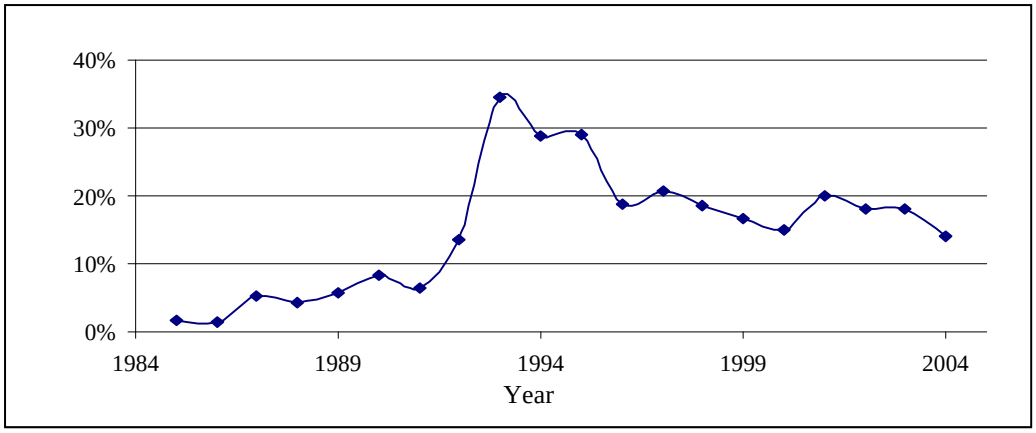
Figure 2.6: Commercial bank lending and deposit interest rates

Commercial banks use multiple interest rates for their different deposit and lending products. Interest rate differentiation was the main strategy which commercial banks used to counter peer rivalry in the market. The establishment of the CIB and publication of all deposit and lending interest rates of commercial banks by the CBSL assisted in keeping the market informed regarding interest rates. During the last two decades, market interest rates have readily responded to both changes in locally- and internationally determined interest rates. Figure 2.6 indicates the gradual reduction in the lending and deposit rates by commercial banks during this period.

The average weighted deposit rates, which are based on the weighted average of the outstanding interest bearing deposits of commercial banks, declined commensurately during the period. Similarly, lending rates indicated a slower downward trend. The 'interest rate spread' is commonly used as an indicator of the efficiency of financial intermediation (Heffernan, 1996). During the period being considered, the interest rate spread declined at a slower rate. This may be a result of slow adjustments in lending rates, high operational costs, lower quality lending portfolios and less

reliance on the non-interest bearing activities. However, the financial reforms have forced banks to adopt rigid risk control procedures, to cut down unnecessary expenses and to be more responsive to market changes. The declining trend in the interest rate spread indicates that the measures used to reduce interest rates have been successful.

During the 1990s, the Sri Lankan government introduced an open-market policy for government securities (see Table 2.1). Aggressive open-market operations affected banks' holdings of government debt. As shown in Figure 2.7, since 1991 the banks' stake in government debt grew significantly. On the other hand, banks' involvement in the open market for government securities has affected the market determined interest rate. The increase in banks' involvement in the open market resulted in an upward trend in interest rates. Furthermore, the government used overdraft facilities provided by the two state banks to feed short-term funding needs. Higher total contribution was reported to be mainly due to the overdraft facilities provided by the two state banks to the public corporations. As indicated in the CBSL 2001 Annual Report, the two state banks provided SLR. 38.1 billion overdraft facilities to the government in 2001. In 2002, the government used market-oriented instruments such as treasury bonds and government restructuring bonds to pay out this debt obligation (Peoples Bank, 2002; Bank of Ceylon, 2002).

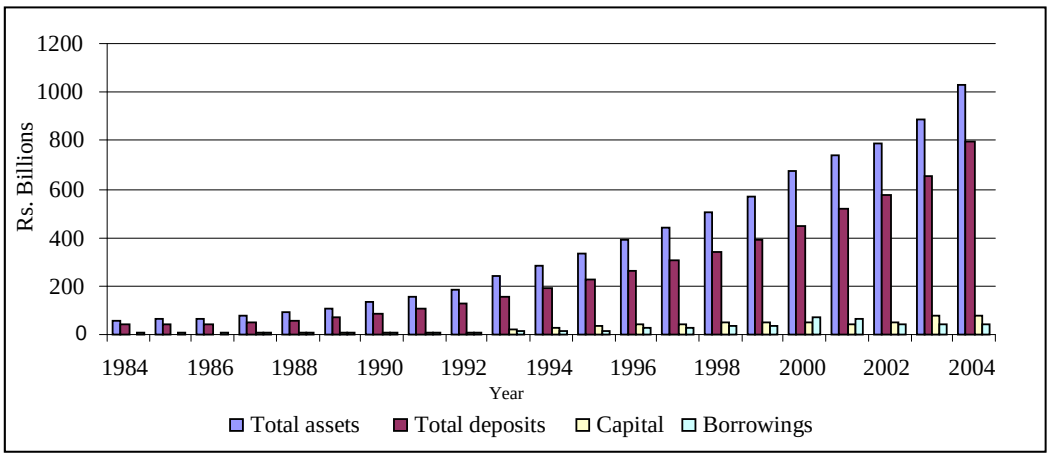


[Sources: Various issues of CBSL Annual Reports]

Figure 2.7: Commercial banks' ownership of government debt as a percentage of total domestic loans

2.4.4 Total assets and liabilities of commercial banks

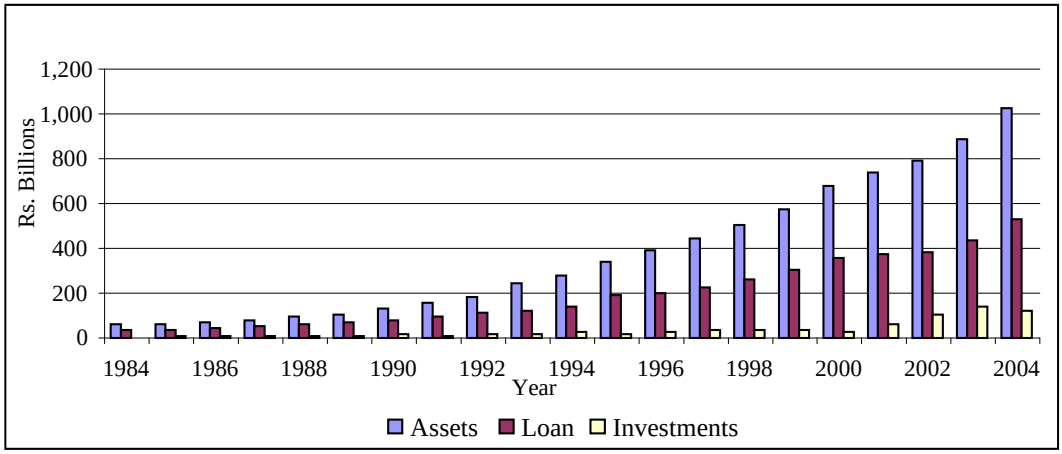
During the past two decades, the total assets and liabilities base of commercial banks has drastically changed. Figure 2.8 and Figure 2.9 exhibit how the assets and liabilities have improved during this period. Compared to 1987 records, the total assets of commercial banks grew by ten-fold in 2004. The improvements were mainly achieved by the expansion of the deposit and lending portfolios of commercial banks. Banks' investment portfolios recorded a comparatively slow growth rate. Even though the total assets base significantly increased, total capital contribution recorded a relatively and comparatively small growth rate.



[Sources: Various issues of CBSL Annual Reports]

Figure 2.8: Funding sources of banks

The new banks were first to use ICT in the banking industry. Prior to 1977, the local banks used manual procedures for banking activities. Manual processing characteristically took a relatively long time to complete each transaction. However, new private-sector banks applied ICT. They also introduced the uni-banking system to Sri Lanka's financial sector. The new banks pioneered the expansion of automated banking facilities throughout the country. These new trends in the industry first started with the introduction of an automated teller machine in the city office of a foreign bank.



[Sources: CBSL Annual Reports]

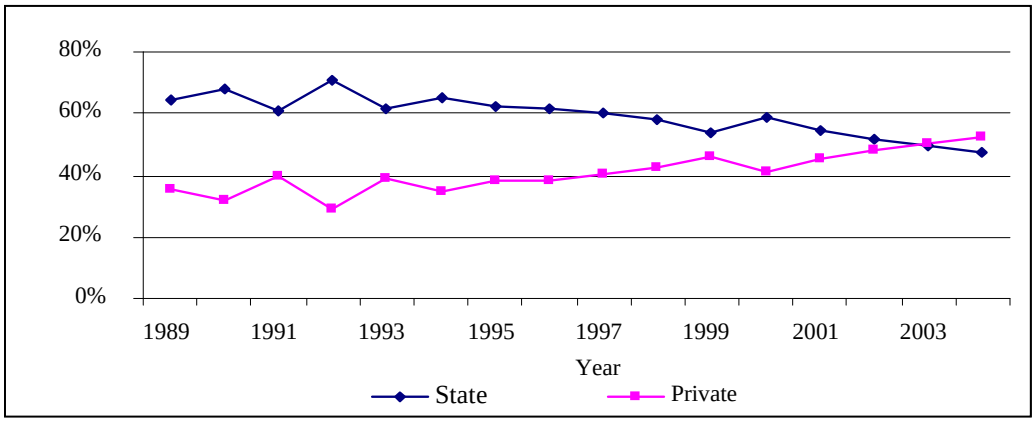
Figure 2.9: Uses of commercial banks' assets

In the beginning, new banks used ICT to stay ahead of the market. Their success in the application of technology caused the established banks to change from manual procedures to automated operations. Under the previous regulated regime, banks tended to offer very limited services to the market with no encouragement for new banking products. With the opening up of the economy, banks differentiated their product lines by introducing services with various features. During the past two decades, many banks, including the foreign banks, have introduced various competitive preferential deposit and lending schemes. Consequently, a significant improvement in the total asset base of banks in Sri Lanka have been recorded.

2.4.5 Ownership of commercial banks' assets

The financial reforms also aimed to reduce the state banks' monopoly in the commercial banking sector. As stated previously, the influence of the powerful trade unions have prevented the 'privatisation' of the two state banks. The reforms enhanced private-sector participation in commercial banking. In 1989, more than 65% of commercial banks' assets were owned by the government sector. However, the state banks' proportion of the total assets declined to 48% in 2004. Figure 2.10 illustrates the changes in ownership of banking assets during the study period. Increase in market share of the private banks has affected the market competition. In

short, the changes in the market structure and competition were attributed to the development in technology. This may have improved the efficiency and productivity of the sector.



[Sources: CBSL Annual Reports]

Figure 2.10: Ownership of commercial banks' assets

2.4.6 Banking concentration

Table 2.4 illustrates the concentration of the Sri Lankan banking industry [which is measured using the Herfindahl-Hirshman index (HHI)[11]] for some market indicators of banking industry such as total deposits, total loans and advances, total assets and total turnover. The concentration ratio shows the changes in market structure throughout the period. All estimated concentration ratios have indicated a gradual reduction in market concentration evidencing an increase in the degree of market competition in the banking industry. The changes in market concentration have resulted from the entrance of new banks as well as the expansion of operational activities of the existing banks.

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[11] $HHI = \sum_{i=1}^{N} \left(\frac{v_i}{V} \right)^2$, N = number of firms, v_i = market share of ith firm, V =total market share (See chapter 6).

Table 2.4: Bank market concentration (HH index)

Year	Deposits	Loans	Total Assets	Turnover
1989	26%	35%	27%	25%
1990	26%	33%	27%	25%
1991	25%	29%	25%	24%
1992	23%	25%	24%	22%
1993	22%	25%	23%	22%
1994	22%	25%	22%	22%
1995	21%	24%	21%	22%
1996	21%	21%	21%	21%
1997	20%	21%	20%	21%
1998	19%	20%	19%	19%
1999	18%	18%	18%	19%
2000	18%	19%	19%	18%
2001	17%	20%	18%	18%
2002	17%	17%	16%	17%
2003	16%	16%	16%	15%
2004	16%	15%	15%	15%

2.5 Synthesise

This chapter examined the extent of regulatory reforms in the financial services sector and their apparent influence on the banking industry in Sri Lanka. The analysis in the chapter has highlighted that the financial services sector in Sri Lanka has experienced a gradual reform process. However, reforms were not undertaken at the same speed throughout the study period. Socioeconomic barriers such as leftwing political upsurge, civil war and the influence of trade unionists have slowed down the reforms. Further, the policy makers have not capitalised on all favorable opportunities to introduce reforms.

Moreover, the chapter has shown that the reforms have affected the structure of the banking sector, generating significant improvements in banking activities during the period. The analysis found in summary:

1. An increase in the contribution of the financial services sector to GDP and the deepening of the sectors' operations;
2. Improvement in the institutional infrastructure of the financial services sector with the number of institutions and scope of operations;
3. Improvement in the assets base and deposit base of commercial banks;

4. Reduction in government ownership of commercial banks' assets;
5. A negative trend in the interest rate margin;
6. High reliance on commercial banks for government budget deficit financing; and
7. A reduction in bank concentration.

Consequently, the banking industry in Sri Lanka has gained improvement in terms of depth of the industry (new entrants, number of branches, foreign banks' involvement, total assets) and resilience (on responding to the concurrent regulatory reforms). Furthermore, these reforms have changed the technology used and the products offered by the banking sector. The changes in market structure have intensified competition not only in the banking industry but also in the overall financial services sector. Diversification of operational activities of banking firms has changed the relative importance of the traditional sources of income of the banking sector, from reliance on interest earned to greater emphasis on fees earned.

Currently, policy makers are focusing on further reforms in the financial services sector. However, there has been no formal evaluation of the outcome of the financial reforms. As stated in the literature, financial reforms target multiple objectives. A comprehensive study leading to an examination of the accomplishments of these objectives is important at this stage. It is worthwhile to examine how the reforms have affected the market structure, competition, efficiency and productivity gains. The next chapter will review the literature related to efficiency and productivity gains and their applications in the banking industry. The findings in the next chapter are used to form a research framework for the study.

CHAPTER THREE

CONCEPTS AND MEASUREMENTS OF EFFICIENCY AND PRODUCTIVITY CHANGE AND THEIR APPLICATION IN THE BANKING INDUSTRY

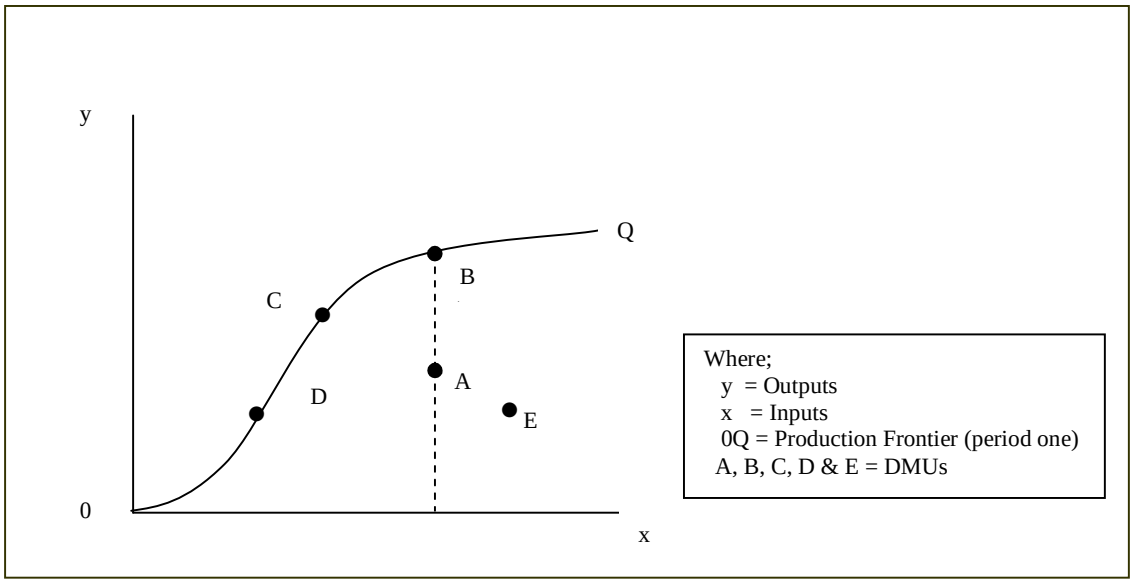
3.1 Introduction

Efficiency and productivity measures supplement the other financial performance measurement methods such as return on total assets, return on capital employed, margin ratios and market to book value ratio. In the recent past, researchers have focused on the issue of efficiency and productivity gains in various industries including the financial services sector. The aim of this chapter is to review the literature related to productivity and measurements of productivity, giving special reference to productivity analysis in the financial services sector.

The chapter is set out as follows. The first section introduces various concepts of productivity. The second and third sections discuss the approaches which can be applied for measuring productivity in a business unit in a given industry. The fourth section provides a general review of the data envelopment analysis (DEA) approach. The fifth and sixth sections mainly focus on issues related to the banking industry; the fifth section presents a literature survey on input and output issues, while the sixth section reviews empirical studies in commercial banking efficiency and productivity which used DEA to measure efficiency and productivity gains.

3.2 Productivity Concepts

Productivity is generally defined as the relation between output (produced goods) and input (consumed resources) and can be regarded as one of the most vital factors affecting competitiveness of a business firm (Robert, 1998). A firm can achieve productivity gains by producing either a greater output from a given level of inputs or by using a minimum amount of inputs to produce a given level of outputs (Coelli, Rao and Battese, 1998). In this context, productivity can be defined as the ratio of the output(s) to the input(s) used.

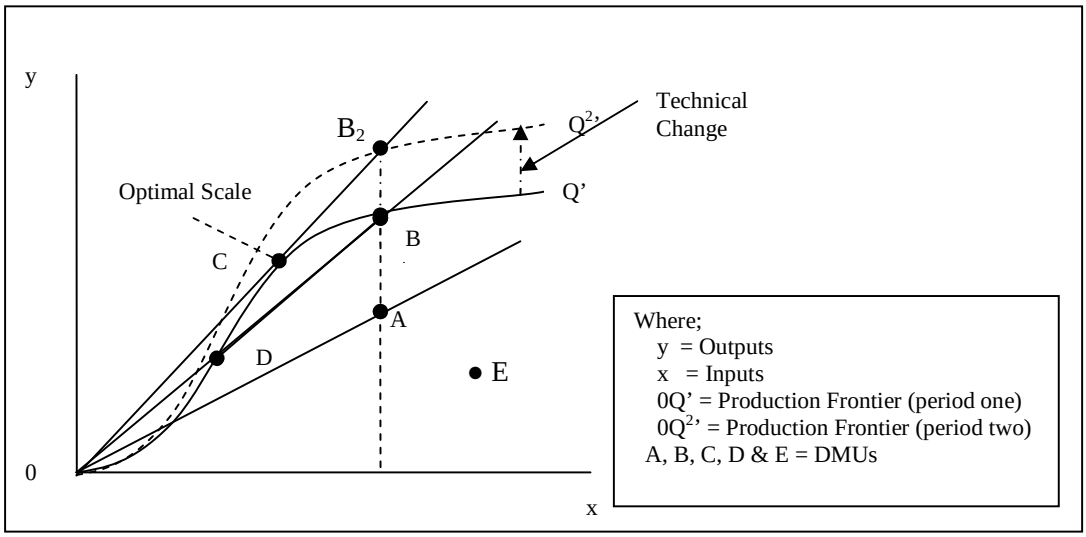


[Source: An extension of Coelli, Rao and Battese (1998, p. 4)]

Figure 3.1: Production frontier and technical efficiency

The terms efficiency and productivity are not precisely the same thing. Coelli, Rao and Battese (1998) used a simple production process which produces a single output using a single input to illustrate the difference between efficiency and productivity based on a diagram reproduced above. The curve 0Q in Figure 3.1 depicts the production frontier, which indicates the maximum possible level of output that can be attained using inputs with maximum efficiency. Accordingly, the production frontier reflects the current state of the technology in the industry under review. Points A, B, C, D and E are current levels of production of respective decision-making unit (DMU) (Coelli, Rao and Battese, 1998). All input and output

combinations on and underneath the production frontier are considered as the feasible production set. Any firm which has a combination of inputs and outputs on the production frontier is considered to be technically efficient. Similarly, firms having input and output combinations below the frontier are considered to be technically inefficient. The technically efficient firms are able to produce the maximum amount of output using a given quantity of inputs with existing technology. Accordingly, firms B, C and D can be considered as the technically efficient firms while A and E are inefficient.



[Source: An extension of Coelli, Rao and Battese (1998, p. 5)]

Figure 3.2: Productivity, technical efficiency and scale efficiency

Figure 3.2 illustrates the difference between efficiency and productivity. Since productivity is defined as the ratio of outputs to inputs, the slope of the ray drawn from the origin to a particular data point can be used to measure productivity. If the firm 'A' wants to achieve the technically efficient output level enjoyed by firm 'B', firm 'A' must be able to gain a higher level of productivity than before. Even firm 'B', which is operating as an efficient firm, can gain a higher level of productivity by achieving the current production level of 'C'. Since firm 'C' has the highest output to input ratio, that point is regarded as the point which exhibits the optimum scale of production. This implies any firm which is operating at any point other than point 'C' has lower productivity. Thus, economically efficient firms should lie on

the point which indicates the optimum scale of operation in the production frontier. All other firms on the production frontier are technically efficient but not allocatively efficient[1]. As indicated in Figure 3.2, only firm 'C' is operating at optimal scale. The other firms, 'B' and 'D', are technically efficient but not efficient in scale. Hence, those firms are not economically fully efficient. Firms 'B' and 'D' should seek improvements in allocative efficiency. For example, firm 'B' can gain economic efficiency by moving to point B_2 without increasing inputs or by moving to point C by reducing both inputs and outputs. In economics, this process is referred to as obtaining scale efficiency or return to scale (RTS).

There are three ways of achieving optimum scale. The first involves constant returns to scale (CRS). CRS exists when a proportional increase in all inputs results in the same proportional increase in output. The second is increasing returns to scale (IRTS) which exists when a proportional increase in all inputs results in a more than proportional increase in output. The last, decreasing returns to scale (DRS) exists when an increase in inputs results in a lower percentage of increase in outputs. The influence of the return to scale depends on the firm's characteristics such as firm size, nature of the industry and overall environment of the economy. As indicated by Coelli, Rao and Battese (1998), the RTS can be investigated by estimating the total elasticity of production[2].

The consideration of scale moves firms from the short-run to the long-run where all inputs may be varied. In the long-run, productivity improvements are expected to stem from both increases in technical efficiency and technical change. Technological change produces an upward shift of the production frontier. Allocative efficiency exists when a firm is able to select an input mix to produce an output mix at a minimum cost. Allocative efficiency and technical efficiency collectively contribute to economic efficiency (Coelli, Rao and Battese, 1998).

1 A firm's ability to use an optimal mix of inputs to produce outputs

2 The total elasticity of production measures the proportional change in output resulting from a change in inputs

Productivity measurement may be limited to single physical units or may involve prices of factors and outputs. The concept of productivity is linked closely with the issues of efficiency and encompasses several efficiency elements such as price efficiency[3], allocative efficiency, technical efficiency and scale efficiency. The overall productivity level of an organisation depends on all these elements.

Improvements in efficiency and productivity gains can be considered as one of the goals of a firm in a competitive market. Therefore, measurements in efficiency and productivity gains provide supplementary information about the firm's performance. These measurements can be considered as non-financial performance indicators as they consider all of the contributors to the firm's performance. In any organisation, whether it is profit-oriented or not, measurements of productivity help to analyse the efficiency of resource use in the organisation. Moreover, productivity indices help to set realistic targets for monitoring activities during an organisational development process by highlighting bottle-necks and barriers to performance. Reynolds and Thompson (2002) stressed that productivity measurement, monitoring and improvement leads to overall gains in profitability. Berger and Humphrey (1997) indicated that the first task in evaluating performance in an institution is to separate those production units which performed better than the other units.

Productivity can be measured by using either partial-factor productivity, which is the ratio of output (measured in specific units) to any input (also measured in specific units), or total factor productivity (TFP), which is the ratio of total outputs to total inputs used in production. Partial measures can be defined for specific operational attributes such as total revenue per labour unit, expenses as a percentage of total assets, and return on assets. In contrast, TFP measures estimate the overall effectiveness of utilization of inputs to produce the outputs. Production frontier analysis (PFA) and index number approaches can be used to estimate TFP. The main PFA approaches which are used for estimating TFP are explained in the section 3.3. The index number approach is an alternative method which can be applied for

[3] Price efficiency is the firm's ability to purchase inputs that meet the required quality and standard of the lowest prices.

estimating total productivity. Grifell-Tatje and Lovell (1996) identified the Tornquvist Index, the Fisher Ideal Index (which is geometric mean of the Laspeyres and Paasche Indices) and Malmquist Productivity Index (MPI) as the main indices that can be used in productivity analysis.

3.3 Production Frontier Approaches

Out of several available alternative approaches the PFA is more popular in empirical studies in efficiency and productivity. The majority of contemporary researchers have relied on relative productivity measures based on PFA. Those studies have used observed data to construct the production frontier for estimating efficiency and productivity gains.

Both econometric (parametric) approaches and linear programming (non-parametric) approaches can be applied to construct a production frontier. The econometric approach uses pre-specified functional forms such as 'the translog production function' (Coelli, Rao and Battese, 1998). The relative efficiency and productivity gains of the firms in a given industry have been measured using the production frontier. Berger and Humphrey (1997) identified two advantages of using frontier analysis as a tool for measuring efficiency and productivity gains. The first is that PFA allows an analyst to select the best performing firms (or branches) within a given industry (or within the branches in the same firms) by measuring relative productivity. The second is that it allows management to objectively identify areas of best practice within complex service operations.

3.3.1 Parametric approaches

There are three parametric approaches, namely, stochastic frontier approach (SFA), distribution free approach (DFA) and the thick frontier approach (TFA). SFA is also known as the econometric frontier approach, which specifies a functional form for the cost, profit or production relationship among inputs, outputs and environmental factors. SFA allows for random error. DFA uses more flexible functional forms and is based on no strong assumptions about the specific distributions of the inefficiency

or random error. TFA specifies a functional form and assumes that deviations from predicted performance values within the highest and lowest performance quartiles of observations represent random error, while deviations in predicted performance between the highest and lowest quartiles represent inefficiencies. Berger, Hunter and Timme (1993) found that the studies based on parametric approaches were not able to incorporate the technologies of both large and small banks together in a single model. For instance, the commonly used translog cost functional specification gives a poor approximation when applied to banks of all sizes (McAllister and McManus, 1993). Favero and Papi (1995) presented the following arguments against the parametric approaches in general:

- Parametric approaches use a specific functional form. Hence the shape of the production frontier is pre-supposed;
- Parametric approaches need to specify assumptions about the form of the production function;
- It becomes impossible to implement diagnostic checking on the fitted model based upon the estimated residual due to the assumptions;
- It is difficult to implement in multi-input multi-output settings.

The outcome of the parametric approaches is significantly influenced by the size of the sample. If the sample is not able to provide an adequate number of observations to be applied for estimating the variables for constructing the production frontier, the estimated econometric model may provide misleading information.

3.3.2 Non-parametric approaches

Contrary to the parametric approaches, non-parametric methods are not based on a pre-specified functional form. DEA and free disposal hull (FDH) are the two main non-parametric approaches used for measuring productivity. DEA provides benchmark indices for evaluating the relative productive efficiency of DMUs in a given industry or sub-units in a firm. Different forms of DEA models have been developed based on different perspectives (see Table 2.2). DEA was first used for comparing the performance of a matched set of school districts (Charnes et al.,

1997). Since then, DEA has been widely used for analysing efficiency and productivity gains in many industries including the service sector. It integrates multiple inputs and outputs into one productivity indicator using a linear programming technique (Reynolds and Thompson, 2002). The linear programming technique allows both controllable and uncontrollable variables and produces a productivity index which relates all units under comparison. The FDH model is an alternative specification of the DEA model in which the points on the line connecting the DEA vertices are not included in the frontier.

In general, non-parametric approaches have the following features/assumptions:

- A specific functional form is not used (Drake and Hall, 2003);
- No measurement error in constructing the frontier (Drake and Hall, 2003);
- No scope for 'luck' to temporarily give a DMU an apparently better measured performance one year than the next;
- No inaccuracies created by accounting rules that would make measured outputs and inputs deviate from economic output and inputs.

However, non-parametric approaches also have some inherent weaknesses. These weaknesses reduce the usefulness of the non-parametric methods to some extent. Some of these weaknesses are listed below (Berger and Mester, 1997):

- Do not allow for random error;
- DEA ignores price information;
- Estimate technical efficiency only and do not account for allocative efficiency;
- Comparability problem arises on the heterogeneity of product mixes of DMUs;
- Difficult to find out whether the output being produced is optimal without value information on the outputs;
- Focus on technological rather than the economical optimization.

Efficiency of a DMU is influenced by three different phenomena (Fried et al., 2002), namely, the efficiency with which management organizes production activities, the environment in which production activities are carried out and the impact of 'good and bad luck'. The deterministic nature of DEA ignores the above phenomena when estimating efficiency of DMUs. Further, Berger and Mester (1997) argued that the parametric approach overcomes many of the shortcomings of non-parametric approaches and showed that the parametric approach can accommodate different definitions of efficiency such as cost efficiency and profit efficiency. However, both parametric and non-parametric techniques suffer from drawbacks. In many empirical studies, a large number of DMUs classify as efficient (Griffin and Kvam, 1999). As such, the ranking of DMUs becomes difficult. Neither technique accounts for the distribution of DMU values in the input/output space that typically distinguish smaller firms from larger ones. Furthermore, efficiency scores for all DMUs are stated with equal confidence, even if some of the DMUs are divergent in terms of input and output values.

3.3.3 Choice of frontier analysis methods

Both parametric and non-parametric approaches have advantages as well as disadvantages. There is no specific set of criteria to select the most relevant approach for constructing the production frontier. Tortosa-Ausina (2002a) pointed out that the choice of technique, either non-parametric or parametric, is somewhat arbitrary, depending on the aims pursued. Coelli and Perelman (1999) applied both parametric approaches and non-parametric approaches to estimate the production frontier of European railways. That study used the corrected ordinary least square method (COLS), the parametric linear programming method[4] and DEA. The three approaches which were used in that study reported similar fingings on the relative productive performance of the DMUs. Coelli and Perelman (1999) showed that researchers can safely select one of the PFA approaches without too much concern about their choice having a large influence upon results. However, they stressed that the use of a parametric approach allows analysts to test their hypotheses. All of the

[4] The parametric estimation is based on the translog Cobb-Douglas functional form.

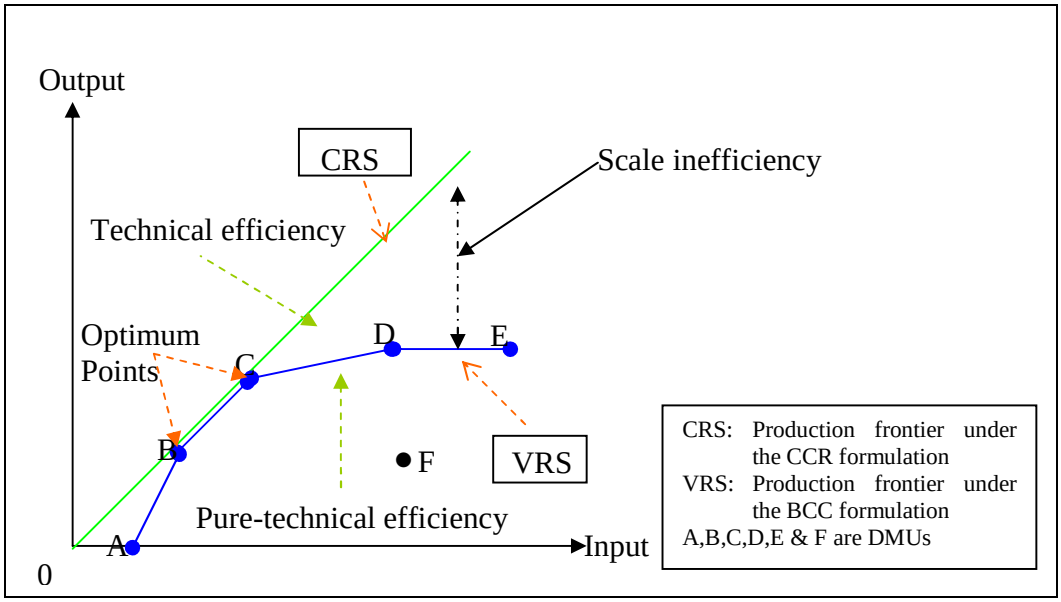
methods are not able to provide robust estimation of the relative efficiency of DMUs. Therefore, they suggested using the geometric average of the efficiency indices identified using alternative approaches.

3.4 Data Envelopment Analysis

DEA is a performance analysis technique which is not based on a pre-defined functional form. It measures the relative productivity of the DMUs. Productivity indexes for each unit are determined by using actual data. The original Charnes, Cooper and Rhodes (1978) formulation (called the CCR model) determines the relative efficiency measure for a DMU by maximising the ratio of weighted outputs to inputs based on the condition that similar ratios for all DMUs are less than or equal to one. Hence, each efficient DMU has a weight equal to unity and inefficient DMUs should have a weight less than one.

The CCR model and Banker, Charnes and Cooper (1984) model (called the BCC model) are the two basic DEA formulations which have been commonly used in empirical studies. The CCR model uses an optimization method of mathematical programming to generalize the single output/input technical measure to the multiple output/multiple input case. It is based on CRS when enveloping the actual data to determine the shape of the production frontier. Contrary to the CCR model, the BCC model uses variable returns to scale (VRS) for identifying the envelopment surface.

Figure 3.3 graphically illustrates the shape of envelopment surfaces for a single input and single output case under CCR and BCC models. Points A, B, C, D, E and F represent the observed performance of six DMUs. The CCR model develops the production frontier on the assumption that all firms are operating at an optimum scale. The line extending from the origin through point B and C is the production frontier identified by the CCR model. Contrarily, BCC ignores the above assumption and introduces a convexity condition to the basic CCR model which allows benchmarking of the inefficient DMUs with similar size DMUs (Coelli, Rao and Battese, 1998). The curve which connects points A, B, C, D and E represents the BCC production frontier.



[Source: An extension of Coelli, Rao and Battese (1998, p. 152)]

Figure 3.3: Envelopment surface under CCR and BCC formulation

As stated above, CCR ignores the relative size of the DMUs when estimating efficiency. It is assumed an increase in output is always proportional to an increase in inputs and thus the scale of production is ignored. On the other hand, BCC models give precedence to the scale of operation in estimating efficiency. Hence, efficiency estimated using BCC refer to pure-technical efficiency[5] while estimates using CCR refer to technical efficiency. The difference between estimated CCR and BCC efficiency scores is denoted as scale efficiency.

DEA uses three projection paths of inefficient units to the envelopment surface for measuring the efficiency, namely, input-oriented, output-oriented and additive. Figure 3.4 graphically represents those projection paths. The input-oriented model identifies technical inefficiency as a proportional reduction in input usage for a given level of output. Contrarily, the output-oriented model identifies technical inefficiency as a proportional augmentation of output for a given level of input. Additive models combine both effects of input utilization and output augmentation (Coelli, Rao and Battese, 1998).

[5] Pure-technical efficiency considers both managerial (technical) and scale effect on the performance of DMUs under consideration (Cooper, Seiford and Kaoru, 2000).

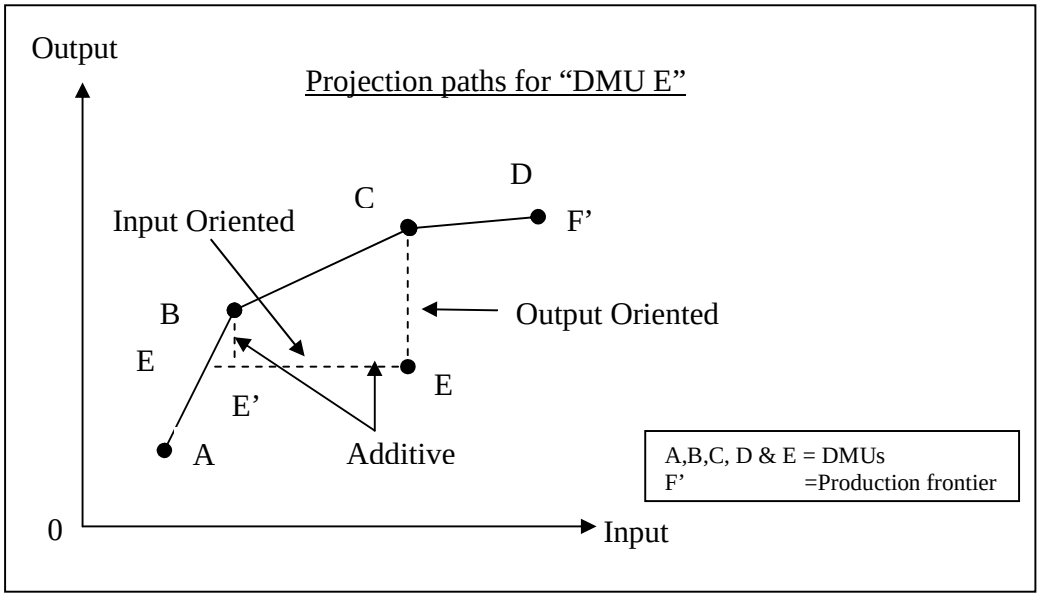


Figure 3.4: Mode of assigning efficiency indices

The traditional DEA limits the efficiency scores of efficient units to 100% in both input-oriented models and output-oriented models. DEA scores for inefficient units are lower than 100%. Both input-oriented and output-oriented models recognize the same DMUs as efficient. However, scores assigned to the inefficient units are not the same in the two projection modes (Lovell and Rouse, 2003).

3.4.1 Different specifications of DEA

Since the publication of the CCR model, DEA techniques have emerged as the most favoured methodology for efficiency analysis. Several alternative DEA models have been formulated and presented by various researchers to overcome problems and weaknesses of the initial DEA specification[6]. Charnes et al. (1997) identified four such DEA models and pointed out that those models address managerial and economic issues and provide useful information on the DMU. Subsequently, Bowlin (1998) highlighted seven DEA models. These supplementary DEA models attempted to address issues such as economics of scale, super efficiency, and statistical noise in the data. Table 3.1 summarises some basic DEA models that have been used in empirical studies of banking and the financial services sector.

[6] See appendix 1 for various applications of DEA in the financial services sector

Table 3.1: Forms of DEA used in banking literature

Model	Contributor	Major features
CCR	CCR(1978)	Input-oriented and constant returns to scale
BCC	BCC(1984)	Input-oriented and variable returns to scale
Additive model	Charnes et al. (1985)	Relate the efficiency results to the economic concept of Pareto optimality
Multiplicative model		The virtual outputs and virtual inputs are formed multiplicatively instead of additively. Constructed frontier is piece-wise log linear
Measures of efficiency dominance model	Bradhan 1996	This model restricts comparison to actual organizations instead of linear combination of organizations
Assurance region model and polyhedral model	Charnes et al. (1990)	Restricts the values that the virtual weights may attain and thereby limits the range of acceptable efficient input-output levels
Categorical variable model	Banker and Morey (1986)	Relaxes the need for the variables to be measured on a constant scale and allows the incorporation of on-off or present-not-present variables in the analysis
Super efficiency model	Andersen and Petersen (1993)	Allows ranking of efficient DMUs
Least-norm projection and observable frontier	Frei and Haker (1999)	An extension of the additive DEA model
Stochastic DEA	Sengupta (2000)	Allows incorporation of random error in input-output data
Equivalent standard DEA	Lovell and Rouse (2003)	Allows outlier identification, sensitivity analysis, and inter-temporal analysis

3.4.2 Selection of the DEA model

As stated in section 3.3.2, a DEA model constructs a production frontier by piecewise comparison of DMUs in the sample and does not use a pre-specified functional form. However, the model requires a specified set of outputs and inputs, and choice of appropriate returns to scale and an appropriate method of efficiency projection. Incorrect choices in relation to these features are likely to diminish the value of analysis (Smith, 1997). This problem is complicated because the DEA model does not provide diagnostic tests to judge the suitability of a chosen model as do econometric frontier estimation models. Hence, even though no functional form

is specified in DEA, model specification must be a central concern. Smith (1997) used Monto-Carlo simulations to examine the impact of model miss-specification on the estimated efficiency scores using DEA. Omissions of a significant variable, inclusion of an irrelevant variable, inappropriate choice of returns to scale assumptions and sample size are probable areas of miss-specification in DEA. Smith's study produced the following implications on model miss-specification.

- The complexity of the production process may diminish the success with which DEA can indicate true efficiency. If the model is simple and DEA representation well specified, DEA provides accurate estimates of true efficiency;
- In a simple production process, an omission of a relevant variable may have a significant effect on the estimated efficiency;
- Inclusion of inappropriate variables may have a modest influence on the estimate;
- Variable returns to scale may be used on the grounds that it offers conservative estimates of achievable productivity improvements. However, incorrect choice of the RTS setting may lead to an incorrect estimation of productivity improvements;
- The distortion from true productivity is reduced with increasing sample size.

Different DEA models address different issues of productivity. These models have attempted to overcome the limitations of initial DEA models. Mainly CCR and BCC models have been applied for estimating efficiency of financial institutions. Most analysts have measured technical efficiency based on input-oriented DEA models. Few studies have used output-oriented models. Since the regulatory environment restricts the flexibility of managerial decision making, the majority of banking productivity studies have applied input-oriented models. Furthermore, the maturity of the industry has affected the selection of orientation methods. Industries in a mature production stage seek to maximize production using standardised production technologies which focus on input minimisation (Golany and Storbeck, 1999). Hence, output-oriented models are more appropriate for measuring the efficiency in

such industries. Contrarily, industries in a growth stage seek to minimize the input usage. Hence, efficiency studies in banking industries considered to be in growth stage are mainly based on the input-orientation (Golany and Storbeck, 1999).

Selection of returns to scale setting is another critical issue in DEA-based studies. Berg et al. (1993) emphasised that VRS is the most appropriate assumption since the scale classification in banking is a classical issue. They proposed that the efficiency scores given by the VRS (BCC) model are more robust to mis-specifications. On the other hand, CRS allows comparison of large banks with much smaller banks. Thus, CRS (CCR) avoids the over-estimation of efficiency of small DMUs in the target sample. However, simultaneous use of CCR and BCC DEA-models allows analysts to decompose technical efficiency into scale and pure-technical efficiency. Hence, the majority of studies on financial institutions have used both CCR and BCC models. The use of both approaches permits analysts to decompose the efficiency estimation into overall technical efficiency, pure-technical efficiency and scale efficiency.

Homogeneity of DMUs is one of the assumptions behind DEA. This assumption does not hold for various reasons. Lack of homogeneity among the firms (size, forms of organization) in the industry and the geographical locations of firms have influenced the model specification. The homogeneity assumption does not hold when there are outliers in the sample. The outliers may significantly over-state or under-state the estimated efficiency scores. In many empirical studies, the outliers have been removed from the study sample to avoid possible distortions in estimated efficiency scores.

Another problem related to the homogeneity assumption arises when the sample is composed of DMUs from different environmental backgrounds. This could be addressed by stratification of the study sample according to the homogeneous features of DMUs. Thereafter, separate production frontiers could be constructed for each cluster to estimate the efficiency (Alam, 2001; Brown, 2001; Drake and Hall, 2003). Unless stratification is done to alleviate heterogeneity in financial

intermediaries, issues outside managers' control may result in incorrect conclusions on the overall efficiency of an industry as well as individual units within the industry (Brown, 2001). Brown illustrated the way of using stratification of DMUs based on the common features for constructing production frontiers for each cluster separately. The sample of 326 Australian credit unions in Brown's study was stratified into four sub-groups according to size, region, assets mix and survived or merger. Brown's result revealed that the efficiency estimation may be distorted if the heterogeneous features are not recognized. As an alternative way of addressing heterogeneity, a categorical variable approach can also be used. Categorical variables can be introduced to DEA models as inputs or outputs to recognize the various features inherent to DMUs which may influence the estimated efficiency (Banker and Morey, 1986). This strategy is mainly used in cross-country comparisons of efficiency.

3.4.3 MPI, scale efficiency and technological change

MPI originally developed by Caves, Christensen and Diewert (1982), has been used in previous studies to decompose various components of estimated productivity improvements and efficiency[7]. A variant of MPI has been used to decompose scale efficiency from technical efficiency. In DEA-based efficiency studies, efficiency losses from scale and managerial decisions have been identified using the MPI (Coelli, Rao and Battese, 1998). Scale efficiency is measured using BCC-DEA and CCR-DEA models. The estimated efficiency using the CCR-DEA model is identified as technical efficiency. Similarly, the estimated efficiency using BCC-DEA is identified as pure-technical efficiency (Cooper, Seiford and Kaoru, 2000). DMUs with estimated efficiency scores of '1' for both CCR-DEA and BCC-DEA models are considered as fully efficient (Banker et al., 2004). If there is a difference in the CRS and VRS estimated efficiency for a particular firm, it is not regarded as a fully efficient DMU (Coelli, Rao and Battese, 1998). The difference between CCR and BCC estimated efficiencies is regarded as scale inefficiency. It can be decomposed by dividing the technical efficiency estimated by CCR by the estimated

[7] Section 4.3.2 describes MPI and its application in productivity improvements.

efficiency using BCC. However, the estimated scale efficiency may distort the real scale efficiency when the sizes of DMUs under consideration are significantly different (Dyson et al., 2001).

3.4.4 Restriction on number of inputs and outputs

According to the DEA techniques, the number of inputs and outputs is always restricted by the number of DMUs in the sample. The ability of DEA to discriminate between efficient DMUs and inefficient DMUs depends on the number of inputs and outputs which are incorporated in the DEA model. Hence, the product of the number of inputs and the number of outputs should not exceed the number of DMUs in the sample (Cooper, Seiford and Kaoru, 2000). As a rule of thumb, Dyson et al. (2001) proposed that the product of the total number of inputs and outputs should be no more than fifty percent of the number of units under investigation to achieve a reasonable level of discrimination. On the other hand, limiting the number of variables may also understate the relative efficiency estimations.

Cinca, Molinero and Garcia (2002) investigated sensitivity of the estimated efficiency to various approaches of input-output specifications and pointed out that two institutions in a given industry may achieve the same efficiency but under different management strategies. These differences are reflected in different weight structures for inputs and outputs. They estimated the efficiency of Spanish savings banks by employing a variety of input-output mixtures. The estimated efficiency scores were derived by using principal component (PC) analysis. They found that the way deposits are treated in the model specification is a vital factor in deciding efficiency scores. Following Avkiran (2000), Cinca, Molinero and Garcia (2002) suggested that the efficiency of DMUs should be estimated using alternative specification methods and should rely on the average estimated efficiency.

There are two ways of using a panel data set to construct the production frontier to overcome the small sample size problem: window analysis and construction of a common frontier for all observations (Cooper, Seiford and Kaoru, 2000; Yue, 1992). However, construction of a common frontier using all available data over several

time periods may reduce the comparability of estimated efficiency changes. DEA window analysis is simply based on the concept of moving averages. Each DMU in different periods is treated as a different unit in the productivity assessment. When there are 'n' number of DMUs with a window of 'm' periods, then the production frontier can constructed using 'n*m' DMUs (Cooper, Seiford and Kaoru, 2000). However, there are no pre-specified criteria for selecting an appropriate width for the window size. Too small a window may reduce the explanatory power of the estimated production frontier. On the other hand, a window of a relatively longer period may distort the information about efficiency changes. However, window analysis may be a useful alternative to overcome the problem of small sample size.

3.5 Input and Output Specification

Input and output specification is another issue which is still to be resolved in DEA studies in the banking industry. There are two main issues to be addressed when recognizing inputs and outputs for the productivity analysis. Firstly, inputs and outputs need to be defined. Secondly, suitable measurements of inputs and outputs need to be used. This section summarises literature on the issues related to banking inputs and outputs.

3.5.1 Issue 1: Definition of inputs and outputs

A fundamental problem in relation to input and output specification arises due to different treatment of deposits. A significant portion of the loan and investment portfolio of a bank is sourced from deposits. On the other hand, commercial banks offer deposit products with various features such as integrated deposit accounts, checking accounts, and accounts linked to loan plans to enhance the banks' competitive positions (Leong and Dollery, 2002). Mester (1987) highlighted two approaches (production and intermediation) which are mainly used in banking literature. Leong and Dollery (2002) identified the production, intermediation and assets approaches as three approaches for recognising banking output. However, Favero and Papi (1995) had previously identified five approaches for input-output specification in the banking industry: the production, intermediation and assets

approaches, which are directly linked to operational functions of banks, plus the user cost and value-added approaches, which are not directly linked to the operational functions of banks. These two approaches mainly consider the nature and significance of banking activities. In practice, researchers have selected different variables even though they have used identical approaches.

Sealey and Lindley (1977) first attempted to develop a positive theory for the behaviour of financial institutions. They highlighted two different views, namely, the technical view and the economic view of financial institutions. They pointed out that the transformation process for a financial firm involves borrowing of funds from savers (surplus spending units) and lending those funds to borrowers (deficit spending units), i.e., financial intermediation. Therefore, outputs of authorised depository institutions (ADI) in a technical sense are a set of financial services to depositors and borrowers. Accordingly, ADI provide three categories of services, namely, administration of the payments mechanism for demand deposit customers, intermediation services to depositor and borrowers, and other services such as trust department activities and portfolio advisory services.

As explained by Sealey and Lindley (1977), both borrowers and depositors have received some utility from the banking services. Hence, they suggested the value addition to each input and output should be considered when defining the firm's products in an economic sense. Based on the theory of the firm, they emphasised that the firms must consider the output of economic production to be priced higher when compared with input prices. Further, market prices should be used to value products. Hence, some services which are considered as outputs in financial institutions in technical sense do not have market prices, they can not be considered as output in the economic sense.

The production approach treats banks as producers of services which use labour and capital to generate deposits and loans (Avkiran, 2000). Under this framework, deposits are included among the outputs because they are viewed as part of the banking services offered (Golany and Storbeck, 1999). Commercial banks provide

intermediary services in the financial system, and thus satisfy the expectations of both borrowers (deficit holders) as well as savers (surplus holders). The success of a bank depends on its ability to serve both parties. Banks use loan products to satisfy borrowers and deposit products to satisfy savers. Hence, the production approach considers services provided to both parties as outputs.

Contrary to the production approach, the intermediation approach regards deposits as an input, which is used for producing the other banking outputs. It is based on the assumption that the main role of banks is to arrange a meeting place for the savers and borrowers to make financial transactions. Banks collect deposits from savers and use these savings to produce loans and other products such as investments. Favero and Papi (1995) indicated that the intermediation approach is most appropriate for banks where most activities consist of turning large deposits and funds purchased from other financial institutions into loans and financial investments.

Elyasiani and Mehdian (1990b) stressed that the production approach can be applied only when functional cost analysis data are available. Since the data on the number of deposits and loan accounts are available only as a part of the functional cost analysis, the ability to use the production approach appears to be limited. Contrarily, the intermediation approach allows the use of the value of the input and output variables. Elyasiani and Mehdian (1990b) highlighted the following advantages of the intermediation approach over the production approach:

- The intermediation approach is more inclusive of total banking costs. These expenses constitute a substantial portion of banks' total costs and their exclusion may distort the empirical results.
- Since the deposits are used for making loans and investments with other inputs, they should be considered as inputs.
- By using the currency value of the input output data, the intermediation approach reduces the potential quality problems of input-output data.

The assets approach is similar to the intermediation approach (Camanho and Dyson, 2004). Outputs are strictly defined by assets and mainly by the production of loans. This approach recognises labour, capital, deposits and other liabilities as inputs. The user cost approach considers the net contribution of the banking revenue when determining input and output. The opportunity cost of each asset and liability item is compared with the financial cost and return. If the opportunity cost of a liability is greater than the financial cost, the item is recognized as an output; otherwise it should be considered as an input. Similarly, if the opportunity cost of an asset is greater than the financial return, it should be recognised as an input; otherwise it should be considered as an output. Under the value-added approach, items in the balance sheet with a substantial share of value-added are considered as the outputs. This approach considers both deposits and loans as outputs of banks.

Berger and Mester (1997) introduced a variation to the value-added approach called the profit approach for recognising input and output variables to measure the profit efficiency. According to them, profit efficiency allows measurement of how close a bank is to producing its maximum possible profit given a particular level of input prices and output prices. Thus, the standard profit function specifies all revenues as output variables and all expenses (mainly variable costs) as input variables. That is, the profit dependent variable allows for consideration of revenues that can be earned by varying outputs as well as inputs.

As stated above, there is no general agreement about the components of banking inputs and outputs. Many studies have applied either the intermediation or the production approaches. Some studies have sought alternative ways of defining inputs and outputs. A summary of input and output variables used in previous studies is presented in Tables 3.2 and 3.3. Nevertheless, the differences in input and output definition have reduced the generalisability of findings from efficiency studies in the financial services sector.

Table 3.2: Input variables used in previous banking productivity studies[8]

Type	**Input**	
Bank specific	Branch size	Number of computers /Office
	Number of Computer terminals	space/Teller hours
	Number of banks	
Borrowed funds	Borrowed money	Purchased funds
Capital	Capital/Equity	Financial capital/Net profits
Deposits	Call deposits	Savings deposits
	Demand deposits	Short term deposits
	Deposits	Small denomination time and savings
	Funds from customers	Deposits
	Retail and wholesale deposits	Time and savings deposits
Non interest	Operating expenses	Non-establishment expenses
expenses	Depreciation cost	Non-personnel expenses
	Establishment expenses	Other expenses
	General and administrative	Total cost
	Non interest expenses	
Interest expenses	Interest expenditure	Interest spread
Fixed assets	Fixed assets /Net fixed assets	Net worth
	Net physical capital	Physical capital
Labour	Clerical staff	Managerial personnel
	Labour (average salary)	No. of staff
	Labour (number / hours)	Number of tellers
		Personnel cost
Problem loans	Credit loss cost	Problem loans
	Loan loss provisions	
Others	Banking funds	Investments
	Net funds from other banks	Loanable funds
	Economic status of the area	Market size
	Income from non-banking sources	Environmental variables

[8] See Appendix 2 for references

Table 3.3: Output variables used in previous banking productivity studies[9]

Type	Output Variables	
Bank specific	Number of business accounts Number of branches Number of employees Service hours	Service variety Interest spread Transaction volume
Capital	Net worth	
Deposits	Total deposits (value/number) New accounts (time savings, certificates of deposits) Core deposits Customer deposits Deposit withdrawals	Commercial accounts Current accounts (value/number) Deposit not at call Time and saving deposits Transaction deposits
Investments	Earning assets Investment/Investment securities/Bonds/Other	Liquid assets Other productive assets Securities
Loans and advances	Loans and advances/Net loan Number of loans Long-term loan/Short-term loan Commercial and industry loans Personal loans/Housing loans Real estate loans	Non-housing loans Inter bank loans Loans to other banks Small loans/Other loans No. credit applications
Non-traditional activity	Non-traditional activity Risk adjusted off-balance sheet activities	Risk-weighted assets Travellers' cheques
Revenue	Income (banking and non-banking) Interest income (gross/net/average) Non-interest income (gross/net) Operating income/Other earnings Revenues/Net profits	Net commission income/Fee-based income/Foreign currency income/Investment income/Real estate income
Other	Annual average increase in total assets Bills discounted	Borrowing Interbank assets/ liabilities

[9] See Appendix 2 for references

3.5.2 Issue 2: Measurement of inputs and outputs

The second major problem related to the input and output specification arises when selecting a suitable method of measurement. There are three main measurement approaches for banking outputs and inputs that could be used in productivity analysis. They are flow measures (the number of transactions processed on deposits and loan accounts), stock measures based on money value (the real or constant monetary values of funds in the deposit and loan accounts), and stock measures based on the number of deposit and loan accounts serviced (Humphrey, 1991). The majority of productivity studies on banks have applied stock measures based on monetary values due to the more ready availability of the required information. However, the use of monetary value-based stock measures may distort estimated efficiency. For instance, Drake and Hall (2003) signalled that the use of personnel expenses rather than employee numbers could result in some bias against those banks that hire quality workers at a higher cost. Some banks hire high calibre banking professionals and pay relatively higher salaries. Since a high personnel cost could be a result of employing high quality labour, analysts have to be mindful of the objective of the research as there is a possibility to bias results.

3.5.3 Issue 3: Non-traditional activities

In the past, efficiency and productivity studies on banks have only considered the traditional services of financial institutions included in the balance sheet. Changes in market competition and the advancement of technology have provided more opportunities for banks to transform their traditional banking products to non-traditional products. Banks' responses to changing financial systems are reflected not only in their balance sheets but also in their off-balance sheet activities. Off-balance sheet activities permit banks to diversify their product range in order to maintain their degree of competition, to expand their customer bases and to improve the significance of fee income in total revenue (Tortosa-Ausina, 2003). Thus, in addition to traditional banking products, banks offer a range of products and services from collection of utility bills to more sophisticated investment and insurance. Berger and Mester (1997) considered those off-balance sheet items as an effective

substitute for directly-issued loans which incur information gathering cost of origination and ongoing monitoring and control. They stressed that if off-balance sheet items are ignored from the efficiency estimation, a scale bias may result.

However, contemporary studies have paid little attention to incorporation of the off-balance sheet activities as an output in efficiency estimation models. Rogers (1998) indicated the ability to use non-interest income to proxy for non-traditional products. Tortosa-Ausina (2003) examined the impact of non-traditional activities to banks' efficiency using two different models based on two different specifications of output. She found supportive evidence that non-traditional activities have an influence on bank efficiency.

3.5.4 Issue 4: Quality aspects

The usefulness of productivity measurements can be improved by incorporating quality aspects into the analysis. Quality in this context is defined as the non-operational aspects which may have an influence on efficiency. Various researchers have attempted to incorporate the various quality issues such as market structure, government intervention in the industry, size of the banks, and problem loans into efficiency studies. When direct measurements are available, these quality aspects can be included as inputs. Categorical variables model may be used represent quality issues (Banker and Morey, 1986).

Further, DEA modelling allows analysts to select inputs and outputs objectively. Some researchers have used this capability to advantage by developing DEA models which may uncover different aspects of management. Chen (2002) used alternative input and output specifications to identify the operational, financial and marketing efficiency of Taiwan's commercial banks. Denizer, Dinç and Tarimcilar (2000) used a two-stage procedure for estimating productive efficiency to overcome the input-output specification problem. They highlighted that the estimated efficiency by the two approaches provided different information about the firms' efficiency. As explained by them, the production approach signalled the managers' ability to use

the available resources effectively. The intermediation approach provided information about the overall efficiency.

3.5.5 Implications of input-output specification

The specification of inputs and outputs in productivity analysis may have a significant influence on the estimated efficiency. However, there is no general agreement with regard to specification of banking inputs and outputs. Discussion in the previous studies has provided the following implications, which may be useful for future research in banking and financial services:

1. The production and the intermediation approaches are the methods which are most widely used.
2. The production approach is more appropriate when evaluating productive performance among the branches of the same bank.
3. The input and output specification may directly affect the outcome of the analysis.
4. It is useful to apply more than one input and output specification before making an inference from the results.
5. The difficulty of collecting accurate data restricts the use of some approaches such as user cost and value added.
6. Traditional input and output specification has ignored the quality aspects.
7. Analysts can select input and output combinations to represent their expectation in efficiency evaluations.

3.6 Application of DEA in the Banking Industry

Since 1978, DEA has been extensively used for measuring efficiency and productivity gains in the service sector industries. Tavares (2002) found 3,203 publications (including 1,259 journal articles and 50 books) related to DEA during the period 1978-2001. This shows the popularity of DEA as a method of estimating efficiency of DMUs. The ability to use DEA for measuring efficiency and productivity gains in service-oriented organizations without defining input and

output prices encourages the use of DEA in such studies on the banking industry. This section makes an analytical evaluation of DEA applications on the banking industry[10].

Berger, Hunter and Timme (1993)[11], and Berger and Humphrey (1997)[12] presented two literature surveys on the application of frontier based efficiency and productivity studies in the financial services sector. An interesting observation of these literature reviews is that only a few studies have addressed efficiency and productivity issues in developing countries. Previous studies have mainly focused on evaluating efficiency and productivity gains in the developed world. Thus, efficiency and productivity in the financial services sector in developing countries have been given a very low priority by researchers. However, with globalization of financial services sector activities, it is important to understand the operational performance of the financial services sector in developing countries as well as the developed countries.

The purpose of this section is to investigate the existing efficiency and productivity gains-related studies in the financial services sector which primarily used DEA to estimate efficiency and productivity gains. Previous literature can be divided into two broad streams: research based on methodological issues and research based on empirical issues. Research based on methodological issues has tested the further development of DEA as a tool of estimating productive efficiency in the banking industry. These researchers have focused on development of a statistical basis for making inferences from efficiency scores estimated by DEA and alternative models which overcome the deterministic nature of the traditional DEA methodology. Research on empirical issues has mainly addressed government policy, managerial decision making, market structure and competition.

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10 See appendix 3.1 for various applications of DEA in banking industry.

11 Berger, Hunter and Timme (1993) found six main areas of financial services sector productivity covered by studies, namely, scale and scope efficiency in banking, X-efficiency in banking, the efficiency implications of bank mergers, the efficiency of thrifts and governmental financial institutions, the efficiency of the insurance industry, and the determinants of financial institutions efficiency.

12 Berger and Humphrey (1997) identified three clusters of empirical studies in financial services sectors, namely on the aim of the studies: (1) informing government policy, (2) address research issue and (3) improve managerial performance.

3.6.1 Methodological issues

Research on methodological issues has covered empirical investigation of the theoretical soundness of DEA for estimating efficiency and productivity gains. These studies have examined alternative ways which can be used to overcome the inherent weakness of the traditional DEA model. Issues include:

- comparability of DEA-based estimates of efficiency and productivity gains with the estimated efficiency and productivity indexes using alternative frontier methods and traditional productivity measurements methods (see Barr and Siems, 1998; Bauer et al., 1998; Coelli and Perelman, 1999; Huang and Wang, 2002; Kumbhakar and Heshmati, 1999; Leong and Dollery, 2002; Premachandra, 2001; Resti, 1997);
- sensitivity of the DEA-estimated efficiency and productivity indexes to the changes in various specification issues (such as input-output, sample size and categorical variables) (see Cinca, Molinero and Garcia, 2002; Tortosa-Ausina et al., 2003);
- ranking of efficient DMUs (see Bauer et al., 1998; Fethi, Jackson and Weyman-Jones, 2002; Lovell and Rouse, 2003); and
- alternative ways for finding statistical evidence for DEA-estimated efficiency indexes (see Alam, 2001).

The following section discusses methodological issues addressed in the previous studies and their implications.

3.6.1.1 Comparability of estimated efficiency and productivity indexes with alternative methods

The existence of alternative methods together with traditional rating-based performance evaluation methods raises an important question about the most reliable efficiency and productivity estimation approach. Since different productivity estimation approaches are based on different sets of assumptions, the estimated efficiency from different approaches may not be the same. Bauer et al. (1998) examined the properties of different frontier analysis methods based on six

consistency conditions[13]. These consistency conditions indicated the minimum requirements for simultaneous use for efficiency rankings derived from various frontier methods in order to be useful in a policy analysis. Different researchers have applied these consistency conditions in various contexts to examine the comparability of productivity indexes estimated using varying approaches.

Bauer et al. (1998) found that main frontier productivity assessment methods (parametric and non-parametric) tend to yield the same distribution of efficiency. Roughly, all methods identified the same banks in the best practice group and in the worst practice group. Compared to the other methods, DEA reported low estimated efficiency. Overall, this study found that all parametric approaches provide efficiency and productivity estimations that are consistent with one another, while DEA does not. Another study in Taiwan (Huang and Wang, 2002,) where four of the Bauer et al. consistency conditions were applied to find the consistency of estimated efficiency based on three frontier methods (DEA, SFA and DFA), found different evidence from Bauer et al.. Huang and Wang's evidence indicated a similar distribution pattern in estimated efficiency with all three methods. However, results indicate different rankings of DMUs when using parametric and non-parametric methods. Estimated efficiency with parametric methods showed less variation across the periods and indicated closer correlation with traditional measures than with the non-parametric methods.

Leong, Dollery and Coelli (2002) used these consistency conditions to examine the observable differences in estimated efficiency indexes using different model specification with DEA productivity estimations. They reached a similar conclusion to Bauer at al. (1998) about the distribution of estimated efficiency indexes. However, different DEA models showed an inconsistent trend throughout the study period. Resti (1997) found that the efficiency and productivity estimations did not

[13] Bauer at al. (2002) identified six consistency conditions [(1) consistent distribution, (2) ranking consistency, (3) identification of best and worst practice firms, (4) consistency of the estimated efficiency over time, (5) consistency with market conditions, and (6) consistency with standard non-frontier performance measures] with which the efficiency estimates derived from the various approaches should comply.

differ dramatically when using the same data and conceptual framework. However, results derived using allocative DEA (ADEA) and SFA (based on a translog flexible form) provided dissimilar explanations about the scale of the large banks. Even though the SFA results provided evidence of increasing returns to scale for large banks, the estimated result on BCC-DEA and CCR-DEA indicated that most large banks had decreasing returns to scale. Even though efficiency scores estimated using the two approaches reported a high correlation, their distributions were not similar. Weill (2004) applied a similar approach to find the comparability of estimated efficiency using SFA, DFA and DEA using data from five European countries. Weill found that the different frontier approaches do not give comparable efficiency indexes.

The longitudinal efficiency analysis approach used by Barr et al. (1999) found strong and consistent relationships between estimated efficiency indexes using DEA and traditional methods. This study suggested that the estimated DEA scores have a positive relationship with variables such as non-interest income to average assets, interest income to average assets, earning assets to average assets, and return on assets. It also indicated negative relationships with bank size, salary expenses to average assets, other non-interest expenses to average assets, interest expenses to average assets, fixed assets to average assets, non-performing loans to average assets and loans to average assets. A similar approach was applied by Leong and Dollery (2002) to examine the productive efficiency of Singaporean banks.

As stated above, the empirical studies provide dissimilar evidence about different efficiency and productivity evaluation methods, even if the same data set is used. Based on the above discussion, the following implications can be identified:

1. Different methods provide different efficiency estimation even though the same data set is used because of differences in assumptions that have been used for each method. DEA ignores the potential for random error when estimating efficiency. On the other hand, SFA or econometric approaches are based on pre-specified functional forms and allow for random error. VRS

and CRS models suggest the shape of the frontier. These assumptions are reflected in the differences in estimated efficiency.

2. Even though individual efficiency estimations are not similar in many cases, the average efficiency estimation with different approaches is often similar. However, distributions of efficiency estimates from different approaches are not similar.
3. Relative to SFA, DEA provides a lower estimation of efficiencies. DEA is affected by the assumption of random error.
4. There are no clear guidelines to identify the most appropriate methods for any particular study.

3.6.1.2 Sensitivity of DEA-estimated efficiency indexes

DEA is based on different assumptions, model specifications and selection of inputs and outputs. As stated above, the number of variables included as inputs and outputs in DEA analysis is constrained by the number of DMUs in the sample. Because of this limitation, some important variables which may have a significant effect on the estimation of efficiency may be excluded from the basic DEA model. Some studies have tested whether the omitted variables have a significant influence over the estimated efficiency indexes (Cinca, Molinero and Garcia, 2002; Tortosa-Ausina et al., 2003). Cinca, Molinero and Garcia found that the estimated efficiency using DEA may be inaccurate if there are any errors in variable definition and model specification.

The wrong choice of basic DEA models such as CRS and VRS, as well as the wrong choice of input and output variables, give incorrect assessment of efficiency. Tortosa-Ausina (2002b) examined how the different specification of inputs and outputs can influence the estimated efficiency. That study found the shape of the distribution of estimated efficiency varies greatly according to the output definition. In general, these studies indicated that issues such as the model specification and the input and output definition may have a great influence over estimated efficiency.

3.6.1.3 Finding the best ranking method

One main task of evaluating efficiency is to identify the most efficient production units in a given industry. DEA assigns equal scores (100% efficient) for all firms on the estimated production frontier. Thus, all DMUs located on the production frontier are given equal ranking in terms of performance. Since these DMUs may not operationally have the same strength, ranking them equally may mislead the users of these indexes. Therefore, ranking the DMUs which are considered to be equally efficient is an unsolved problem associated with traditional DEA models (such as CCR, BCC and Additive).

To overcome this problem, some studies have applied super-efficiency DEA models (Fethi, Jackson and Weyman-Jones, 2002; Lovell and Rouse, 2003). These models allow estimating the super-efficiency scores for the DMUs which are considered to be equally efficient by conventional DEA models. Super-efficiency scores can be used for ranking of efficient DMUs into extremely efficient and non-extremely efficient DMUs, observing the sensitivity of efficiency classifications, identifying outliers, overcoming the truncation problem, and calculating and decomposing a MPI. However, these super-efficiency models have not been tested to a great extent in the financial services sector. One such study has been done by Fethi, Jackson and Weyman-Jones (2002) using data from the Turkish banking industry. This study indicated a wide variation of estimated efficiency using traditional DEA models and the stochastic DEA model.

3.6.1.4 Statistical inference from estimated efficiency

The lack of statistical evidence for the significance of estimated efficiency is one of the main criticisms of the DEA. The majority of empirical studies have used descriptive statistics to make inferences from estimated efficiency. However, these explanations have been inadequate to get clear evidence of the reliability of estimated efficiency. Therefore, some researchers have attempted to explore alternative ways of making statistical inferences from estimated efficiency. To overcome this disadvantage, some studies have employed statistical methods such as the central limit theory (CLT), and non-parametric bootstrapping (Alam, 2001). CLT

assumes that the distribution of time means (averaging over firms at a point in time) become asymptotically normal in a sample with a large number of firms. The appropriate confidence intervals can be found using the student 't' distribution. However they indicate that the CLT can not be applied when the sample is not large.

3.6.2 Sources of inefficiency

A bank may improve efficiency and productivity gains through three main sources, namely, pure-technical, scale and technological change. Due to the inadequacy of available price information for inputs and outputs in the banking industry, few studies have investigated inefficiency resulting from non-optimum allocation of resources. Scale and pure-technical inefficiency are estimated using BCC and CCR DEA models. Technical change is estimated from the frontier shift in two consecutive periods. The sources of inefficiencies are observed by MPI-like indexes. Identification of sources of inefficiency helps DMUs in two ways. Firstly, they are informed of the reasons for the inefficiency. Secondly, they are helped to formulate strategies for enhancing DMUs' efficiency and productivity gains.

Empirical studies have given mixed signals on sources of efficiency gains. Yue (1992) found that the main source of inefficiency in the largest 60 commercial banks in Missouri is technical inefficiency. The contribution of scale diseconomies is relatively low. Drake (2001) investigated the efficiency of 10 UK banks during 1984-1995. That study found increasing returns to scale in small banks and decreasing returns to scale in large banks. Consequently, Drake suggested that the banking industry in the UK suffers from scale diseconomies particularly for the smallest and the largest banks (i.e., except medium sized banks).

Darrat, Topaz and Yousef (2002) found that allocative (regulatory) and technical inefficiency (managerial) have affected the efficiency of Kuwait banks. Over the period 1990-1993, the productivity growth in US rural banks was attributed to technological change rather than the pure-technical change or scale change (Devaney and Weber, 2000). Elyasiani and Mehdian (1990a) found that during the period 1980-1985, US banks enjoyed a positive technical change. Drake and Hall

(2003) investigated technical and scale efficiency in Japanese banks using a cross-section of data to find evidence for efficiency of potential bank mergers. The result signalled that the Japanese banks exhibited considerable overall inefficiency with a sample mean for overall efficiency of 72.36%. Drake and Hall found that the main reason for productive inefficiency is pure-technical inefficiency, and the exclusion of problem loans from productivity analysis may overestimate the potential economies of scale. In another study in Turkey, which aimed to find the improvement in efficiency and productivity gains from deregulation, the main source of productivity gain was found to be catching up with the best practice banks rather than technical progress (Isik and Hassan, 2003a). This result further suggested that the domestic banks suffer from diseconomies of scale.

In contemporary frontier-analysis studies, many researchers have focused on the short-run production frontiers. Prior (2003) attempted to construct long-term and short-term cost frontiers using non-parametric methods to find the capacity efficiency in Spanish savings banks. Prior separated inputs into variable and fixed inputs, with the short-run frontier constructed by considering variable inputs and the long-run frontier constructed using both fixed and variable inputs. The difference between estimated efficiencies using long-run and short-run cost frontiers is identified as capacity efficiency. The study revealed that a significant portion of inefficiency in Spanish commercial banks arose due to capacity underutilization.

One main objective of these studies was to find an appropriate scale of operation for banking institutions. However, the results are somewhat complicated. Many studies suggested that either large banks or small banks were not able to gain the benefit of economies of scale of operations. The problem of optimum scales for banking operations is yet to be resolved.

3.6.3 Policy issues

A large number of previous studies have examined how commercial banks have reacted to various policy issues introduced by policy makers. The financial services sector is the backbone of an economy. Since the behaviour of the financial services

sector directly influences the performance of overall economic activities, policy makers generally attempt to introduce more productive policies. The outcomes of implemented policies must be evaluated to identify probable policy changes. Hence, this area is popular in efficiency and productivity studies. Previous research on policy issues can be classified into six areas: (1) deregulation, (2) economic crises, (3) the effect of mergers and acquisitions, (4) ownership structures of banks and their influence, (5) management performance and (6) market structures. This section describes research related to these policy issues.

3.6.3.1 Deregulation of the financial industry

The main aim of deregulation of the financial services industry is to provide opportunities for technological advancement to improve service quality and to enhance competition by reducing government intervention. Improvements in resources allocation is a primary goal of financial deregulation that can be achieved only on enhancement in efficiency and productivity gains (Humphrey, 1991). Many studies of efficiency and productivity gains in the banking industry have been focused on the success of policy changes related to deregulation. Deregulation studies have mainly focused on the following issues in relation to efficiency and productivity gains:

- Productivity improvements after deregulation
- Entry of new firms and productivity
- Entry of foreign banks
- State-owned banks and privately-owned banks
- Mergers and acquisitions.

Although the primary goal of deregulation and liberalisation has been to improve bank efficiency and productivity gains, empirical studies have provided mixed results. Most studies have found that the short-term effects of deregulation on efficiency and productivity gains are negative. Some studies have indicated that the benefits of liberalisation and deregulation can be expected only in the long run. Furthermore, outcomes of liberalisation in different countries are not similar.

Elyasiani and Mehdian (1990a) reported a 12.98% non-neutral and labour-biased rate of technological change during the deregulation period in the USA. In another study, they found that the productivity gap between small banks and large banks has widened during the post-deregulation period (after 1979). Their results showed relatively low average estimated efficiency for small banks with both pooled and separate production frontiers. However, the small banks were able to report technological progress over the period 1979 to 1986. These results suggested that small banks in the USA were adversely affected by the relaxation of some favorable regulatory restrictions to small banks, such as the branching restriction and interest rate ceilings. Alam (2001) examined differences in productivity improvements in various states in the USA during the post-deregulation period and found that the outcomes of regulatory changes lag for a few periods.

New banks in Portugal reported relatively higher efficiency scores than the old banks, indicating 59% overall efficiency improvements in the banking industry after deregulation (Canhoto and Dermine, 2003). Canhoto and Dermine stressed that a rapid deregulation process with a well-staffed banking system may lead to positive efficiency gains from deregulation.

A study in Austria reported a decline in estimated efficiency immediately after deregulation (1990-1996) and later an increase in estimated efficiency (1996-1997) (Ali and Gstach, 2000). Conversely, Denizer, Dinç and Tarimcilar (2000) found relatively stable productivity growth during the period before deregulation and a negative productivity growth after deregulation. The estimated scale inefficiency scores indicated the Turkish banking system suffered from 5% to 25% efficiency loss in production processes and 7% to 36% in intermediation due to the scale problem. A similar fluctuation pattern in the estimated efficiency of all banks during the study period (1970-1994) signalled that banks were responding to economic changes in a similar pattern.

Deregulation may cause a bank to improve its management practices (technical efficiency), to change the scale of operations (scale efficiency) and to improve

service quality by introducing new technologies (technological change). Further investigation of the productivity improvements due to deregulation of the banking industry in Turkey revealed that these changes have resulted from better management practices rather than improved scale (Isik, 2003). Furthermore, that study signalled that the inefficient banks may imitate efficient banks to catch up with best practice. Isik and Hassan (2003b) revealed that the impact of deregulation on different banking groups was not uniform. Even though all banks reported significant improvements in productivity after deregulation, their technology may not have advanced as expected. Diseconomies of scale are one main factor which has affected estimated efficiency and productivity gains.

The literature related to deregulation shows different results with regard to improvement in efficiency and productivity gains from deregulation. The research investigating productivity improvements has provided the following implications:

1. The relationship between productivity improvements and deregulation is not clear.
2. The productivity improvements from deregulation depend on the prevailing environment in the banking industry. The economic, social and political environments directly influence the way the deregulation benefits are realised. Countries with well-staffed banking systems reported positive efficiency gains from deregulation.
3. In most countries, the deregulation process has taken a relatively long period and the expected gains could not be realised immediately after deregulation. According to some research, rapid deregulation facilitates more positive efficiency improvements.
4. The benefits of deregulation can be realised in the long run.

3.6.3.2 Economic crises

In the early 1990s, after enjoying economic booms, many Asian countries suffered economic recessions which influenced all economic activities in the affected countries. Fukuyama (1995) investigated how the Japanese banking industry was

affected by the economic downturn and by the intensified competitive pressures among the different forms of banks[14]. The research indicated that the recession had mixed results among different forms of banks, but that technical efficiency was stable over the next three years. The average values of the three productivity change indexes in the first time period (1989-90) (before the collapse) were greater than those in the second period (1990-91). The results indicated that the collapse had reduced the efficiency of all banks in the second period except for one former sogo (mutual) bank[15]. However, two-period productivity indexes indicated technological advance but not technical efficiency progress. Further, these results indicated an inverse relationship between bank size (revenue) with both the technological change indexes and the MPI.

3.6.3.3 Mergers, acquisitions and organisational structural changes

The optimum scale of banking operations is a controversial issue which has been debated among practitioners as well as researchers during the past few decades. With liberalisation of the financial services industry, smaller firms were not able to survive the intense competitive pressure from large banking institutions. On the other hand, larger banks were not able to utilize their excess resources optimally. To protect smaller financial institutions, policy makers in some countries have encouraged mergers and acquisitions and changes to the forms of business. In Australia, smaller credit unions were encouraged to merge. Similarly, in the UK, credit unions were forced to convert to limited liability companies. With these changes, policy makers expected to enhance the efficiency and productivity gains of the financial services industry.

Avkiran (1999) used DEA-based efficiency scores to examine the public benefits of mergers using data from 25 Australian commercial banks. The efficiency gains were examined by measuring overall operating efficiency, employee productivity, profit performance and the industry mean relative efficiency scores. Outcomes of bank mergers have been reviewed by comparing the pre-merger and post-merger

[14] As stated by Fukuyama (1995), the banking industry in Japan consists of five forms of banks: city banks, regional banks, sogo banks, trust banks and long-term credit banks.

[15] Sogo banks is a regional banking system which operated in Japan before 1989.

estimated efficiency. The results indicated that the role of the merger in efficiency gains is not necessarily positive. It depends on the acquiring firm's ability to maintain pre-merger efficiency levels. In contrast, Worthington (2001) found that there were efficiency improvements for the merged credit unions in Australia during 1993-1997 relative to those that did not merge. Using an unbalanced panel data set and Tobit model, Worthington (2001) investigated factors that influenced post-merger efficiency in co-operative deposit-taking institutions in Australia. The study found that credit unions with a higher proportion of real estate and commercial loans, a higher level of non-interest income, and a higher expenditure on information technology have high technical efficiency. Further, regression results indicate that credit union mergers have positively influenced technical efficiency.

Batchelor and Gerrard (2002) found that takeovers have effected productivity improvements through technological advancement in local banks in Singapore. Ralston, Wright and Garden (2001) revealed that technical and scale efficiency benefits were gained by both acquirers and targets in some credit union mergers in Australia, but almost an equal number of mergers reported efficiency decreases post-merger. However, the study was not able to find where an acquirer's superior efficiency was transfered to a target. Fried, Lovell and Yaisawarng (1999) investigated merger benefits for credit union members, both acquired and acquiring, and features of successful and unsuccessful mergers using a large sample of US credit unions which were subject to merger during 1998-1995. The study suggested that there was no deterioration in service provision in the acquiring credit unions after merger. The acquired credit union members often received some benefit during the first three years. However, some credit unions showed poorer performance after the merger.

In another study, Kohers, Huang and Kohers (2000) used two hypotheses (the relative efficiency hypothesis and the low efficiency hypothesis[16]) to investigate the

[16] The relative efficiency hypothesis suggests that, after acquiring a poorly managed bank, an efficient bidder can make value enhancing changes. The low efficiency hypothesis suggests that the lower the frontier efficiency level of either or both the bidder and the target, the greater the potential for value enhancement.

relationship between the potential performance gain from mergers and the stock market returns. The study employed both SFA and DEA to estimate the relative efficiency. The study found that the two-day cumulative abnormal returns in the stock market after the merger announcement had a significant negative relationship with the estimated efficiency both in the target and bidder banks, thus confirming the low efficiency hypothesis.

Drake and Simper (2003) investigated the influence of the conversion of UK mutual credit unions into public limited companies (PLC) on productive efficiency. Credit unions and PLCs operate under different management and ownership styles. The prime objective of co-operative credit unions is to improve the welfare of the members. In contrast, PLCs aim to maximize profits to enhance the wealth of the shareholders. Hence, the conversion made a drastic change in the activities and policies of the previous credit unions. Before the conversion, credit unions' operations concentrated on the mortgage market, especially residential finance. They were expected to earn a return for entrepreneurship. On the other hand, PLCs rely on equity financing, and must earn a return for shareholders. Drake and Simper (2003) used DEA to estimate the efficiency gain from the conversion. The estimated efficiencies showed that the conversion had a temporary positive effect on the firms' efficiencies.

Studies on the mergers and acquisitions of financial institutions have provided contradictory evidence from different countries for efficiency and productivity gains. Previous studies have indicated that getting larger will not always have a positive influence on efficiency and productivity gains. Some studies have suggested mergers of financial institutions may have affected positive improvements to productivity (Batchelor and Gerrard, 2002; Crystal, Dages and Goldberg, 2002; Fried, Lovell and Yaisawarng, 1999) and some have not (Avkiran, 1999). There are no adequate studies on which to base a general conclusion about the relationship between organizational changes and banks' productivity.

3.6.3.4 Ownership forms and their influence

Previous studies have predicted that ownership forms or organizational forms which produce stronger incentives to control inputs and boost output may lead to more efficient and productive operations. These studies also have presumed that the quality of management of state-owned banks generally is not good when compared with that of the privately-owned and foreign banks. Lack of continuity, seniority-based promotion, politically-motivated employment and recruitment, low salaries and politically-influenced operational decisions have decreased productivity in state-owned banks (Denizer, Dinç and Tarimcilar, 2000). The profit motivation of the privately-owned and foreign banks leads to more productive use of banking assets than the state-owned banks. Contrary to the case in state-owned banks, these banks give precedence to performance when making human resource management and operational decisions.

The less bureaucratic management system in privately-owned banks allows more flexible operational environments. However, in many countries, a few large state-owned banks have controlled a significant portion of banking activities, and governments in less developed countries mainly take assistance from state-owned banks to fund huge budget deficits (Denizer, Dinç and Tarimcilar, 2000). Governments have given the priority to state-owned banks to serve as bankers to government institutions. Further, regulatory control may not be favourable for the expansion of privately-owned banks. These factors may affect a level playing field for the banking firms. Financial liberalisation in many countries has removed some of the previous impediments to equal opportunities for all banks.

When compared to the other institutions, foreign banks have less autonomy to offer banking activities freely in a host country. However, entry of foreign banks allows local banks to identify and easily implement new banking services and technologies which leading foreign commercial banks are using (Isik and Hassan, 2003a). The foreign banks may increase the capital and services provided and strengthen the technology which the local banks use.

Based on these arguments, some previous studies have investigated the influences of foreign and state banks on efficiency in local banks. These studies predicted that public-sector banks may have relatively lower efficiency and foreign banks may have relatively higher efficiency than their counterparties. Isik and Hassan (2003) found financial deregulation in Turkey has reduced the performance gap between public-sector banks and private-sector banks. In another study in Turkey, Denizer, Dinç and Tarimcilar (2000) found that the relative efficiency of private-sector banks is higher than that of the state and foreign banks. However, foreign banks outperformed the state banks. Furthermore, the study indicated that the foreign banks operated at a relatively better scale when compared to the local banks by confirming their ability to utilise banking resources with more productive operational technologies.

Noulas (2001) found that, although the private banks appear to be more efficient than the state banks in Greece, the efficiency gap between them is not significant. The study indicated that the private-sector banks are better in controlling non-interest expenses. However, another study in the Hellenic banking industry provided somewhat different evidence (Noulas, 1997). That study found that the state banks recoded productivity gains through technological progress. Noulas also found that the private-sector banks in Hellenic recoded productivity gains through increased efficiency. Pal, Mukherjee and Nath (2000) found that private-sector banks, as well as foreign banks, performed better than state banks by estimating operational efficiency of 68 major Indian commercial banks with an output-oriented DEA model. On the other hand, Sathye (2000) found that private-sector banks are less efficient than state banks. Further, his study found that reform has affected efficiency gains in Indian banks.

The influence of foreign banks on efficiency is best illustrated by studies in European Economic Community (EC) countries. After the establishment of a common monetary union, the banks have had an opportunity to extend their services to other EC countries. Hence, some studies have investigated how the common financial market has affected efficiency. In general, these studies have found the

opening-up of the European financial system intensified competition in the banking industry. The intense competition has encouraged banking firms to improve their services drastically to compete with the more efficient banks in the region (Hasan, Lozano-Vivas and Pastor, 2000). The main differences in these studies are that the DEA models incorporate country-specific variables, such as demography, regulation and environmental conditions. Hasan, Lozano-Vivas and Pastor[17] found that the commercial banks in Spain, Denmark, and Portugal are relatively more efficient than those in other EC countries. However, this study found the specific benefits which the major international banks enjoyed were outweighed by the home country benefits which the local banks experienced.

3.6.3.5 Management performance

Managerial decisions directly affect the efficiency of DMUs. Policy makers are particularly interested in identifying how managers make decisions to cope with future uncertainty. Generally, policy makers use CAMEL (capital adequacy, assets quality, management quality, earnings ability and liquidity of banks) ratings which mainly rely on traditional accounting measures for evaluating banks. However, traditional accounting measures are not able to provide accurate information about the quality of management which is vital for predicting the future of a bank. Barr, Seiford and Siems (1994) indicated that since managers make decisions which affect overall performance, DEA-based efficiency estimation can be used for determining managers' performance.

One main advantage of using DEA for analysing efficiency and productivity gains is its flexibility in selection of input and output combinations. In some efficiency and productivity studies, different input and output specifications have been applied as proxies for various forms of managerial efficiency. In one such study, Athanassopoulos, Soteriou and Zanios (1997) used three different input and output combinations to estimate efficiency of three different managerial activities, namely transaction, production and intermediation. In another study, efficiency has been estimated based on three different perspectives: operating, marketing and financial

[17] This study used data from 612 commercial banks in 10 EC countries.

(profitability) aspects in Taiwanese commercial banks (Chen, 2002). Estimated efficiency was regressed with variables which represented ownership and size. That study indicated that the state banks enjoyed relatively high marketing and financial efficiency, but less operational efficiency when compared to the private-sector banks. It also revealed that large-scale banks operated at higher financial and marketing efficiency but lower operational efficiency.

3.6.3.6 Market structure

Market structure and concentration are considered to be another research cluster focused on government policy. Market power explanations indicate a positive relationship between market concentration and profitability. The efficient structure paradigm indicates that efficient firms compete more aggressively in the market and gain dominant market shares and also have high profits because of their low cost of production. One of the main arguments for mergers and acquisitions is the potential productivity improvements. The empirical studies in this paradigm have investigated whether there are any productivity improvements resulting from the mergers and acquisitions in the banking industry. Berger and Humphrey (1997) pointed out that existence of a high degree of local market overlap between merging institutions (which allows greater potential for eliminating duplicated expenditure on bank operations) and the greater existing efficiency level of the acquiring firm are two plausible pre-conditions which may affect the expected benefit from mergers.

3.7 Synthesise

This chapter has provided a brief review of the theoretical and empirical literature on efficiency and productivity studies, with special reference to the banking industry and DEA-based studies. Several important issues needing further attention are identified and outlined below.

The empirical studies have mixed evidence on the outcomes of financial liberalisation. While some countries have enjoyed positive outcomes, some other countries have not been able to maintain previous gains which they had before

liberalisation. Therefore, it is difficult to derive a conclusion about the outcome of financial liberalisation in a particular country based on studies made in other countries. The majority of those studies have focused mainly the influence of deregulation on efficiency and productivity change. Few studies have investigated that how the deregulation have effected to change the market structure and their on to the improvements in efficiency and productivity gains. Changes in market structures and competition may have a direct impact on efficiency and productivity gains. Thus, this study aims to investigate how the structural changes resulted on financial reforms influenced to the efficiency and productivity change and overall operational performance in DMUs.

Only a few studies have investigated the ability of firm-specific factors to explain the changes in banks' efficiency and productivity. Moreover, the explanatory power of macroeconomic factors has been taken into consideration only in cross-country studies. Together with firm-specific factors, changes in macroeconomic factors may have a significant influence on efficiency and productivity gains. On the other hand, liberalisation measures may directly or indirectly affect the macroeconomic environment of the country. Therefore, it is worthwhile to investigate these factors and their influence on the banking industry. Overall, this survey has highlighted that the financial services sectors in developing countries have not been adequately researched. In-depth analysis of these markets is essential to formulate the required policies. The findings in other countries are probably irrelevant to a particular country. Not only are differences in the social, political and economic environments important but the geographical environment may also have a significant influence over efficiency and productivity gains. Therefore, it is essential to do a country-specific analysis.

The literature discussed in this chapter provides an insight about the contemporary research in efficiency and productivity gains in the banking industries. The next two chapters will use these literatures to form an analytical framework for analysis of efficiency and productivity gains and to identify factors affecting the banks' technical efficiency.

CHAPTER FOUR

AN ANALYSIS OF EFFICIENCY AND PRODUCTIVITY CHANGES OF THE BANKING INDUSTRY IN SRI LANKA

4.1 Introduction

This chapter investigates efficiency and productivity improvements of the Sri Lankan banking industry during the post liberalisation era. Discussion in this chapter is based on Proposition I, set out in section 1.5 which assumes that "financial reforms have improved the efficiency and productivity gains of the banking industry in Sri Lanka".

The previous chapter presented models of efficiency and productivity measurements used in the literature. This chapter extends those models to analyse the efficiency and productivity changes of the Sri Lankan banking industry. The chapter comprises eight sections. The next section elaborates on Proposition I. The third section introduces and justifies methodologies adopted in estimating efficiency and productivity changes. The fourth section introduces input and output specifications used for measuring efficiency and productivity changes. The fifth section explains the composition of the sample data. The sixth section presents results, discussion and implications of efficiency analysis. The penultimate section presents discussion and implications of assessment of productivity improvements. The final section presents conclusions on the analysis of efficiency and productivity changes in banks in Sri Lanka.

4.2 The Study Proposition

Chapter Two highlighted that the financial services sector in Sri Lanka has undergone a series of regulatory reforms during the period 1977-2004. The reforms aimed at reducing government intervention in the market by allowing greater participation by the private sector. The 'political view'[1] shows that government intervention in the banking industry is driven by the determination of politicians to control investment (La-Porta, Lopez-de-Silanes and Shleifer, 2002). Such intervention may lead to underutilisation of the capacity of the financial services. Relaxation of regulatory provisions, which gave distinct advantages to the government-owned institutions in an industry, allowed all institutions to perform in a similar regulatory and operational environment. This may result in greater competition and lead to improved efficiency and productivity gains of the industry. It is proposed that financial deregulation in Sri Lanka may have led to improved efficiency and productivity of the banking industry in the country. The next section presents the analytical framework used for addressing the proposition.

4.3 Method of Estimating Banks' Efficiency and Productivity Changes

This study adopts DEA, a non-parametric frontier approach, in order to evaluate the efficiency of banks in Sri Lanka and incorporates an analytical framework similar to those applied by other researchers (Barr et al., 1999; Denizer, Dinç and Tarimcilar, 2000; 1996; Drake, 2001; Elyasiani and Mehdian, 1990). The size of the Sri Lankan banking sector is comparatively small. As such, the sample does not allow application of parametric frontier approaches, as those approaches need a relatively large sample to make unbiased predictions. In contrast, the mathematical programming approach used in DEA allows the construction of a production frontier using a relatively small sample. It also provides researchers with more freedom to select appropriate model specifications to suit the objective of the analysis. The DEA process has the capacity to incorporate multi-inputs and multi-outputs in its assessment, and allows the progressive assembling of production frontiers without

[1] See Chapter Two section 2.2.2 (page 13).

using a pre-specified functional form. For these reasons, this study adopts DEA methodology.

Either input-oriented or output-oriented DEA models can be used to estimate efficiency. Input-oriented models measure cost efficiency (input efficiency) aimed at cost minimisation. Similarly, output-oriented models measure profit efficiency (output efficiency) based on revenue maximisation. Output-oriented DEA estimations are preferred when measuring efficiency in a mature industry, and input-oriented models are more appropriate for infant industries. Input-oriented DEA models are useful to understand how an industry has improved its efficiency while optimising the usage of inputs in the production process. Accordingly, the input-oriented approach identifies the input waste (or excess capacity) in the production process. On the other hand, the output-orientation estimates the efficiency—assuming that the inputs are fixed. As such, output-oriented estimations are not appropriate for assessing efficiency in an industry that is evolving.

Financial reforms, as well as development in information and communication technologies, have effectively expanded operational activities of the banking industry during the last two decades. Further, banks tend to introduce more cost effective innovative products to challenge competition from new institutions entering the financial services sector. Hence, this study adopts input-oriented models following previous research (Barr et al., 1999; Denizer, Dinç and Tarimcilar, 2000; Dietsch and Lozano-Vivas, 2000; Drake, 2001; Elyasiani and Mehdian, 1990).

4.3.1 DEA model formulation

Several mathematical programming DEA models have been represented in the literature. However, the basic DEA model is based on a productivity ratio index which is measured by the ratio of weighted outputs to weighted inputs. DEA extrapolates Ferrell's (1957) single-output to single-input technical measure to a multiple-output to multiple-input technical measure. This model assumed that j^{th} DMU uses a *'m'* dimensional input vector, x_{ij} $(i = 1,2,\ldots m)$ to produce a *'k'*

dimensional output vector, y_{rj} *(r = 1,2,…,k)*. The DMU under evaluation is denoted by '0'.

$$w_0 = \frac{\sum_{r=1}^{k} u_r y_{rj0}}{\sum_{i=1}^{m} v_r x_{ij0}} \qquad \text{Equation 4.1}$$

where w_0 is the relative efficiency, x and y are the input and output vectors respectively, and u_r and v_i are the weights of output r and input i. The above ratio accommodates multiple inputs and outputs in efficiency estimation and measures the relative efficiency based on input and output weights. However, a unique set of weights for all DMUs may be difficult to identify, because different DMUs have different input and output combinations (Charnes, Cooper and Rhodes, 1978) (CCR). CCR proposed the use of a set of weights that accommodates those differences. They suggested that each DMU should assign weights that allow it to be shown more favourably, compared with all other DMUs under comparison. Thus, the respective weights for each DMU should be derived using the actual observed data instead of fixing in advance (Cooper, Seiford and Kaoru, 2000). CCR introduced the following fractional programming problem to obtain values for input weights and output weights.

Basic CCR formulation

$$Max \quad w_0 = \frac{\sum_{r} u_r y_{rj_0}}{\sum_{i} v_r x_{ij_0}} \qquad \text{Equation 4.2}$$

Subject to

$$\frac{\sum u_r y_{ri}}{\sum v_r x_{ij}} \le 1, \quad for\ each\ j = 1, ..., n$$

$$u_r, v_i \ge 0 \quad r = 1, ..., k \quad i = 1, ..., m$$

[Source: Cooper, Seiford & Kaoru (2000)]

where w_0 is the relative efficiency, x and y are the input and output vectors respectively, u_r and v_i are the weights of output r, and input i, n, m and k denote the

number of DMUs, inputs and outputs respectively. The above fractional programming problem is based on the objective to estimate the optimum input and output weights for each DMU under evaluation. It measures the relative efficiency of DMU_0 based on the performance of the other banks in the industry. For that, the weighted input and output ratio is maximised subject to given constraints. The first constraint of the model limits the estimated efficiency of the DMUs to one. The second constraint in the above model indicates that all variables, including input and output weights, are non-negative. Estimated input and output weights are used to find the efficiency index '*w*'. The fractional programming problem can be transformed into a linear programming model (CCR), as illustrated in equation 4.3.

Basic CCR formulation (Multiplier form)

$$
\begin{aligned}
&Max\ w_0 = \sum_r u_r y_{rjo} \\
&Subject\ to \\
&\qquad \sum_r v_i x_{ijo} = 1 \\
&\sum_r u_r y_{rj} - \sum_r v_i x_{ij} \le 0 \quad for\ \ j = 1,2,...n \\
&\qquad u_r \ge 0 \quad for\ \ r = 1,2,...k \\
&\qquad v_i \ge 0 \quad for\ \ i = 1,2,...m
\end{aligned}
$$

Equation 4.3

[Source: Cooper, Seiford & Kaoru (2000)]

The above linear programming problem aims to maximise the sum of weighted outputs of DMU_0 subject to virtual inputs of DMU_0 while maintaining the condition that the virtual outputs cannot be exceeded by virtual inputs of any DMUs. Both the fractional programming problem and the linear programming problem have the same objective function. CCR-inefficient firms are given an efficiency ratio $W_0 < 1$. Efficiency indices of efficient firms are equal to '1'. Furthermore, there is at least one efficient unit that is used as the referencing unit for estimating relative weights for the inefficient units. Both linear programming problems outlined above can be used to directly estimate 'θ'.

Basic CCR formulation (Dual problem/envelopment form)

$$Min\ \theta$$

Subject to

$$\begin{aligned} \theta x_{ij_i} - s_{\bar{i}} - \sum_j x_{ij}\lambda_j &= 0 \quad for\ i = 1,2,...m \\ -s_{\hat{r}} + \sum_j y_{rj}\lambda_j &= y_{rj_0} \quad for\ r = 1,2,...k \\ s_{\bar{i}}, s_{\hat{r}}, \lambda_j &\geq 0 \end{aligned} \qquad \text{Equation 4.4}$$

where y_{rj} is the amount of r^{th} output produced by DMU j using x_{ij} amount of i^{th} input. θ denotes the CCR efficiency of DMU j. Both y_{rj} and x_{ij} are exogenous variables and λ_j vector of weights (intensity variables) assigned to each DMU under observation. Variables s_i and s_r represent input and output slack. The weights determine the combination of technologies of each firm to construct the production frontier. Thus, each weight is a decision variable determined by the solution of the linear programming model identified as equation 4.4. The first constraint of the above model implies that the combination of the input of the firm j is less than or equal to a linear combination of inputs in the firm on the frontier. Similarly, the second constraint ensures that the observed output of firm j is less than or equal to a linear combination of inputs in the firm on the frontier. The last constraint ensures that the main decision variable θ_J (efficiency of j^{th} firm) lies between one (1) and zero (0) by limiting the values to equal or greater than zero (CCR).

The values given under slack variables indicate the scope for improving the DMUs' operations without affecting the current level of operations. DMUs in an optimal scale of operation have zero values for $s_{\bar{i}}$ and $s_{\hat{r}}$. In other words, if the optimal value θ is equal to unity and both input slack s_i and output slack s_r are equal to zero in a unit under review, further efficiency improvements cannot be expected in such units. However, there may be some DMUs with slack variables with non-zero values. It signals that additional efficiency improvements can be gained by reducing

(increasing) specific input (output). Non-zero slack variable in a particular DMU indicates that the DMU is not operating at the optimum scale.

The original CCR model assumed that all DMUs under consideration were operating on an optimum scale. The BCC-DEA formulation relaxed the assumption of optimum scale. The CCR model estimated the TE. BCC accommodates the scale effect by relaxing the constant return to scale assumption by incorporating a third constraint to the efficiency evaluation model. Generally, it relies on the convex combination of the efficient units, instead of the linear combination—as in the case of the CCR. Accordingly, this can be achieved by adding another constraint to the original CCR model ($\sum \lambda_j = 1$). The efficiency estimation of these two models can be used to identify the three components of efficiency: technical, pure-technical (PTE) and scale efficiency. The BCC-DEA formulation is given below.

Basic BCC formulation (Dual problem/envelopment form)

$$Min\ z_0 = \quad \theta - \varepsilon \sum_i s_{\bar{i}} - \varepsilon \sum_r s_{\hat{r}}$$

Subject to

$$\begin{aligned} \theta x_{ij_i} - s_{\bar{i}} - \sum_j x_{ij}\lambda_j &= 0 \quad for\ i = 1,2,...m \\ -s_{\hat{r}} + \sum_j y_{rj}\lambda_j &= y_{rj_0} \quad for\ r = 1,2,...k \\ \sum \lambda_j &= 1 \\ s_{\bar{i}}, s_{\hat{r}}, \lambda_j &\geq 0 \end{aligned}$$

Equation 4.5

Objective functions of the above linear programming models set the input combination of *i* at a minimum level to produce an output that is equal to the output of firm *j*. Hence, the optimisation solution to the above models determines the lowest fraction of inputs needed to produce output at least as great as that actually produced by firm *j*. Thus, this process says that θ_J is equal to or less than one. If θ_J is equal to one, then firm *j* is as efficient as the other firms in the frontier. On the other hand, if θ_J is less than one, the firm is not as efficient as the firm in the frontier.

CCR and BCC formulations are applied to estimate the TE and PTE respectively. Previous studies have employed an MPI-like index to decompose scale effect on a DMU's inefficiency. A firm's TE is a function of PTE and the SE. Therefore, PTE should be separated from the TE to identify SE (Coelli, Rao and Battese, 1998).

$$TE_{CCR} = PTE_{BCC} \times SE \quad \text{Equation 4.6}$$

$$SE = TE_{CCR} \div PTE_{BCC} \quad \text{Equation 4.7}$$

where

TE_{CCR} = Technical efficiency

PTE_{BCC} = Pure technical efficiency

SE = Scale efficiency

This study estimates the SE for each DMU based on the estimated efficiency in the BCC and CCR models. This analysis has helped to identify the effectiveness of existing scales of operation.

The study used a 16-year panel data set compiled from banks in Sri Lanka. During this period, financial and regulatory environments of the country have gradually changed. Thus, constructing a separate frontier for each year is more appropriate for estimating the efficiency of banks. However, the number of banks in Sri Lanka does not provide an adequate number of observations to construct a production frontier with reasonable discriminatory power. DEA techniques' power of discriminating inefficient units from efficient units depends on the number of units under observation, and the number of inputs and outputs in the model. Prior studies have employed two approaches for improving the discriminatory power of small samples, namely:

1. Pooled data: A common production frontier is constructed for the whole sample using pooled data. Each DMU in the whole sample period is considered as a separate DMU.
2. Window analysis (Asmild et al., 2004; Avkiran, 2000; Charnes et al., 1985; Fu and Heffernan, 2005): The number of production frontiers is constructed

using pooled data of a pre-determined window period based on the principle of moving averages (Charnes et al., 1994). Each DMU within a window period is considered as a separate DMU.

There are two advantages of using pooled data to construct the production frontier. The first allows comparison between the performances of a DMU in a particular period with its own performance in other periods. The second enhances the discriminatory power of DEA models by increasing the number of data points in the analysis. It should be noted that there are no pre-specified criteria for determining the length of a window period. However, many previous studies have used a three-year window period as an appropriate window size. Once a window size is defined the observation of that window is viewed in an inter-temporal manner (Asmild et al., 2004). All observations related to a window period are treated as separate DMUs in efficiency analysis with their original form ignored. However, these approaches disregard technological changes that may take place within two consecutive periods. Hence, the estimated efficiency scores may potentially be distorted. These distortions may be severe in estimated efficiency on common frontiers constructed using whole sample data. Therefore, this study uses the second approach (constructing production frontiers based on three-year windows) for constructing the production frontier.

In this study, descriptive statistics, window analysis and longitudinal graphical analysis are used to investigate the influence of deregulation on the banking sector in Sri Lanka. Further, descriptive statistics for each cluster of banks (which are defined in section 4.5 of this chapter) are calculated and compared. The significance of the identified differences in efficiency of the different forms of banks are tested using the Mann-Whitney Test statistics (Sprent, 1990). The Mann-Whitney test, also known as the Wilcoxon rank sum test, is a non-parametric test used to test the difference between the medians of two independent groups. This test is a non-parametric equivalent of the two sample '*t* test'. In most applications, this test is called the Mann-Whitney U-test, but alternative names are sometimes used. Since the theoretical distribution of estimated efficiency scores using DEA is not known,

this study uses the Mann-Whitney test to examine whether the distribution of estimated efficiency in two banking segments is similar. The relevant test statistics are estimated using SPSS version 11.5.

4.3.2 Malmquist total productivity index (MPI)

MPI has been widely used in previous research to measure productivity improvements in the banking industry after government policy changes (Berg, Forsund and Jansen, 1992; Casu and Girardone, 2005; Grifell-Tatje and Lovell, 1996; Isik and Hassan, 2003; Sturm and Williams, 2004). Two alternative methods—base period method and adjacent period method—have been used to estimate MPI. The adjacent period method estimates productivity change in two consecutive periods and estimates productivity changes on a yearly basis, while the base period method estimates productivity changes using a pre-specified base period. Thus, the adjacent period method is more suitable for studies based on unbalanced panel data. Hence, this study applies the adjacent period MPI to investigate productivity improvements.

The MPI uses a distance function[2] approach to measure productivity improvements. Caves, Christensen and Diewert (1982) first introduced the idea of using a distance function approach to analyse changes in productivity based on a general production function. DEA-based MPI was first introduced by Fare et al. (1994) in a study of productivity improvements in Swedish hospitals using the conceptual basis provided by Ferrell (1957) and Caves, Christensen and Diewert (1982). Following Fare et al. (1994), the input-oriented MPI was expressed using input distance functions with respect to two periods as follows. The equation represents the productivity change of a production unit over the time span of 't' and 't+1'.

$$M_i\left(x_{t+1}, y_{t+1}, x_t, y_t\right) = \left(\frac{D_{ci}^{t}\left(y_{t+1}, x_{t+1}\right)}{D_{ci}^{t}\left(y_t, x_t\right)} * \frac{D_{ci}^{t+1}\left(y_{t+1}, x_{t+1}\right)}{D_{ci}^{t+1}\left(y_t, x_t\right)} \right)^{1/2} \qquad \text{Equation 4.8}$$

[2] The input (/output) distance function addresses the impact of the minimum proportional reduction (/increase) of the input(/output) mixture for a given output (/input) mix (Coelli et al. 1998)

where 'D (●)'[3] is the input distance function and $M_i(x_{t+1}, y_{t+1}, x_t, y_t)$ is the MPI which shows the change in productivity of the DMU under review on the constant return to scale ('c'). 'y_t', 'x_t', 'y_{t+1}' and 'x_{t+1}' are shown as outputs (y) and inputs (x) of the year 't' and the year 't+1' respectively.

The productivity change in a given two consecutive period contains two components, namely, change in technical efficiency (catching up effect[4]) and change in production technology (frontier shift effect). Fare et al. (1994) showed that MPI can be decomposed into two elements to find the catching-up effect and frontier-shift by reproducing the above equation as follows:

$$M_i(x_{t+1}, y_{t+1}, x_t, y_t) = \left(\frac{D^t_{ci}(x_{t+1}, y_{t+1})}{D^t_{ci}(x_t, y_t)} \right) * \left(\frac{D^t_{ci}(x_t, y_t)}{D^{t+1}_{ci}(x_t, y_t)} * \frac{D^t_{ci}(x_{t+1}, y_{t+1})}{D^{t+1}_{ci}(x_{t+1}, y_{t+1})} \right)^{1/2}$$

Equation 4.9

$$Total\ productivity\ change = Efficiency\ change \times Frontier\ shift$$

The first element of the equation on the right hand side stands for the efficiency change, and the second element stands for the frontier shift between time period 't' and 't+1'. Based on the above equation, two separate equations have been constructed to estimate the efficiency change and impact of frontier shift (Fare et al., 1994).

$$Efficiency\ change = \left(\frac{D^t_{ci}(x_{t+1}, y_{t+1})}{D^t_{ci}(x_t, y_t)} \right)$$

Equation 4.10

$$Frontier\ shift = \left(\frac{D^t_{ci}(x_t, y_t)}{D^{t+1}_{ci}(x_t, y_t)} * \frac{D^t_{ci}(x_{t+1}, y_{t+1})}{D^{t+1}_{ci}(x_{t+1}, y_{t+1})} \right)^{1/2}$$

Equation 4.11

3 'D (●)' denotes a distance function.

4 Catching-up effect is the improvement of technical efficiency in a given two consecutive period by reducing the efficiency gap between efficient and inefficient DMUs

If productivity of a DMU has improved between two periods, the MPI reveals a value greater than one. Conversely, an MPI less than one indicates declining productivity between two periods. Productivity improvements from technological changes and efficiency changes are also interpreted in a similar manner (Coelli, Rao and Battese, 1998).

Both parametric and non-parametric approaches have been applied in previous studies to estimate MPI. This study relies on a non-parametric DEA[5] approach. Respective MPIs are estimated using 'DEA-Solver software' developed by Kaoru Tone. Both VRS and CRS approaches have been applied in applications on productivity changes (Krishnasamy, 2004; Mukherjee, Ray and Miller, 2001). MPI estimated using the CRS approach ignores the difference in size between DMUs in the sample, thus providing relatively higher discriminatory power when using a small sample. Therefore, this study is limited to the CRS-based MPI. Respective MPIs are estimated from individual year data to facilitate the estimation of productivity and technical and technological changes.

4.4 The Banking Model

As stated in Chapter Three, previous studies have used a number of approaches of input and output specification, namely, production, intermediation, assets, user-cost and value-added. However, there is no apparent consensus evident in the literature to identify the most appropriate approach. This study uses two input and output specifications to recognise the significance of intermediary roles and assets transformation roles in the banking industry in Sri Lanka (Arshadi and Karels, 1997). The main reasons to restrict this study to the above two models are explained below.

- Availability of required data: data for this study are gathered through secondary sources. Therefore, specification of input and output is limited to the available information.

[5] See Coelli, Rao and Battese (1998) for more information on DEA models used for estimating MPIs.

- Sample size: this study is based on a relatively small sample. The number of inputs and outputs which can be incorporated into a DEA model is restricted by the sample size (Cooper, Seiford and Kaoru, 2000). Therefore, all important input and output variables cannot be incorporated into a single model.
- Various sources of efficiency and productivity improvement: different combinations of input and output can be used to estimate the different aspects of firm efficiency and productivity improvement. The two specifications used mainly focus on two functions of banking institutions, namely, intermediation and asset transformation.
- Completeness of the assessment process: these two models incorporate all important input and output variables to the assessment process.
- Discriminating power of the specific DEA models: DEA discriminatory power is controlled by the number of inputs and outputs in the model and the number of DMUs under observation. Inclusion of more input and output variables into a model reduces the DEA's discriminatory power. As such, use of a few models with different input and output variables may permit the assessment of efficiency under different perspectives.

The first model used in this study aims to measure efficiency in intermediation. It specifies inputs and outputs based on the standard intermediation and the profit approaches (which is a variation of the value-added approach). Thus, it allows incorporation of the impact of both risk and return of intermediation process in efficiency estimation. Table 4.1 presents input and output variables used in this study and their definitions. All variables in Model One, except loans and other advances, were extracted from banks' income statements. Since all those variables are related to the day-to-day operation of banks, estimated efficiency scores using Model One can be used to proxy the operational efficiency in intermediation.

Table 4.1: Specification of input and output variables

Variables	Definition	Model One	Model Two
Interest expenses	The amount paid as interest on all liabilities including deposits, debentures and other long-term and short-term loans.	Input	
Personnel costs	The total expenses of banking staff, such as wages and retirement benefits.	Input	
Premises and establishment expenses	Expenses incurred in providing other basic infrastructure such as communication, rent, depreciation and insurance.	Input	
Deposits	Total funds collected on deposit mobilisation.		Input
Other loanable funds	Funds which can be used for granting loans and advances from all sources, including debentures and other long term and short term borrowings other than deposits.		Input
Number of employees	Total number of full-time workers.		Input
Loans and advances	Rupee amounts of total loans provided.	Output	Output
Interest income	Income received as the interest on banks' loan portfolios.	Output	
Other income	The income generated from sources other than banking activities.	Output	
Other earning assets	Total investment made on operational assets other than the loans and advances such as investments.		Output

Input and output variables which are included the second model aim to measure efficiency of the asset transformation role of Sri Lankan banks. The model measures how banks' resources have been effectively allocated in different asset portfolios. It includes three input variables: deposits, other loanable funds and number of employees; and two output variables: loans and advances and other earning assets. All non-revenue-generating assets are excluded from the model. All output and input variables, except the number of employees, are proxied by corresponding monetary values in published financial statements.

4.5 Data and Sample

In this study, it was assumed that the bank generates funds for lending activities through deposit mobilisation (customer deposits). Thus, the study sample includes all locally established commercial and savings banks in Sri Lanka. Both savings and commercial banks use customer deposits for financing their products. As explained before, the savings banks are not allowed to accept the current (checking account) deposit. However both savings and commercial banks in Sri Lanka operate under the same operational and regulatory infrastructure. Further, both savings and commercial banks have maintained an island-wide branch network.

Registered finance companies which are authorised to accept only time deposits can be considered as major players in the domestic deposit market. However, their operational activities are entirely different from commercial and savings banks. Similarly, some licensed specialised banks (such as merchant and development banks) are entitled to accept customers' deposits. However, they mainly rely on borrowings and other sources. Therefore, those licensed specialised banks and registered finance companies were excluded from the study sample.

Foreign banks primarily provide wholesale banking services to the corporate sector through their limited branch networks spread only in the urban areas. On the other hand, local banks in Sri Lanka mainly provide retail banking services. Further, their branch networks are not limited to the urban areas. Therefore, this study is limited to local banks. The sample covers a 16-year cross section from 1989 to 2004. Bank-related data for the study are mainly collected from published financial statements of local banks. The macroeconomic data are collected from various annual reports and other publications of the CBSL.

Before 1988, the corporate sector in Sri Lanka followed conservative financial information disclosure policies. The minimum disclosure policy adopted before 1988 restricted information contained in the annual final accounts. In 1988, changes in accounting standards, which aimed to improve the quality and coverage of financial information contained in the corporate annual reports, were introduced.

The new format of accounts introduced in 1988 provides all required information for the study in the annual reports of local banks. Therefore, this study is restricted to a 16-year period that uses the new format of accounts. Further, all banks which have operated for more than three years within the study period are included in the sample.

DEA models need data to be free from measurement errors or noise to make more accurate estimations (Mester, 1996). Since the data used in this study are mainly extracted from audited accounts, it is expected those data will have an acceptable level of reliability. As previously stated, the new format of annual accounts[6] provides a broad view of operational results and financial status of reporting firms. Therefore, it is possible to develop a comprehensive database for the study using the annual report data.

Table 4. 2: Corresponding periods of each window

Window	Corresponding years in each windows	Point of estimation
WIN_1	1989, 1990, 1991	1990
WIN_2	1990, 1991, 1992	1991
WIN_3	1991, 1992, 1993	1992
WIN_4	1992, 1993, 1994	1993
WIN_5	1993, 1994, 1995	1994
WIN_6	1994, 1995, 1996	1995
WIN_7	1995, 1996, 1997	1996
WIN_8	1996, 1997, 1998	1997
WIN_9	1997, 1998, 1999	1998
WIN_10	1998, 1999, 2000	1999
WIN_11	1999, 2000, 2001	2000
WIN_12	2000, 2001, 2002	2001
WIN_13	2001, 2002, 2003	2002
WIN_14	2002, 2003, 2004	2003

[win = window]

As stated before, the sample is composed of 16 years of unbalanced panel data. Only six banks are represented in the first year of the sample period. However, the number increased to 12 banks in the last year, thus aggregating to 157 observations. Fourteen three-year moving windows have been drawn from the sample period and used as the pooled data to construct 14 production frontiers for efficiency assessment. The

[6] See SLAS 03 : Presentation of Financial Statements

three-year windows are named by their respective middle years as shown in Table 4.2.

Three modes of classification are used to cluster banks in the sample for analysis of estimated efficiency and productivity scores as given below:

- by function: banks which are functioning as savings banks and banks which are functioning as commercial banks;
- by ownership: privately-owned banks and state-owned banks;
- by relative experiences: banks which existed before 1987 (old) and banks which commenced operation after 1987 (new).

Efficiency differences in various types of banking units are examined on the mean estimated efficiency scores. The Mann-Whitney test is used to test the significance of differences in efficiency distributions of various forms of banks. The trends in estimated efficiency in various forms of banking firms are examined using a longitudinal graphical representation.

4.6 Analysis of Estimated Efficiency Scores

This section presents results and discussion of an analysis of estimated efficiency scores. First, it presents mean values, standard deviations and correlation coefficients of input and output variables used in the efficiency analysis. Second, it produces the results and discussion of efficiency analysis using the intermediary and assets approach.

4.6.1 Mean and standard deviation of input and output variables

Table 4.3 presents descriptive statistics of all input and output variables used in this study. These statistics indicate that mean deposits of banks have increased four-fold (1990-Rs.14,376 million and 2003-Rs.68,664 million) and other loanable funds approximately six-fold (1990-Rs.2,010 million and 2003-Rs.13,149 million) during the study period. Similar trends to the deposits were recorded by loans and advances

(1990-Rs.9,450 million and 2003-Rs.42,996 million). Personnel cost has increased from Rs.386 million in 1990 to Rs.1721 million in 2003.

Table 4.3: Descriptive statistics of input and output data

Window-period	Interest Expenses	Personnel Expenses	Establishment Expenses	Advances	Deposits	Number of Employees	Interest Income	Other Income	Other Loanable Funds	Earning Assets
1990	1,343	386	223	9,450	14,376	3,881	1,911	359	2,010	4,638
	(1,269)	(459)	(215)	(10,669)	(13,191)	(4,051)	(1,746)	(308)	(2,741)	(7,685)
1991	1,804	477	300	11,365	18,051	4,019	2,468	445	2,691	6,016
	(1586)	(539)	(287)	(11,464)	(15,481)	(4,036)	(2,113)	(363)	(3,888)	(9,174)
1992	2,313	602	405	13,531	22,162	4,150	3,194	581	3,542	7,435
	(1,897)	(657)	(386)	(12,587)	(17,612)	(4,007)	(2,619)	(521)	(5,398)	(10,862)
1993	2,839	739	515	16,546	27,371	4,267	4,061	695	5,241	10,280
	(2,222)	(790)	(470)	(14,763)	(20,757)	(3,950)	(3,205)	(658)	(7,617)	(13,765)
1994	3,053	816	582	18,823	30,549	3,996	4,570	763	5,780	10,860
	(2,594)	(883)	(584)	(18,172)	(25,566)	(3,915)	(3,884)	(765)	(8,083)	(15,463)
1995	3,361	861	623	20,620	33,679	3,805	5,014	814	6,427	12,336
	(3,066)	(940)	(707)	(20,167)	(29,946)	(3,906)	(4,513)	(888)	(8,824)	(17,676)
1996	3,497	881	622	21,766	35,099	3,515	5,177	887	6,666	12,861
	(3,435)	(1,035)	(813)	(22,364)	(33,995)	(3,873)	(5,055)	(1,091)	(9,317)	(19,519)
1997	3,646	976	593	23,838	38,592	3,515	5,485	962	7,619	14,165
	(3,558)	(1,158)	(796)	(24,285)	(37,077)	(3,871)	(5,330)	(1,176)	(10,537)	(20,759)
1998	3,650	1,050	509	25,948	40,726	3,367	5,510	931	8,101	14,531
	(3,708)	(1,272)	(669)	(26,605)	(40,015)	(3,823)	(5,497)	(1,203)	(11,696)	(21,870)
1999	3,874	1,154	463	29,805	44,282	3,307	5,862	953	10,857	15,087
	(3,946)	(1,403)	(486)	(30,585)	(43,175)	(3,775)	(5,810)	(1,212)	(17,559)	(22,974)
2000	4,769	1,249	471	34,313	48,576	3,214	6,780	1,011	12,356	16,989
	(4,963)	(1,523)	(415)	(36,727)	(47,432)	(3,712)	(6,898)	(1,246)	(20,321)	(25,388)
2001	5,157	1,342	542	37,546	53,884	3,111	7,453	1,118	13,112	19,905
	(5,260)	(1,625)	(470)	(39,091)	(53,025)	(3,607)	(7,494)	(1,224)	(19,841)	(29,181)
2002	5,103	1,517	603	39,833	60,492	2,998	7,823	1,272	12,540	25,047
	(5,179)	(1,832)	(513)	(40,296)	(60,022)	(3,459)	(7,730)	(1,276)	(15,920)	(35,300)
2003	4,429	1,721	668	42,996	68,378	2,912	7,650	1,459	13,149	27,492
	(4,383)	(2,082)	(560)	(41,555)	(67,664)	(3,291)	(7,364)	(1,532)	(13,453)	(39,702)
Pooled	3,606	1,090	521	27,524	42,574	3,458	5,537	957	8,757	15,857
	(3,911)	(1,479)	(568)	(32,263)	(48,343)	(3,766)	(5,991)	(1,191)	(13,636)	(26,762)

[Note: Standard deviations are in parentheses. All values in the table except number of employees are in millions of Sri Lankan rupees.]

After adjusting for the change in the number of workers, the mean labour expenses have increased six-fold. The main reason for the decrease in the average number of workers may be the entrance of medium-scale banking institutions to the industry. On the other hand, increases in labour costs may have been due to both normal salary increases and the increase in more highly-skilled banking professionals.

Almost all of the variables indicate high standard deviations. Specifically, variables such as personnel expenses, number of employees, other loanable funds and earning assets indicate high coefficients of variation[7]. The Sri Lankan banking industry comprises few big banks and a number of medium- and small-scale banks. Thus, the recorded differences in values of observed variables result from those scale differences. However, the methodology used allows assessment of efficiency and productivity improvements of DMUs ignoring their scale of operations (Cooper, Seiford and Kaoru, 2000).

Table 4.4: Correlation of input and output variables (pooled data)

	Interest expenses	**Personnel expenses**	**Establish -ment**	**Deposits**	**Other loanable funds**	**No. of employees**
Advances	0.762	0.936	0.822	0.857	0.873	0.732
Interest income	0.976	0.882	0.765	0.968	0.733	0.723
Other income	0.659	0.855	0.833	0.781	0.890	0.685
Other earning assets	0.799	0.520	0.340	0.799	0.362	0.321

Table 4.4 identifies correlations among input and output variables. As explained by Avkiran (1990), correlation coefficients among input and output variables can be used to show the appropriateness of such variables. The recorded high correlation coefficients between input and output variables, except in a few cases, confirm that selected input and output variables for performance evaluations are appropriate. However, other earnings assets which have been used as an output in the second specification show low correlations with establishment expenses, other loanable funds and number of employees. The recorded low correlation of other earnings

[7] See Appendix 3 for coefficients of variation

assets with loanable funds and number of employees may have little effect on the estimation of efficiency in the asset transformation process since such assets represent a small proportion of total assets.

The remainder of this section presents the estimated efficiency scores. The discussion of estimated efficiency scores begins by reproducing the average estimated efficiency scores in each window. Second, average efficiency scores of different forms of banks (which is based on mid-year mean efficiency scores of three year windows) are presented, together with the Mann-Whitney test scores. Further, graphical presentation is used to highlight the trends in efficiency and differences in estimated efficiency scores in different forms of banking units. Graphical presentation is used to make a longitudinal analysis of estimated efficiency trends.

4.6.2 Efficiency in intermediation

Figures 4.1, 4.2 and 4.3 represent an estimated mean efficiency score of 14 three-year moving windows[8]. In general, these graphs show a negative trend in estimated efficiency scores throughout the period, indicating three phases of efficiency evaluation as outlined below:

- from 1989 to 1994, a declining trend in estimated efficiency;
- from 1995 to 2000, a stable trend;
- from 2001 to 2002, a sharp decline followed with a little recovery.

The first window (in Figure 4.1) shows that the average TE score in intermediation [TE(I)] is 98.9% in 1989, indicating a low wastage of inputs (inefficiency) in the production processes. However, in 2004 the estimated TE(I) declined to 90.2%, indicating an overall downward trend in efficiency. A similar trend is also exhibited in PTE in intermediation [PTE(I)] (1989—100%, versus 2004—90.9%) and SE in intermediation [SE(I)] (1989—98.9%, versus 2004—91.5%). The remaining part of this section discusses the efficiency trends and the potential grounds for those trends.

[8] Mean estimated efficiency scores in each window are presented in Appendix 4

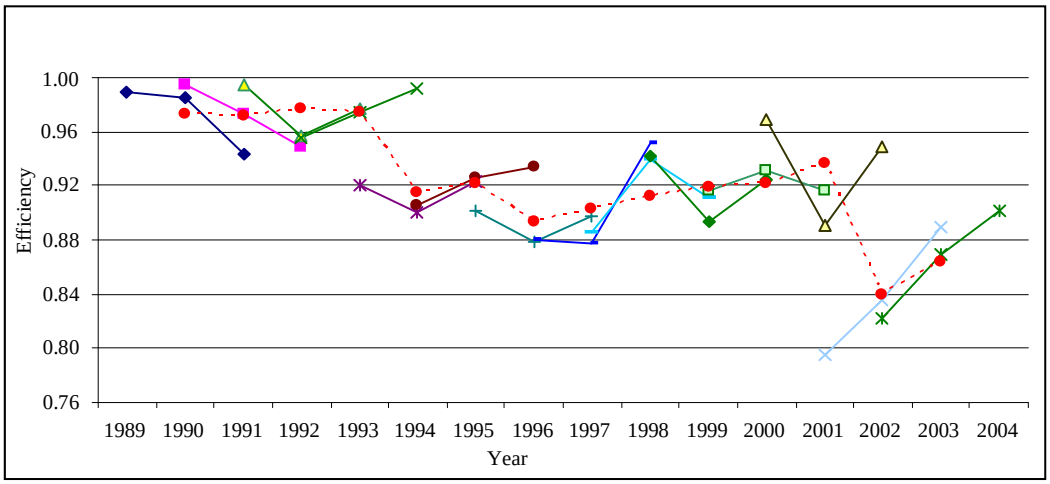

Figure 4.1: Average TE(I) - Window analysis

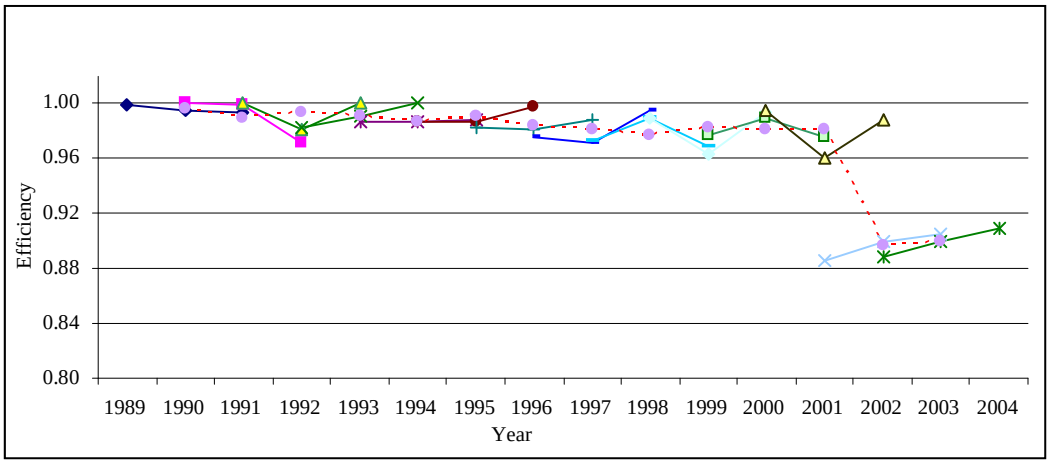

Figure 4.2: Average PTE(I) - Window analysis

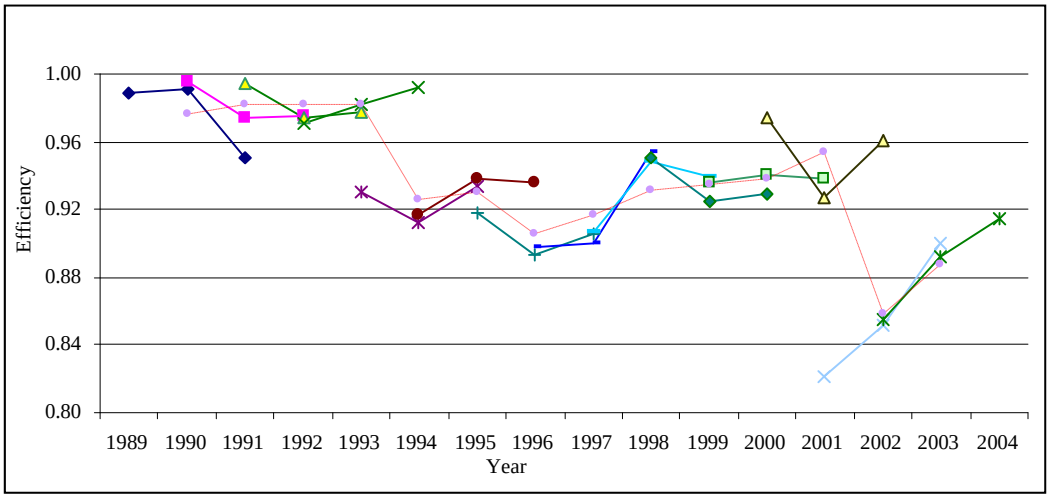

Figure 4.3: Average SE(I) - Window analysis

As indicated in the above, the estimated efficiency scores during the period 1989 to 1994 show a declining trend. In this period, the regulations that controlled new entrants were withdrawn. Implementation of the *Banking Act 1988*, along with the establishment of the CIB and the repurchase market for government securities, occurred contemporaneously. This followed the adaption of Article VIII of IMF[9] which facilitates free international monetary transactions. The opening of two new privately-owned banks subsequently increased the concentration of the banking market. During this period, the Colombo Stock Exchange recorded a peak in the stock market price index. The improvement in the capital market attracted a substantial portion of Sri Lanka's financial assets to the stock market. The introduction of unit trusts and primary share issues by many publicly listed companies considerably increased the attraction of funds to Sri Lanka's financial markets. The relative scarcity of skilled banking staff and the immediate need for more labour inputs were the initial causal factors in a noticeable rise in the personnel costs of Sri Lanka's banking industry. These circumstances may have adversely affected the banks' intermediation function.

The second phase, which was experienced from 1995 to 2000, records a stable trend in estimated efficiency in intermediation with slight upward trend. The introduction of new electronic trading on the government bond market and the strengthening of the CBSL's supervisory and monitoring role took place in this period. The introduction of Sri Lanka's Inter Bank Offer Rate, the removal of restrictions on foreign individuals trading and investing on the Colombo Stock Exchange (CSE), the relaxation of limits on foreign shareholding and ownership of Sri Lankan commercial banks, and the introduction of Sri Lanka's floating exchange rate also took place during this period. Banks were also forced to become more competitive to counter pressure from other forms of financial service providers such as leasing companies, development banks and insurance firms. Furthermore, in late 1990, the government changed its direction from the privatisation of two state-owned banks to

[9] In the adaptation of Article VIII of IMF, sovereign nations are obliged to refrain from imposing restrictions on the making of payments and transfers for current international transactions, or from engaging in discriminatory currency arrangements or multiple currency practices, except with IMF approval.

commercialisation, allowing management greater freedom to give more market orientation to operations of those banks. Accordingly, the limited autonomy offered to state commercial banks has favourably affected their performance.

The third phase starts with a sharp drop in estimated efficiency score in 2001. This period is most important in terms of the contemporary social, political and economic environment. Due to the growing threats of terrorism, the Sri Lankan government increased its defence expenditure in 2000 which resulted in a considerable budget deficit. The government relied on domestic borrowings to finance the fiscal deficit. First, the use of domestic debt for financing the deficit created a short-term credit restriction by local commercial banks, especially the two state-owned banks. Second, the government introduced a tax on debit transactions on all deposit accounts in banks from 2002. These actions had an impact on the estimated efficiency scores (especially the estimated efficiency scores for the window period 2000-2002) of the Sri Lankan banking system.

A number of changes took place during the same period. These included the withdrawal of the lower limits on statutory reserve requirements (SRR); the increase in the risk-weighted capital adequacy ratio (CAR) (by 10%), the introduction of daily determination of SRR on commercial banks' deposits, the removal of stamp duty and the national security levy from financial transactions, the reduction of the repurchase rate and reverse repurchase rate, and the introduction of single borrower limits. These regulatory changes impacted on the efficiency of the banks. However, the removal of stamp duty and the national security levy from financial transactions was not sufficient to counter the negative influences of the other policy changes on the evident performance of the banks.

Figures 4.4, 4.5 and 4.6 depict mid-year estimated mean efficiency scores in three-year windows. Tables 4.5 and 4.6 present overall means and the Mann-Whitney Test scores, which measure the significance of the differences in estimated efficiency between banking clusters. The aim of these figures and tables is to demonstrate differences in efficiency among different types of banks.

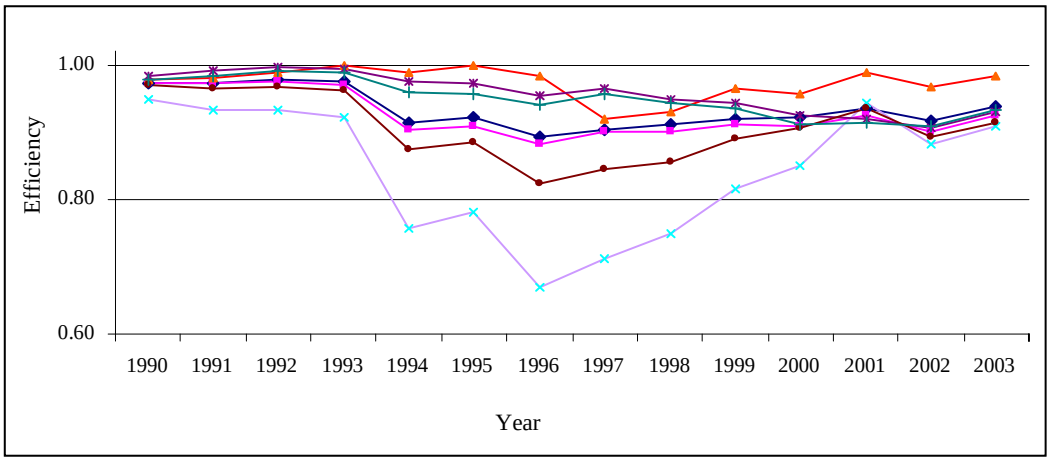

Figure 4.4: TE(I)-Mid-year

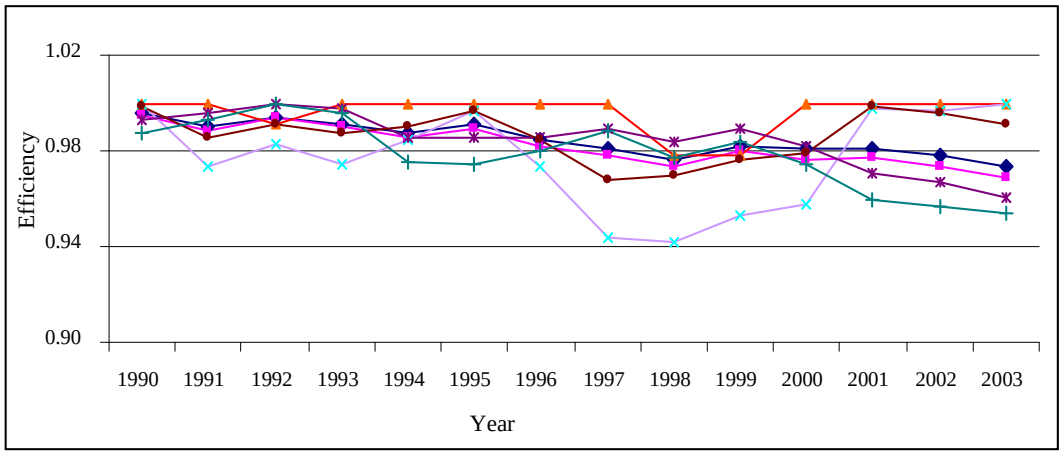

Figure 4.5: PTE(I)-Mid-year

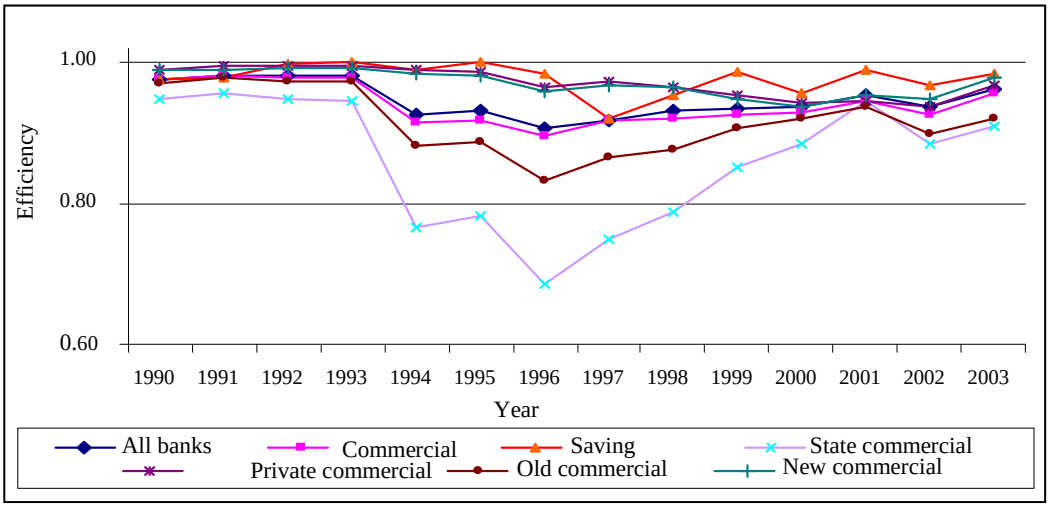

Figure 4.6: SE (I)-Mid-year

The estimated mean efficiency scores, based on mid-year results[10] in each three-year window, are a better indication of the banks' efficiency. All graphs representing different types of Sri Lankan banks record a declining trend in efficiency during the first half of the study period (1989-1996). However, during the second half of the study period, all banks show a very slight upward trend in efficiency. This upward trend coincides with the third phase of the financial reforms.

Table 4.5: Descriptive statistics - Efficiency scores in intermediation

	TE(I)	PTE(I)	SE(I)
All banks	0.931 (0.090)	0.984 (0.026)	0.945 (0.079)
Commercial banks	0.922 (0.095)	0.981 (0.028)	0.939 (0.085)
Saving banks	0.973 (0.028)	0.996 (0.008)	0.978 (0.026)
Privately-owned commercial banks	0.951 (0.051)	0.982 (0.023)	0.967 (0.042)
State-owned commercial banks	0.843 (0.135)	0.977 (0.037)	0.860 (0.118)
Old banks	0.906 (0.117)	0.987 (0.028)	0.916 (0.103)
New banks	0.940 (0.055)	0.974 (0.026)	0.964 (0.045)

[Standard deviations are given in parentheses]

All banks: The estimated overall means of the TE(I), PTE(I) and SE(I) scores show a similar trend. The first window (1990) produces a TE(I) of 97.2%, a PTE(I) of 99.6%, and a scale efficiency score of 97.7%. The last window indicates a slight drop in efficiency with a TE score of 93.6%, PTE score of 97.4% and SE score of 92.6%. However, during the early part of the period from 1990 to 1996, a sharp drop in the TE(I) was experienced by Sri Lankan banks. This may be due to the combined effect of the entry of new banks, the investment in the adaption of technology, and competition with new entrants such as unit trusts, leasing firms and other specialised financial services—all competing for market share. Furthermore, developments in financial markets, especially in the CSE, may have affected the financial services

[10] See Appendix 5 for mean estimated efficiency scores for different types of banks

industry in Sri Lanka. The trend in overall average efficiency scores indicates that efficiency improvements as a result of the financial sector reforms may not be achieved in the short-run but, rather, in the long-run.

Table 4.6: Mann-Whitney test scores – Efficiency in intermediation

	TE(I)	PTE(I)	SE(I)
Savings vs. commercial banks	573.0 [-3.22**]	544 [-3.58**]	696 [-2.39**]
Privately-owned vs. state-owned commercial banks	462.0 [-4.47**]	979 [-0.74]	348 [-5.30**]
Old vs. new commercial banks	1264.0 [-0.70]	764.0 [-4.02**]	994.0 [-2.43**]

['Z' scores are given in parentheses. '**' indicates that test scores are significant under 5% level.]

Savings and commercial banks: The sample includes both savings banks and commercial banks. It is important to note that there was only one state-owned savings bank (National Savings Bank (NSB)) in operation until 1997. The government directly promoted national savings through NSB by granting various types of tax concessions and other incentives. In return, NSB is used as a major funding source for the government. The NSB also provides various lending and savings products nationwide via its branch network and through state post offices. The financial reforms introduced in the third phase withdrew some of the incentives granted to NSB. In addition, the government allowed NSB to set its own interest rates.

Table 4.5 shows that savings banks produced a TE(I) score of 97.3%, a PTE(I) score of 99.6% and a SE(I) score of 97.8% and commercial banks reported a TE(I) score of 92.2%, a PTE(I) score of 98.1% and a SE(I) score of 93.9% during the period 1989-2004. The estimated Mann-Whitney test statistics for the efficiency scores given in Table 4.6 indicate that differences between scores in all three measures are significant in the case of savings banks versus commercial banks. However, the differences in estimated efficiency scores between commercial banks and savings banks have narrowed during the latter part of the study, indicating that financial reforms have improved the efficiency of commercial banks in the long-run.

Privately-owned and state-owned commercial banks: Financial reforms aimed to reduce government involvement in the banking industry by removing some operational restrictions which controlled the privately-owned banks' performance. Thus, examination of improvements in efficiency of privately-owned banks relative to the state-owned banks is important. The analysis of estimated efficiency scores shows that state-owned commercial banks have recorded the lowest estimated efficiency scores during the study period. Those banks record an average TE(I) score of 84.3%—with a PTE(I) score of 97.7% and a SE(I) score of 86%—signalling that the main source of inefficiency is the scale of operation. On the other hand, compared to state-owned commercial banks, privately-owned commercial banks report a relatively higher average TE(I) score of 95.1%—with a PTE(I) score of 98.2% and a SE(I) score of 96.7%. The results also show that the efficiency gaps between Sri Lanka's state-owned commercial banks and privately-owned commercial banks have widened, particularly during the first part of the study period. This result shows that the removal of operational restrictions has generated improvement in the average efficiency of privately-owned commercial banks. Furthermore, results show that the commercialisation process introduced in 1995 has improved the efficiency of state-owned banks and has reduced the efficiency gap when compared with privately-owned banks. In other words, state-owned commercial banks would have been equally efficient as privately-owned banks if the boards of management had a similar level of autonomy in decision making.

Differences in estimated efficiency scores, especially in state-owned commercial banks, may have been a consequence of the scale losses due to persistent control by the government. The Mann-Whitney statistics presented in Table 4.6 indicate that there are significance differences in estimated TE(I) scores and SE(I) scores between privately-owned and state-owned commercial banks. However, estimated PTE(I) scores are not significantly different. Differences in ownership, autonomy of management, operational environment, as well as objectives of the institutions, may have impacted on the differences in estimated efficiency scores.

Old banks and new banks: Although financial reforms came into effect in 1977, the first new local bank entered the banking market in early 1987. However, the number of Sri Lankan local banks doubled by the end of 2004. The newly-entered banks pioneered information communication technologies in the Sri Lankan banking industry. Old banks still mainly relied on manual-based traditional banking transaction methods. The diversified range of services offered by the new banks intensified competition throughout the banking industry. This is confirmed by higher efficiency scores of new banks compared to the old banks over the period 1989 to 2004. For instance, new banks recorded TE(I), PTE(I) and SE(I) efficiency scores of 94%, 97.4% and 96.4% respectively. The corresponding figures for old banks are 90.6%, 98.7% and 91.6%. Although the overall average efficiency score of new banks is higher than that of the old banks, the efficiency of new banks in the last window period (2002-2004) has decreased in comparison with the first window period (1989-1991). The average TE(I), PTE(I) and SE(I) scores in the first window period are 97.7%, 98.7% and 98.9% respectively, whereas these values reduce to 93.3%, 95.4% and 97.8% in the last window period. During the period under review, old banks recorded a higher PTE(I) in many of the years, while maintaining relatively high scale inefficiency. On the other hand, new banks are able to outperform old banks in technical and scale efficiency. The Mann-Whitney test scores indicate that there is not a significant difference in TE(I) between the recorded performances of the new and the old banks. However, the differences in PTE(I) and SE(I) are significant.

Overall, the analysis provides mixed evidence relating to the financial reforms. The shift from a negative trend in the second half of the study to a positive trend shows that banks took a long time to respond to policy changes. The next section examines the effectiveness of the asset transformation process in the banking industry in Sri Lanka.

4.6.3 Efficiency in asset transformation

Transformation of financial assets into small units that satisfy the expectations of borrowers and savers is a main function of banking institutions (Santomero, 1984). Under the asset transformation function, banks collect deposits and use those deposits to produce products (such as loans, advances and leasing) and invest excess cash in earning assets (such as treasury bills, debentures and shares). Asset transformation requires the intermediary to produce services and bear the associated risk (Arshadi and Karels, 1997). Banks have to maximise their use of the financial resources they hold after maintaining liquidity ratios and other legal reserve requirements. Furthermore, a bank's ability to allocate financial resources optimally to income generating uses may allow it to gain superior performance over other banks. Therefore, the second model examines efficiency in asset transformation.

Figures 4.7, 4.8 and 4.9 graphically present the estimated mean TE in asset transformation [TE(A)], PTE in asset transformation [PTE(A)] and SE in asset transformation [SE(A)] scores for each three-year window. The trend exhibited in those figures is dissimilar to the trend recorded in Figures 4.1, 4.2 and 4.3. Overall, the trend in estimated efficiency scores suggests that there is a reduction in efficiency during the study period.

As explained previously, asset transformation is aimed at maximising the use of the banks' resources to create portfolios of income generating assets. Recorded efficiency scores indicate that the banks were not able to utilise their funds fully to create such assets. In general, an economic development strategy would increase the demand for funds. Banks contribute to economic development by providing intermediary services to channel excess funds from savers (surplus holders) to satisfy borrowers' (deficit holders') demand for funds. In turn, efficiency of asset transformation helps banks to increase their market potential in the future. The overall downward trends reported in efficiency scores show that the amount of non-productive assets was increasing in banks in Sri Lanka.

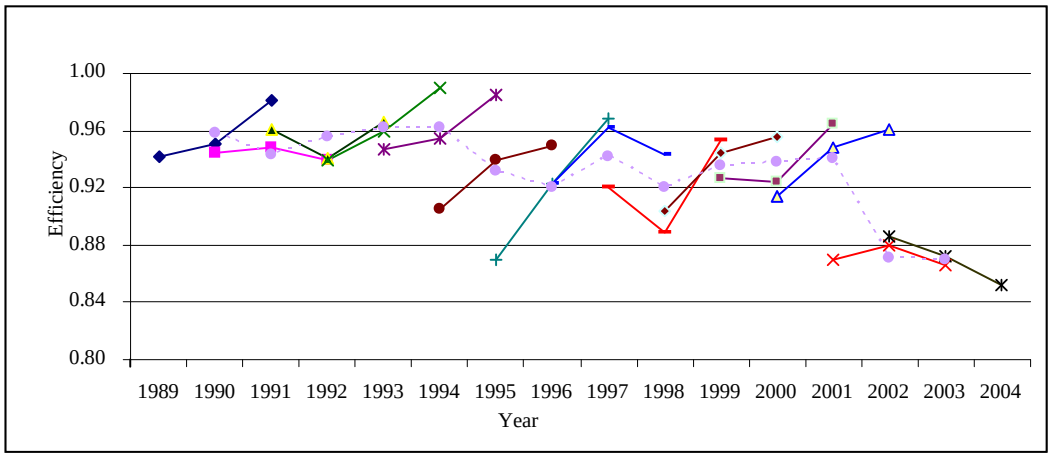

Figure 4.7: Average TE(A) - Window analysis

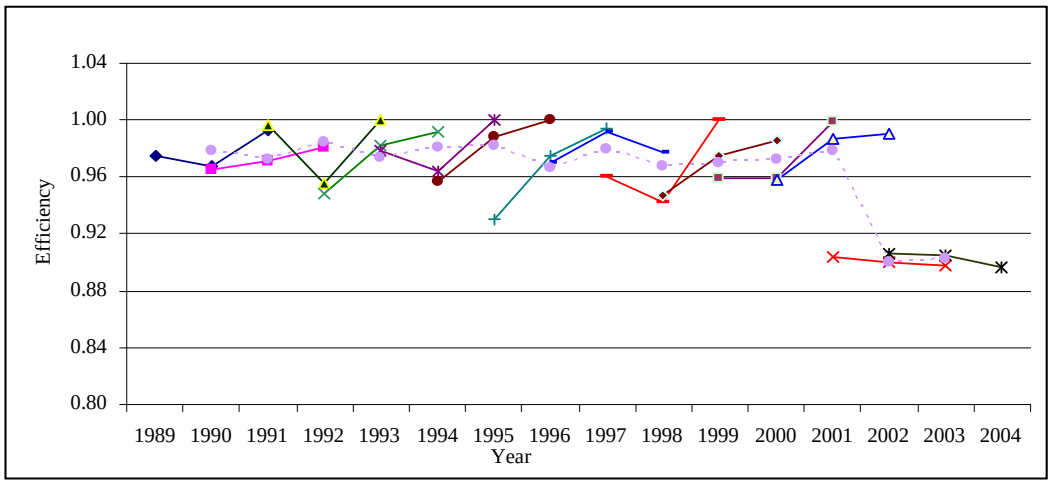

Figure 4.8: Average PTE(A) - Window analysis

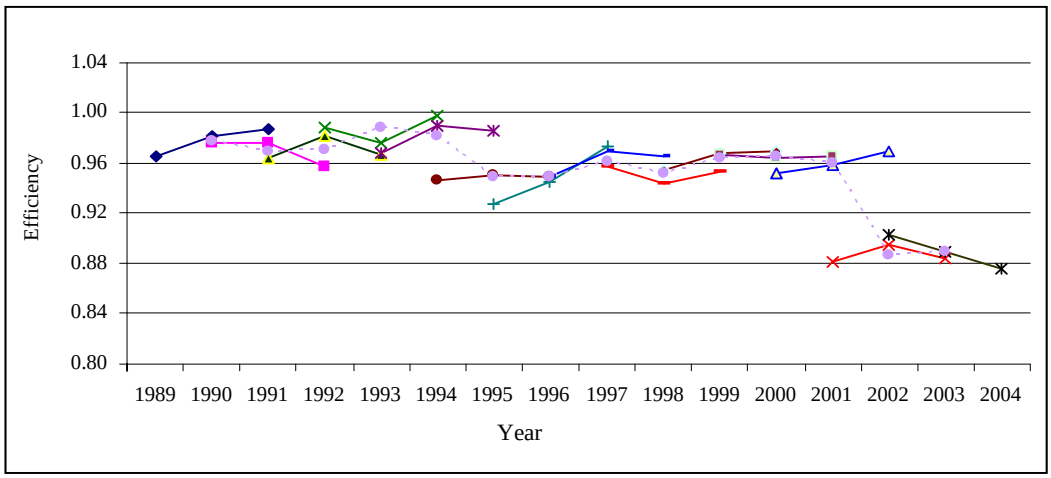

Figure 4.9: Average SE(A) - Window analysis

Relatively stable trends with slight fluctuations in estimated efficiency scores are recorded until 2001. Thus, the estimated efficiency in asset transformation also records sharp drops in efficiency in 2001. The drop in estimated efficiency scores in 2001 indicates that the credit restrictions following the financing of the government fiscal deficit have adversely affected banks' efficiency. Further, this result indicates that financial distress in the economy may reduce the operational efficiency of banks. Overall, Figures 4.7, 4.8 and 4.9 indicate that Sri Lankan banks have not shown significant efficiency changes until 2001. Further, the estimated efficiency scores recorded in the rest of the study period show a recovery in the recorded efficiency drop during the previous period.

Some reform measures which were introduced during the period 1989-2004 affected the asset transformation process. The establishment of a secondary market for government securities, along with the removal of credit ceilings on loans and advances granted for the purchase of immovable properties, expanded the investment opportunities for banks. Furthermore, establishment of the credit information bureau facilitated banks to be more aggressive in the lending market. Altogether, these reforms enhanced the asset transformation process of banks in Sri Lanka. On the other hand, the new provision introduced for issuing certificates of deposit helped banks in increasing their deposit bases. In addition, the establishment of a secondary market for government securities provided new alternative ways of managing the banks' liquidity positions.

Factors such as changes in cash and near-cash balances in banking firms[11] and lower growth in productive assets compared with growth in the total assets base of banks[12] adversely affected the banks' efficiency. Furthermore, the government's fiscal policies also negatively influenced banks' operational efficiency. The debit tax imposed in 2001 on all debit transactions in bank accounts adversely affected short-

[11] As indicated in CBSL Annual Report – 1999, the total amount maintained as cash balances by all commercial banks increased by 12% in 1998 and 41% in 1999.

[12] Commercial banks reported 59% growth in total assets in 1999 and only 15.6% growth in total loans and advances. In particular, due to the fear of the Millennium-bug, banks tended to keep more liquid assets during the period 1998-1999.

term deposits in banks. The unofficial credit ceiling imposed on all loans granted by state commercial banks affected the investment portfolio of those banks.

The results also indicate that the change in government at the beginning of the second half (in 1994) negatively affected the asset transformation function of banks. The commencement of a new political regime created a sharp drop in the financial services sector in general. As an example, the CSE reported a drop in the all-share price index[13] during the same period (1994-1996). Stagnation of economic activities was reported due to the fear of possible economic policy changes, which may have lead to a more controlled economy. However, no such radical changes in economic polices were reported after 1994. Further, the banking sector severely suffered from irrecoverable loans granted on political intervention during the 1987 to 1994 period (Bandara, 1998). Accordingly, the recorded stable trend in estimated efficiency scores, especially during the period 1989 to 2000, means that early financial reforms have not made either negative or positive effects on the asset transformation process.

Table 4.7 shows the mean estimated efficiency (of asset transformation) scores of different forms of banks. As indicated in the table, Sri Lankan banks record a TE(A) score of 94.2%, a PTE(A) score of 97.6% and a SE(A) score of 96.5%, indicating relatively high efficiency levels with very low standard deviations. It appears that savings banks, which record a TE(A) score of 99.4%, a PTE(A) score of 99.8% and a SE(A) score of 99.6%, are most efficient in asset transformation. Moreover, commercial banks record a TE(A) score of 93.2%, a PTE(A) score of 97.2% and a SE(A) score of 95.9%. State-owned banks report the lowest mean estimated efficiency scores during the period 1989-2004. The recorded low mean efficiency score in state-owned banks suggests that those banks have not fully utilised resources such as deposits, other loanable funds and human resources to produce productive asset portfolios. Furthermore, the recorded low mean SE(A) score relative to the average PTE(A) score suggests that a large portion of the inefficiency in asset transformation originates from a sub-optimal scale of operations.

[13] The all-share price index (ASP) is the main index which reflects the movement in overall price levels of the Colombo Stock Exchange. As indicated in the CBSL Annual Report 1999, the average ASP dropped by 323 points in the first period (1994—986.7 and 1995—663.7).

Table 4.7: Descriptive statistics – Efficiency in asset transformation

	TE(A)	PTE(A)	SE(A)
All banks	0.942 (0.057)	0.976 (0.030)	0.965 (0.045)
Commercial banks	0.932 (0.058)	0.972 (0.031)	0.959 (0.046)
Saving banks	0.994 (0.010)	0.998 (0.004)	0.996 (0.008)
Privately-owned commercial banks	0.940 (0.051)	0.969 (0.032)	0.969 (0.033)
State-owned commercial banks	0.912 (0.069)	0.980 (0.026)	0.930 (0.064)
Old commercial banks	0.922 (0.060)	0.975 (0.028)	0.946 (0.054)
New commercial banks	0.943 (0.052)	0.968 (0.034)	0.973 (0.031)

[Standard deviations are in parentheses]

Table 4.7 shows that new banks record high mean estimated efficiency scores (TE(A) score of 94.3%, PTE(A) score of 96.8% and SE(A) score of 97.3%) relative to old banks (TE(A) score of 92.2%, PTE(A) score of 97.5% and SE(A) score of 94.6%). Even though the average size of old banks is larger than the new banks, new banks record a higher average SE(A) score than old banks. The production technologies used in asset transformation by the new banks may have influenced their recorded efficiency.

Figures 4.10 (a & b), 4.11(a & b) and 4.12 (a & b) graphically present mean estimated efficiency scores in asset transformation in each window of different types of banks. Overall, all banks record a stable trend in estimated efficiency scores, with minor fluctuations. State-owned commercial banks report the lowest TE(A) scores of 85.5% and SE(A) scores of 86% in 1998. The lowest PTE(A) score of 93.6% is reported by state-owned commercial banks in 2000. Overall, figures indicate there is very little gap in estimated efficiency among different forms of banks.

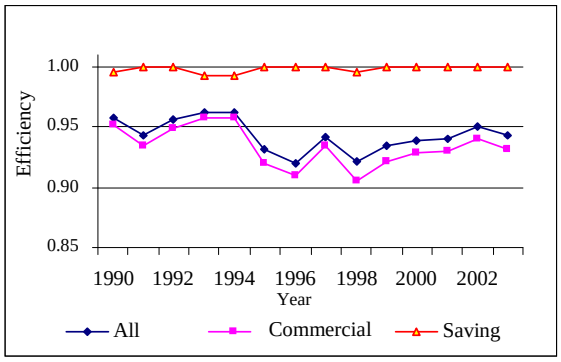

Figure 4.10a: TE(A) of all banks

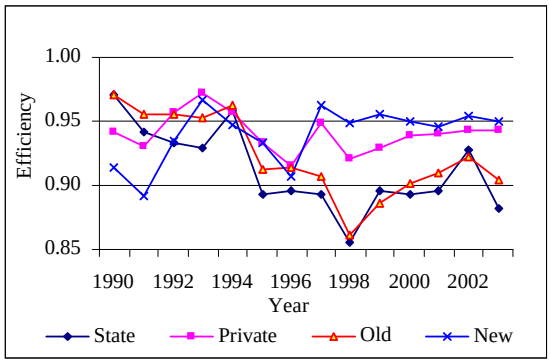

Figure 4.10b: TE(A) of Commercial banks

Figure 4.10: TE(A) – Mean value of mid-year

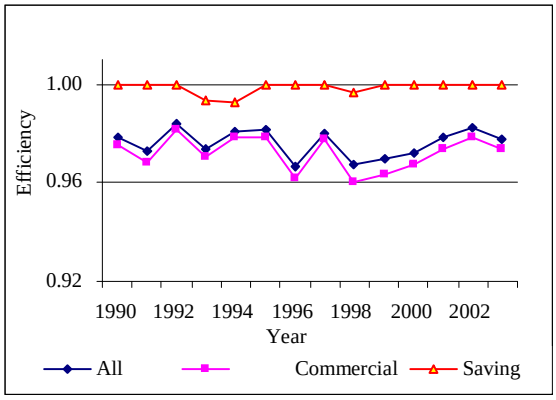

Figure 4.11a: PTE(A) of all banks

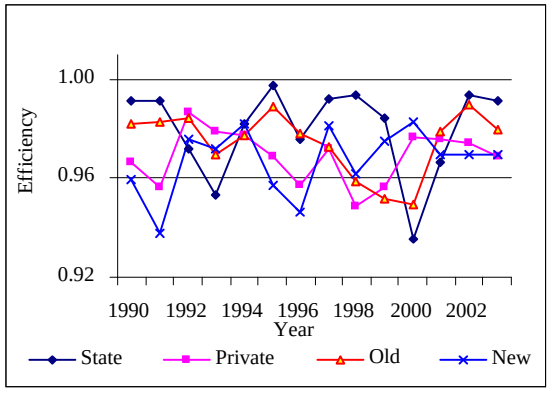

Figure 4.11b: PTE(A) of commercial banks

Figure 4.11: PTE(A) – Mean value of mid-year

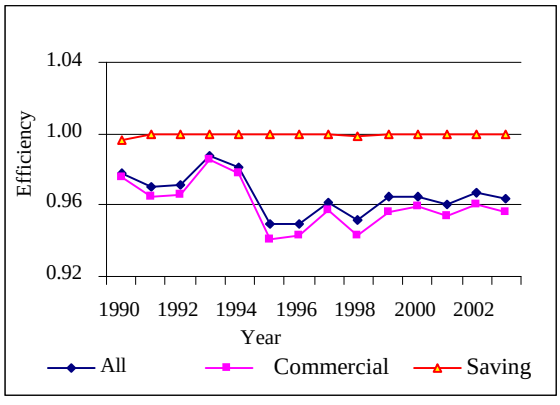

Figure 4.12a: SE(A) of all banks

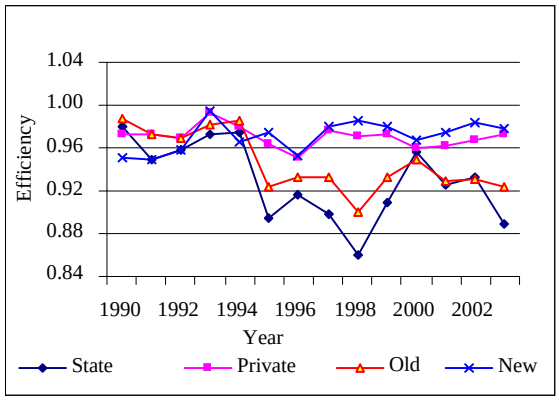

Figure 4.12b: SE(A) of commercial banks

Figure 4.12: SE(A) – Mean value of mid-year

The estimated TE(A) and SE(A) of state-owned commercial banks are lower than the estimated efficiency scores of privately-owned banks. However, state-owned banks have shown relatively high PTE(A) than the privately-owned banks. The recorded high PTE(A) and low SE(A) indicate that the main cause for technical inefficiency of state-owned banks is the under-utilisation of their productive capacity. Moreover, new banks out-performed old banks by reporting higher estimated efficiency scores throughout the study period.

The year 1994 coincided with major political change and the start of the third stage of the financial reforms. As mentioned before, regulatory changes related to the risk management in commercial banks, the minimum capital requirements, the statutory reserve requirements and the CBSL supervisory capacity took place in this period. These changes adversely affected the asset transformation role, particularly in commercial banks.

Table 4.8: Mann-Whitney test scores – Efficiency in asset transformation

	TE(A)	PTE(A)	SE(A)
Savings vs. commercial banks	182.5 (-5.84**)	525.5 (-5.93**)	261.5 (-5.31**)
Privately-owned vs. state-owned commercial banks	858.0 (-1.59)	824.0 (-1.85)	716.0 (-2.62**)
Old vs. new commercial banks	981.5 (-1.79)	1204.0 (-0.60)	821.5 (-2.52**)

['Z' scores are given in parenthesis. '**' indicates that test scores are significant under 5% level.]

The Mann-Whitney Test scores presented in Table 4.8 reveal that differences in estimated efficiency scores between savings and commercial banks are statistically significant. On the other hand, estimated SE(A) scores have shown significant differences for all cases. These findings suggest that recorded efficiency differences in different forms of commercial banks mainly resulted from issues related to the scale of operations.

Recorded estimated efficiency scores in savings banks in all years are very much closer to 100%, indicating that such banks were able to maintain high level of efficiency throughout the study period. Further, these results suggest that commercial banks are less efficient than savings banks. Overall, estimated efficiency scores using the asset approach shows that the banking industry in Sri Lanka is adept in performing the asset transformation role. The next section reviews the outcome of efficiency analysis made in the previous section and highlights the implications of the overall analysis.

4.6.4 Nature of RTS

Tables 4.9 and 4.10 present information on the RTS recorded by each bank in each window[14]. As can be seen in both tables, CRS were evident in the majority of efficient banks. CRS is considered as the most productive scale of operations (Avkiran, 2000). Further, evidence on RTS indicates some banks achieved CRS even though they were not technically efficient. Interestingly, only a few banks were in the IRS. As indicated in previous research, banks in IRS may enter into a market merger or other form of business collaboration with the major banks to expand their scale of operations (Avkiran, 2000). However, this study does not support such strategic moves since the majority of banks are either in CRS or DRS.

Both efficiency measurements show that a large number of inefficient banks in Sri Lanka were in the DRS during the study period. Particularly during the latter part of the study, the number of banks in DRS has increased. Further, as identified in efficiency analyses, most large and old banks were scale inefficient. The result on RTS confirms that the main cause of inefficiency of those banks were the excessive scale of operations. As suggested by Avkiran, those banks which were in the DRS are required to downsize their scale of operations. The operations of such banks may be rationalised by reducing the number of bank branches and restructuring human resources.

[14] See Appendix 6 for information on RTS for different type of banks

Table 4.9: Nature of RTS (efficiency in intermediation)

Window	IRS		CRS		DRS		Total DMUs
	Efficient	Inefficient	Efficient	Inefficient	Efficient	Inefficient	
1989-91	0	0	10	1	5	5	21
1990-92	2	0	11	2	4	2	21
1991-93	0	1	13	0	6	1	21
1992-94	0	0	13	0	5	3	21
1993-95	0	0	11	1	7	4	23
1994-96	0	0	14	0	5	6	25
1995-97	0	0	14	1	7	6	28
1996-98	0	0	15	1	6	7	29
1997-99	1	0	14	2	6	8	31
1998-00	0	1	15	1	6	9	32
1999-01	0	0	13	1	8	11	33
2000-02	1	2	10	1	11	9	34
2001-03	0	0	10	2	13	10	35
2002-04	0	0	13	4	9	10	36
Total	4	4	176	17	98	91	390

Table 4.10: Nature of RTS (efficiency in asset transformation)

Window	IRS		CRS		DRS		Total DMUs
	Efficient	Inefficient	Efficient	Inefficient	Efficient	Inefficient	
1989-91	3	3	9	2	3	1	21
1990-92	2	5	9	1	3	1	21
1991-93	2	1	10	2	4	2	21
1992-94	0	0	11	3	3	4	21
1993-95	4	2	12	4	1	0	23
1994-96	1	0	12	2	6	4	25
1995-97	1	0	13	8	2	4	28
1996-98	2	1	13	2	6	5	29
1997-99	3	4	8	4	7	5	31
1998-00	2	6	9	5	4	6	32
1999-01	4	4	11	3	6	5	33
2000-02	2	2	12	3	10	5	34
2001-03	1	2	14	4	9	5	35
2002-04	2	1	13	6	9	5	36
Total	29	31	156	49	73	52	390

4.6.5 Findings of the assessment of banks' efficiency

The DEA technique identifies benchmarking units for measuring relative efficiency of DMUs from the sample of DMUs under observation by piece-wise comparison of DMUs. Thus, estimated efficiency scores of a sample of DMUs are not appropriate to compare with the estimated efficiency scores from another sample of DMUs. Furthermore, issues related to model specification and input and output orientation used in assessment of efficiency may also reduce the comparability of estimated efficiency scores with other studies. Therefore, comparison of estimated efficiency scores of a sample with another may distort the reality. Thus, the comparison of estimated efficiency scores has to be limited to samples which have similar political, economic and social characteristics. In other words, it is important to consider the homogeneity of samples. Accordingly, the study needs to limit the comparison of estimated efficiency scores to banks in Sri Lanka.

Sri Lanka commenced its financial services sector reforms in the late 1970s. This study covered the second and third phases of financial reforms. Since the reforms did not progress in a gradual fashion as planned, the impact of the reforms on banks' efficiency is difficult to highlight. However, the estimated efficiency scores in intermediation and asset transformation show that Sri Lankan banks have recorded a high level of efficiency with an overall downward momentum throughout the study period. Mean average efficiency scores slightly reduced by the end of the period. On the other hand, existing commercial banks, both private-sector and state, were not able to respond to regulatory reforms and intense competition from new entrants to the banking industry.

The trends in estimated efficiency scores also suggest that the gradual reforms may have adversely affected the stability of the banking industry at the time of reforms. The introduction of new policies, as well as the reversal of policies, is common in countries which have adopted gradual reform processes (Hoj et al., 2006). The patterns of the estimated efficiency movements indicate the impact of concurrent policy adjustments on the banks' planning, operational and strategic decisions.

Window analyses of mean estimated efficiency scores show that banks in Sri Lanka had a negative trend in estimated efficiency scores in intermediation and a stable trend in estimated efficiency scores in the asset transformation process with slight fluctuations during the study period. Estimated efficiency scores in both aspects record a clear drop in estimated efficiency scores in the window which represents years 2001, 2002 and 2003. However, overall estimated efficiency scores imply that banks' responses to regulatory changes are not uniform in different aspects of banking, such as asset transformation and intermediation. These findings suggest that the intermediation process, which links banks' operations with the external environment, takes a relatively longer time period to respond to regulatory changes than the asset transformation process. Since the asset transformation process is dependent on internal operational decisions, banks are able to respond quickly to policy changes related to the asset transformation.

The recorded drops in estimated efficiency in 2001-2003 show the financial repercussions created by fiscal deficit as well as debit taxes which restricted banking operations. The sensitivity of the banking industry to political change has been manifest in both estimations. In both cases, trends in estimated efficiency scores have turned during the period 1994 to 1996, during which Sri Lanka experienced a swing in the general election results.

The estimated efficiency (intermediation) scores of different types of banks show a negative trend at the first half of the study period which turned into a positive trend in the second half—indicating that the financial reforms have contributed to increase banks' efficiency in the long-term. This suggests that banks may take a relatively long period to respond to regulatory changes.

Except in the case of PTE(I), the privately-owned commercial banks record higher mean efficiency scores than the state-owned commercial banks in the intermediation models. Further, recorded mean scores in SE(A) for privately-owned commercial banks and state-owned commercial banks have shown significant differences. The results also indicate a reduction in efficiency gap between state-owned and

privately-owned banks during the second half of the study period. This coincides with the introduction of a commercialisation program of state-owned commercial banks. Thus, the results imply that the ownership structure is not important in the banking industry in Sri Lanka. However, autonomy in strategic and operational decision-making may have a significant influence on efficiency. Further, the results show that commercialisation is a success as an alternative approach to privatisation of state-owned banks.

The analysis of sources of efficiency shows that a large portion of banks' inefficiency originated from the scale of operations. New banks, which are predominantly small, have recorded a relatively lower level of scale inefficiency. In both the asset transformation and the intermediation processes, new banks show superior performance. Further, analysis of the nature of RTS shows that the majority of inefficient banks were in the DRS. This implies that the excessive size of operations of old commercial banks is one of the main barriers to efficiency improvements. The differences in banking technologies which those banks are using may be a main reason for the low efficiency which old banks record. New banks have used new information and communication technologies to gain a higher level of efficiency over their more experienced competitors.

Overall, the analyses of trends of the estimated efficiency scores in each window period show a slight downward trend in efficiency during the study period. But further analyses on mean estimated efficiency scores (intermediation) of each window of different types of banks provide some interesting evidence about the effect of financial reforms on banks' efficiency. The results show that all banks in Sri Lanka were not able to respond to regulatory reforms successfully at the time of introduction. However, the upward trend recorded in the latter part of the study period confirms the fact that the efficiency (intermediation) improvements from financial reforms can be realised in the long run. These findings are similar to Ali and Gstach (2000) who reported a declining trend in Austria immediately after deregulation and later an upward trend, and Denizer, Dinç and Tarimcilar (2000) who found a declining trend immediately after deregulation in Turkey.

4.7 Analysis of Productivity Changes

This section presents results of the assessment of productivity changes in the intermediation and asset transformation processes. The respective productivity indices are estimated using DEA-based MPI. Tables 4.11 and 4.12 report geometric means[15] of the MPIs aggregated into sub-groups based on different types of banks, together with decomposition into the constituent components of productivity changes: the catch-up (CAT) and frontier shift (FRN). Those indices are calculated on the basis of individual banks' data for the period 1989 to 2004 using an adjacent period method. If a recorded value of an index is greater than one it indicates productivity progress. If a recorded value of an index is lower than one it indicates deterioration (regress) of productivity of that bank. An index value equal to one indicates that there is neither progress nor regression in productivity.

The two models (intermediation and asset transformation) show slightly different evidence about productivity changes. As shown in Table 4.11, Sri Lankan banks do not record either productivity gains or losses in the intermediation process. However, a 3.4% (geometric means of all banks' productivity) total productivity improvement has been recorded in asset transformation (see Table 4.12). Decomposition of the productivity change shows that the recorded gain has, for the most part, mainly resulted from FRN (by 5%). During the period, a small productivity regress has been recorded from CAT. This finding suggests that some Sri Lankan banks have improved their technologies in asset transformation during the study period.

[15] Reported geometric means are subject to errors resulted on aggregation. It may not satisfy the basic property which says that the total productivity change (MPI) is equal to the product of efficiency change (CAT) and frontier shift (FRN).

Table 4.11: Productivity gains/losses in intermediation

Win	Average			Savings			Commercial			Privately-owned			State-owned			Old			New		
	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN
1989-90	0.872	0.946	0.921	1.006	0.956	1.052	0.851	0.946	0.921	0.801	0.881	0.909	1.030	1.150	0.895	0.966	1.075	0.899	0.661	0.730	0.906
1990-91	0.916	0.972	0.942	0.836	0.885	0.945	0.930	0.972	0.942	0.956	1.022	0.936	0.847	0.916	0.925	0.896	0.968	0.925	1.004	1.028	0.977
1991-92	0.946	0.943	1.003	1.150	1.224	0.939	0.916	0.943	1.003	0.900	0.885	1.017	0.793	0.787	1.008	0.881	0.859	1.024	0.990	0.996	0.994
1992-93	1.007	0.978	1.029	1.047	1.000	1.047	1.000	0.978	1.029	1.004	0.990	1.014	1.080	1.012	1.068	1.027	0.996	1.031	0.949	0.932	1.017
1993-94	1.024	1.061	0.965	0.925	0.925	1.000	1.042	1.061	0.965	1.020	1.091	0.934	1.201	1.074	1.118	1.081	1.104	0.979	0.967	1.048	0.922
1994-95	1.040	0.961	1.081	0.947	0.941	1.006	1.056	0.961	1.081	1.007	0.918	1.097	1.139	1.009	1.128	1.102	0.983	1.121	0.970	0.930	1.043
1995-96	0.931	0.898	1.037	1.553	1.351	1.151	0.840	0.898	1.037	0.816	0.786	1.039	0.985	1.045	0.943	0.934	0.961	0.972	0.755	0.701	1.077
1996-97	0.987	0.997	0.989	0.783	0.949	0.825	1.015	0.997	0.989	1.005	0.995	1.010	1.034	1.062	0.973	1.036	1.057	0.980	0.995	0.952	1.046
1997-98	0.922	0.930	0.992	0.511	0.506	1.011	1.024	1.044	0.981	1.037	1.057	0.981	1.111	1.130	0.983	1.068	1.063	1.005	1.070	1.104	0.969
1998-99	0.972	1.020	0.954	1.154	1.088	1.061	0.976	1.032	0.946	0.915	0.983	0.931	1.056	1.142	0.925	0.998	1.074	0.929	0.870	0.937	0.928
1999-00	0.960	0.974	1.039	1.010	0.949	1.092	0.931	0.951	1.032	0.942	0.984	1.022	1.072	1.138	1.007	1.052	1.076	1.023	0.874	0.909	1.030
2000-01	0.897	1.001	0.897	1.025	0.960	1.068	0.890	1.004	0.887	0.862	1.012	0.852	0.995	1.161	0.857	0.942	1.050	0.897	0.818	0.979	0.835
2001-02	1.043	1.042	1.002	0.965	1.050	0.919	1.052	1.049	1.003	1.083	1.065	1.017	0.949	0.918	1.033	1.010	1.019	0.991	1.105	1.057	1.045
2002-03	1.062	0.986	1.077	0.928	1.004	0.925	1.072	0.985	1.088	1.074	0.967	1.111	1.194	0.936	1.274	1.114	0.952	1.170	1.078	1.006	1.071
2003-04	1.069	1.002	1.067	0.923	0.994	0.928	1.080	1.003	1.076	1.072	0.985	1.088	1.224	1.048	1.168	1.130	0.981	1.152	1.084	1.022	1.060
Mean	0.990	0.983	0.999	0.992	0.977	1.003	0.987	0.990	0.996	0.977	0.984	0.995	1.052	1.018	1.015	1.021	1.006	1.003	0.965	0.971	0.993

Table 4.12: Productivity gains/losses in asset transformation

Win	Average			Savings			Commercial			Privately-owned			State-owned			Old			New		
	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN	MPI	CAT	FRN
1989-90	1.080	0.994	1.086	1.435	1.735	0.827	1.030	0.906	1.136	1.096	0.960	1.142	0.908	0.808	1.124	0.988	0.889	1.111	1.119	0.942	1.188
1990-91	1.052	0.971	1.083	0.754	0.524	1.440	1.112	1.077	1.033	1.152	1.110	1.038	1.036	1.013	1.022	1.074	1.054	1.018	1.192	1.122	1.062
1991-92	0.947	0.843	1.124	0.713	0.566	1.260	0.993	0.901	1.103	1.112	0.975	1.141	0.792	0.769	1.029	0.929	0.860	1.080	1.135	0.987	1.150
1992-93	1.025	1.060	0.967	1.036	1.051	0.985	1.024	1.062	0.964	1.012	1.056	0.958	1.047	1.072	0.977	1.011	1.045	0.968	1.050	1.097	0.957
1993-94	1.077	1.052	1.023	1.158	0.992	1.168	1.064	1.063	1.001	0.985	0.994	0.991	1.240	1.213	1.022	1.087	1.098	0.990	1.019	0.995	1.024
1994-95	1.090	1.015	1.073	1.274	1.686	0.756	1.061	0.933	1.138	1.151	0.990	1.162	0.902	0.827	1.091	1.022	0.906	1.128	1.146	0.989	1.158
1995-96	1.139	1.019	1.118	0.667	0.447	1.491	1.218	1.130	1.078	1.294	1.185	1.092	1.017	0.980	1.038	1.023	0.955	1.071	1.450	1.337	1.085
1996-97	1.051	0.969	1.085	0.942	0.868	1.086	1.066	0.983	1.085	1.071	0.977	1.096	1.050	1.000	1.050	1.100	1.021	1.077	1.033	0.945	1.092
1997-98	0.936	0.967	0.967	0.903	1.075	0.840	0.944	0.942	1.002	0.954	0.954	1.000	0.916	0.907	1.010	0.916	0.900	1.018	0.973	0.986	0.987
1998-99	1.092	0.962	1.135	0.997	0.845	1.180	1.116	0.993	1.124	1.086	0.959	1.131	1.214	1.101	1.103	1.143	1.006	1.136	1.090	0.980	1.113
1999-00	0.961	0.901	1.067	0.866	0.846	1.023	0.983	0.913	1.077	1.017	0.954	1.066	0.874	0.784	1.114	0.995	0.926	1.076	0.974	0.904	1.078
2000-01	1.258	1.201	1.047	1.124	1.045	1.075	1.289	1.239	1.041	1.235	1.177	1.050	1.498	1.483	1.010	1.192	1.155	1.032	1.373	1.310	1.047
2001-02	0.989	0.945	1.046	1.058	1.082	0.977	0.975	0.917	1.062	1.037	0.985	1.053	0.784	0.717	1.094	0.931	0.873	1.067	1.011	0.955	1.059
2002-03	0.881	0.932	0.945	0.872	0.764	1.141	0.883	0.970	0.910	0.849	0.923	0.920	1.032	1.184	0.872	1.005	1.142	0.880	0.809	0.870	0.931
2003-04	0.992	0.981	1.011	1.036	1.090	0.951	0.984	0.961	1.024	0.988	0.971	1.018	0.968	0.922	1.050	1.049	0.991	1.058	0.943	0.941	1.002
Mean	1.034	0.985	1.050	0.969	0.913	1.061	1.045	0.995	1.050	1.064	1.008	1.055	1.004	0.967	1.038	1.028	0.984	1.045	1.077	1.016	1.060

Further, the above findings suggest that banks in Sri Lanka have recorded relatively higher productivity in the asset transformation process than the intermediation process during the study period. Additionally, the result indicates that protective regulations related to interest rate determinations, lack of external and internal competition and a highly collusive environment in the banking industry may have forced Sri Lankan banks to adhere to non-price competition. Thus, banks have focused on improvements in productivity in asset transformation, rather than focusing on improvements in intermediation.

Geometric means of all banks' productivity indices (intermediation) show eight increases (in the periods 1991-92, 1992-93, 1994-95, 1995-96, 1999-2000, 2001-02, 2002-03 and 2003-04) from FRN and five increases (in the periods of 1993-94, 1998-99, 2000-01, 2001-02 and 2003-04) from CAT, resulting in five increases in total productivity (in the periods 1992-93, 1993-94, 1994-95, 2001-02, 2002-03 and 2003-04) out of 15 comparisons made during the period 1989 to 2004. Neither the commercial banking sector nor the savings banking sector recorded significant gains from productivity improvements in intermediation.

MPIs in asset transformation show 12 increases in FRN (excluding the periods 1992-93, 1997-98 and 2002-03) during the same period. Further, the results show only five increases in CAT (in the periods 1992-93, 1993-94, 1994-95, 1995-96 and 2001-02) confirming that the main contributor to productivity improvements in asset transformation is the FRN which resulted from advancement of technologies used. Further analysis of estimated productivity indices shows that both the savings (6.1%) and the commercial banking (5%) sectors gained productivity improvements in asset transformation from FRN during the study period. Overall, these findings suggest that banks in Sri Lanka have focused more on improvement in asset transformation than in intermediation.

No productivity gain in intermediation has been made either by the commercial banking or by the savings banking sectors. The commercial banking sector recorded

the highest total productivity loss (-11%) in intermediation in 2000-01 and the highest total productivity gain (8%) in 2003-04. The estimated productivity indices for individual periods show that most of the productivity gains in commercial banks originated from FRN. Further, changes in CAT have not significantly contributed to overall productivity gains, suggesting that the main aim of commercial banks was to seek improvements in productivity through the adoption of new technologies.

Commercial banks recorded considerable productivity gains (4.5%) in asset transformation mainly from FRN (5%). However, the savings banking sector records a total productivity loss (-3.1%) even though the sector records a 6.1% gain on FRN. Both sectors have recorded productivity losses on CAT. In the commercial banking sector, both privately-owned (5%) and state-owned (3.8%) banks record productivity improvements from FRN. State-owned commercial banks (1.8% on CAT and 1.5% on FRN) and old commercial banks (0.6% on CAT and 0.3% on FRN) record 5.2% and 2.1% total productivity gains respectively during the study period. These results indicate old and state-owned banks have improved their performance by expanding existing technologies and achieving higher levels of efficiency. Further, recorded MPIs suggest that both new commercial banks and privately-owned commercial banks have not gained productivity improvements either on FRN or CAT during the study period.

Among all forms of banks, new banks have recorded the highest total productivity gain (7.7%) in asset transformation during the study period. The highest total productivity gain of the commercial banking sector is reported in 1995-96 (21.8%) which is mainly contributed by the privately-owned commercial banks recording a (29.4%) total productivity gain. However, the state-owned commercial banks recorded a marginal total productivity improvement during the study period. These results suggest that increased threat of competition on commercialisation of state-owned banks may have affected the productivity gains in the sector.

While old banks record a modest productivity gain (2.1%) in intermediation, new banks record a productivity regress (-4.5%). The decomposition of old banks' total

factor productivity gains shows that the main contributor for productivity gains in intermediation is the FRN. Both the negative FRN (technological change) and the negative effect of CAT (losses in efficiency) have caused productivity regress in new banks. The primary reasons for productivity regress in intermediation may be that new banks have given less attention to improving either technical efficiency or advancement of technologies in the belief that they are at the most productive scale of operation. Similarly, old banks may have attempted to mitigate differences in operational efficiency with new banks in order to maintain their competitive position in the market.

On the other hand, recorded total productivity indices in asset transformation shows that new banks achieved higher productivity gains (7.7%) both in frontier shift (6%) and catch-up (1.6%) compared to the old banks (2.8% on total productivity gain, 4.5% on frontier shift and -1.6% on catch-up). These results indicate that new banks are more successful in incorporating new technological advances to improve asset transformation than the old banks.

Overall, assessment of productivity change suggests that Sri Lankan banks have been able to gain improvements in productivity in asset transformation. However, the results show that there are no significant improvements in intermediation processes. Further, results show that most productivity gains have been achieved in the latter part of the study. It also signifies that regulatory reforms may have helped banks to improve their productivity in the long-term. Based on the results of productivity analysis, the following observations can be highlighted:

1. Banks in Sri Lanka have recorded productivity gains in asset transformation, indicating that banks have focused on gaining advantage through non-price competition. There is no productivity gain recorded in intermediation processes.
2. Productivity gains on assets transformation have been recorded from FRN (advancement of technologies, rather than improvement of efficiency).

3. State-owned commercial banks and old commercial banks made relatively higher improvements in productivity.

4.8 Conclusion

This chapter examines the trends in efficiency and productivity changes of the banking industry during the post-deregulation period and the responses of different forms of banking firms to the reform process. Efficiency scores and total factor productivity growth are estimated using the input-oriented DEA model. Two input and output specifications are used to represent efficiency and productivity gains in intermediation and asset transformation. The main limitation faced in this study is the number of banks in the sample. Hence, efficiency scores are estimated based on three-year moving averages for the local bank sample. All productivity indices are estimated based on adjacent period MPI.

This chapter is based on a proposition which assumed that financial reform has improved banking efficiency and productivity gains. The analysis of mean estimated efficiency scores in both models—which used intermediation and asset approaches for specification of input and output variables—indicated a reduction in estimated efficiency. However, the mean estimated efficiency (intermediation) scores of different types of banks show that there is a negative trend in efficiency in the first half and a positive trend at the end of the second half of the study period. Overall, this study found no evidence to support the view that reforms improved the banks' efficiency. However, the results suggest that reforms may bring efficiency improvements in the long term. These findings are similar to Ali and Gstach's (2000) findings in Austria which reported a negative trend in the early years.

Since the intermediation process is externally driven, even firms that have made the necessary adjustments take some time to gain the benefits of reforms. Low variations in estimated efficiency scores for asset transformation confirm this argument. Since many decisions related to asset transformation are internal decisions, banks were able to respond quickly to the policy adjustments related to

the asset transformation function, indicating that banks' responses depend on the type of decisions affected by policy change. Further, these results suggest that the main source of inefficiency of banks in Sri Lanka is scale inefficiency arising from sub-optimal size of operation. Particularly, the scale issue more severely affects old banks (including both state-owned banks and privately-owned banks) which can be regarded as the large banks in the industry. Small, new commercial banks were able to perform better than the old banks.

The estimated MPIs show that Sri Lankan banks have recorded no improvement in productivity in intermediation. However, the asset transformation process records total productivity gains mainly from frontier shift. For the most part, old banks and state-owned banks have shown productivity gains. This finding suggests that banks in Sri Lanka mainly focus on non-price competition.

Overall, this chapter shows how the efficiency and productivity changes have evolved during the last 16 year (1989-2004) period. Furthermore, the recorded trends have shown that the changes in efficiency of banks may have been affected by some other factors with the financial reforms. Thus, the next chapter investigates the factors affecting the technical efficiency of banks in Sri Lanka.

CHAPTER FIVE

DETERMINANTS OF EFICIENCY OF BANKS IN SRI LANKA

5.1 Introduction

The results outlined in Chapter Four show that efficiency and productivity of the banking industry in Sri Lanka has changed during the study period. However, the results indicate that movement in the estimated efficiency of banks during the period is dissimilar across banks. For example, although financial reforms have removed distortions in the market, responses of the banks were different. While some banks recorded improvements in efficiency and productivity gain, others did not. This suggests that there are factors, other than regulatory, which may control banks' performance. Thus, analysis in this chapter is based on Proposition II which states that "the efficiency of banks in Sri Lanka is affected by a range of micro and macroeconomic factors, together with financial deregulation".

The performance of institutions depends upon the strengths, weaknesses, opportunities and threats they are facing. Those forces originate from both external and internal environments of the firm. Hence, both firm-specific and environmental factors may influence the efficiency of a bank. Consequently, banks with sound internal and external environments may perform better than other banks in the industry. Thus, the investigation of factors which influence firms' efficiency is important.

5.2 Background of the Analytical Framework

A production process can be regarded as a complex, adaptive, on-going social system that is sensitive to changes in socio-economic environments. Convergence of labour, capital and socio-economic environments and the way they are balanced and coordinated into an integrated whole are important, particularly in service-oriented industries (Prokopenko, 1987). Therefore, recognition and utilisation of key factors from socio-economic environments which have significant influence over firms' performance are necessary conditions for improvement in efficiency and productivity gains.

5.2.1 Determinants of bank efficiency

Variables representing socio-economic environments can be broadly divided into three groups, namely, microeconomic, macroeconomic, and other factors. Microeconomic factors have limited influence over particular industry segments and include endogenous factors such as product lines, capital employed, input utilisation, people, the organization and system, work methods, and management styles—all of which a firm's management can control. Microeconomic factors also include exogenous factors such as market share, which may not be quite so susceptible to control through managerial decisions. Macroeconomic factors such as per capita income of the consumer population, inflation, gross national product, economic growth rates and population may influence the improvement in efficiency and productivity gains of all industries in general. Other factors include all non-economic factors. Table 5.1 summarises some factors which have been considered in previous studies.

Researchers have arbitrarily selected different combinations of variables according to the objectives of their analyses. For example, when researchers address policy matters they have given greater weight to regulatory factors such as capital adequacy, type of ownership, nature of banking activities and problem loans (Ali and Gstach, 2000; Barr, Seiford and Siems, 1994; Dietsch and Lozano-Vivas, 2000; Grifell-Tatje and Lovell, 1996; Hermalin and Wallace, 1994).

Table 5.1: Microeconomic, macroeconomic and other factors affecting banks' efficiency

Factor	Study
Microeconomic factors	
Size	Barr et al. (1999); Darrat, Topuz and Yousef (2002); Favero and Papi (1995); Leong and Dollery (2002); Leong, Dollery and Coelli (2002); McKillop, Glass and Ferguson (2002); Miller and Noulas (1996)
Profitability	Casu and Molyneux (2003); Casu, Girardone and Molyneux (2004); Darrat, Topuz and Yousef (2002); Maghyereh (2004); Miller and Noulas (1996)
Capital ratio	Casu and Molyneux (2003); Casu, Girardone and Molyneux (2004); Darrat, Topuz and Yousef (2002); Leong and Dollery (2002); Maghyereh (2004)
Loans to total assets	Leong and Dollery (2002); McKillop, Glass and Ferguson (2002)
Fixed assets to total assets	Leong and Dollery (2002)
Problem loans	Barr et al. (1999); Maghyereh (2004); McKillop, Glass and Ferguson (2002); Pastor (2002)
Risk	Leong and Dollery (2002)
Purchased funds	Barr et al. (1999)
Liquidity	McKillop, Glass and Ferguson (2002)
Market power	Darrat, Topuz and Yousef (2002); Devaney and Weber (2000); Favero and Papi (1995); Maghyereh (2004); Miller and Noulas (1996)
Macroeconomic factors	
Per capita income	Chaffai, Dietsch and Lozano-Vivas (2001); Grigorian and Manole (2002); Hasan, Lozano-Vivas and Pastor (2000)
Inflation ratio	Grigorian and Manole (2002)
Stock market capitalization	Grigorian and Manole (2002)
Liberalisation	Maghyereh (2004)
Other Factors	
Specialization	Favero and Papi (1995); Mukherjee, Ray and Miller (2001)
Location	Casu and Molyneux (2003); Casu, Girardone and Molyneux (2004); Devaney and Weber (2000); Favero and Papi (1995); Miller and Noulas (1996)
Ownership	Favero and Papi (1995); Maghyereh (2004)
Number of branches	Dietsch and Lozano-Vivas (2000); McKillop, Glass and Ferguson (2002)
Bank branch concentration	Chaffai, Dietsch and Lozano-Vivas (2001); Dietsch and Lozano-Vivas (2000)
Population concentration	Dietsch and Lozano-Vivas (2000); Hasan, Lozano-Vivas and Pastor (2000)

However, for general assessment of efficiency, researchers have freely selected variables from the sample environment. For instance, Leong and Dollery (2002) used factors such as agency problems[1], regulator and organizational structure[2], risk management[3], and size and technology[4] in a study which aimed to identify the properties of DEA-estimated efficiency scores.

Favero and Papi (2002) used variables such as firm size, productive specialization, of each ownership, market structure and localisation as explanatory variables of DEA-estimated efficiency in a study which focused on factors determining the efficiency of banks in Italy. Miller and Noulas (1996) investigated the resultant high competition in the banking market from regulatory changes and identified bank size, profitability, market power and location as the most influential factors. Grigorian and Manole (2002) examined determinants of the efficiency of financial institutions in transition countries and tested the relationships of DEA-estimated efficiency scores with bank-specific variables to represent financing, market concentration, foreign versus local banks, and new versus old banks. Therefore, these applications confirm that the objective analysis determines the selection of factors for further studies.

5.2.2 Empirical approaches used in previous studies

Prior studies have applied three techniques for investigating factors affecting the estimated efficiency and productivity gains indexes. They are:

- multivariate regression analysis (generalised least square methods and Tobit) (Ali and Gstach, 2000; Darrat, Topuz and Yousef, 2002; Favero and Papi, 1995; Grigorian and Manole, 2002; Miller and Noulas, 1998);

1 Agency problems arise when ownership and management are separate.
2 Firm structure and organization depend on existing regulation.
3 A bank management's capability to predict the future will lead to a reduction in unanticipated loses.
4 Bank size and technology indicate the firm's overall ability to respond to environmental uncertainty (Leong & Dollery 2002)

- longitudinal graphical approach (Barr et al., 1999; Leong and Dollery, 2002); and
- DEA itself (Chaffai, Dietsch and Lozano-Vivas, 2001; Pastor, 1999, 2002).

The first approach, multivariate regression analysis, uses DEA-estimated efficiency scores as dependent variables and a range of other factors as the explanatory variables. The second, longitudinal approach, examines the general trends of estimated productivity within a longer time period and uses graphical representation to exhibit the relationship between estimated productivity and each factor. The third approach uses the DEA technique, together with Malmquist type indices, to find the aggregate effect of other (non-production) variables on estimated efficiency[5] (Pastor, 1999, 2002).

Both DEA techniques and the longitudinal approach do not provide sufficient information to test hypotheses. However, the statistical significance level provided with the estimated coefficient for each explanatory variable included in the model allows analysts to test the hypotheses when using regression techniques. Accordingly, previous studies employed this approach to test the hypotheses. On the other hand, the longitudinal approach has been used to identify the influence of factors which may lag over a longer time period, such as the impact of policy changes on productivity (Barr et al., 1999). In contrast, DEA-based approaches have been used in cross-country comparison of estimated efficiency to separate the country-specific environmental influences from estimated efficiency to find the true efficiency. The main advantage of multivariate regression analysis over other approaches is its ability to test the hypotheses. Accordingly, this study uses the regression method to investigate determinants of banks' efficiency. The remaining discussion is limited to prior studies using a similar approach.

[5] There are two DEA models, in which the first incorporated only input and output variables directly related with the production process (for estimating the true efficiency) and the second model included both production and non-production factors affecting the production process (to estimate the total efficiency), used for estimating efficiency. The difference between estimated efficiency scores in these two models is decomposed using a Malmquist type index and identifies the aggregates affecting the other variables (Pastor 1999; 2002).

5.2.3 Previous applications

Previous empirical research presents mixed evidence of factors affecting the estimated efficiency scores of banks. However, methodological differences, as well as differences in regulatory and economic environments, have greatly influenced the outcome of these studies. Thus, the comparison of these results with other research needs careful analysis.

As stated previously, the combination of factors and their proxy variables investigated in different studies are not comparable. For example, the same variable has been used as proxy for different factors, or different proxy variables have been used to account for the same factor in different studies. For example, return on total assets and return on equity are used alternatively to represent profitability. Furthermore, the predicted signs for explanatory variables are also not comparable. Favero and Papi (2002) and Isik and Hassan (2003) used different size groups which were incorporated as dummy variables in these models to understand the size effect on estimated efficiency. In another study, Miller and Noulas (2000) regressed the value of the total assets directly with estimated efficiency scores. Consequently, the estimated coefficient for the variable may be greatly influenced by the definition used for the variable.

Previous studies produced dissimilar evidence on factors affecting banks' technical efficiency. Favero and Papi (2002) found that inefficiency is best explained by productive specialization[6], size and, to a lesser extent, location in Italian banks. In another study, Miller and Noulas (2000) found bank size and profitability have a significant positive relationship with pure-technical efficiency in large US banks. In a study of transition countries (located in eastern Europe), Grigorian and Manole (2002) found that equity capital ratios, market shares, foreign ownership and old banks were positively related to estimated efficiency scores. Ali and Gstach (2000)

[6] Productive specialization = (total intermediation margin)

$$= \frac{\text{Profit from banking services}}{\text{profit from banking services} + \text{profit from non} - \text{banking services} + \text{interest margin}}$$

found that small banks in Austria performed better than medium-sized banks. Darrat, Topuz and Yousef (2002) found a negative relationship between bank size and estimated efficiency in Kuwait, which was similar to the findings of Ali and Gstach (2000). Further, Ali and Gstach (2000) pointed out that low competition in the banking industry may adversely affect estimated efficiency in large and medium-sized banks.

Darrat, Topuz and Yousef (2002) also found that market power, profitability and capitalization are positively related to estimated efficiency. Naceur and Goaied (2001) found that the principal determinants of a bank's performance are, by order of importance, labour productivity, bank portfolio composition, capital productivity and bank capitalization. Sathye (2000) measured the productive efficiency of banks in India using DEA and found that the efficiency of private-sector commercial banks as a group is, paradoxically, lower than that of public-sector banks and foreign banks in India. He suggested that the existing policy of reducing non-performing assets and rationalization of staff and branches may have enhanced the productivity of Indian banks.

Casu and Molyneux (2003) examined the factors influencing European commercial banks after convergence into a common monetary union by using bootstrap methods for computing the confidence intervals for efficiency scores derived from non-parametric frontier methods. Their regression results indicated that the geographic location has the most significant influence on bank efficiency. They did not find significant evidence for the relationship of estimated efficiency with average capital ratio and the return on average equity.

The DEA-based approach has been used in cross-country comparisons of bank efficiency. Pastor (1999) proposed the use of a sequential DEA procedure consisting of three phases[7] to address the influence of loan losses and environmental factors

[7] Pastor (1999) suggested separating bad loans into two segments according to cause - managerial actions and outside factors. In the first phase, he suggested estimating efficiency without environmental factors. In the second phase, the DEA or SFA is used to estimate efficiency with

when evaluating efficiency improvements. He used DEA to disaggregate the estimated technical efficiency into risk management effect, environmental effect and pure-technical effect. Pastor (2002) extended this framework by developing separate DEA models which incorporate risk and environment factors. He found a high variation in efficiency estimations between two countries using a model that did not incorporate the environmental variables. The model that incorporated the environmental variables reported comparatively low efficiency variations between two countries. Hence, Pastor argued that the cross-country differences arise not only as a result of differences in managerial decision-making, but also environmental differences.

Lozano-Vivas, Pastor and Pastor (2002)[8] used a similar approach to Pastor (1999) to examine the operating efficiency differences among commercial banks across 10 European countries. They used two different models with and without environmental variables to examine the influence of the country. The estimated efficiency without environmental variables was significantly different from the efficiency estimated with environment variables. Pastor (2002) employed a quite different methodology for comparing the input-oriented efficiency among four European Union countries. Pastor (2002) emphasised the significance of incorporation of the risk factors together with environmental variables in cross-country studies. Country-specific risk factors indicate the social and political environment which may directly influence firms' operational decisions. Pastor used provisions for loan losses as a proxy for the risk factor. He employed both parametric and non-parametric approaches to estimate productivity and used graphical representation to compare the outcomes. His analysis incorporated environmental as well as risk factors, and found relatively low productivity estimations for all countries.

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the bad loans resulting from managerial actions. In the third phase, he suggested estimating efficiency with the environmental variables.

[8] Lozano-Vivas, Pastor and Pastor (2002) recognised three types of environmental variables as the variables that affect the efficiency variation in a given market. These are variables representing the country's economic conditions (per capita income, per capita salary, the population density and density of demand), variables representing the bank performance (income per branch, deposits per branch, and branches per capita) and the regulatory environment and competitiveness (average capital ratios and return on equity).

The main implication of previous studies is that the relationships among efficiency, productivity and other factors are not consistent. The outcome depends on the relative importance of factors in a given country. However, only a few studies have examined the explanatory power of macroeconomic factors on technical efficiency. Stock markets and debt markets may have a very limited influence over a bank-based financial system. However, financial system liberalisation aims to enhance the direct capital transfers through stock and capital markets too. Particularly in developing countries, financial liberalisation policies are aimed at both the banking sector and the capital markets. With liberalisation, changes in the purchasing power of money, interest rates, and international trade activities may have influenced technical efficiency of the banking industry. However, previous studies have given very little emphasis to such factors.

5.3 Methodology

Having considered the previous studies, this study uses the multivariate regression analysis approach to examine the characteristics and their influence. This section introduces the empirical model and potential determinant variables of technical efficiency.

5.3.1 Model selection

The empirical model used in this study is taken from the literature[9] which investigates the explanatory variables of the efficiency of DMUs. Most previous studies have used two-stage procedures to regress the point estimation of efficiency with a number of explanatory variables. At the first stage, point estimation of efficiency has been measured based on a non-parametric DEA approach. As a second stage, the estimated efficiency scores are regressed with a range of explanatory variables.

There are two main problems in using DEA-estimated data in regression analysis. As explained by Xue and Harker (1999), since DEA-estimated efficiency scores are

[9] See section 3.6.2.

clearly interdependent, normal procedures applied in regression analysis may not be valid. To overcome this problem, they have shown the usefulness of the bootstrap approach. The effectiveness of the bootstrap approach mainly depends on the size of the original sample. However, the sample used in this study is not large enough for the proposed procedure. Therefore, this study is limited to the two-stage procedure used in previous research.

The second problem is the nature of the dependent variable. Since dependent variables are estimated parameters and are bounded by one and zero, least square regression analysis is not appropriate (Saxonhouse, 1976). Therefore, this study uses a Tobit multiple regression[10] which allows limited dependent variables. It is assumed that the estimated efficiency distribution 'θ' is a truncated, normal and exponential distribution. To estimate the relevant variables in the Tobit model, a method of maximum likelihood is employed (Gujarati, 2003). The relationships between the estimated efficiency scores (dependent variable) and the other independent variables are explained by the following Tobit model.

Let $z_1,\ldots,z_i$ be the determinants of banks' efficiency (where i is the number of determinants) which are explained in Table 5.2. If the distribution of inefficiency in banks (θ_i) is explained by an exponential distribution function, it can be explained as:

$$\theta_{nj}^{*} = \begin{cases} \sum_{k=0}^{l} z_{kj}\delta_k + u_j & if \quad \theta_j \rangle 0 \\ 0 & if \quad \theta_j \le 0 \end{cases} \qquad \text{Equation 5.1}$$

$$where \quad u_j \; of \; the \; normal \; N\left(0,\sigma^2\right)$$

Z_{kj} is a vector of observed variables explaining the banks' efficiency. 'n' denotes the number of observations used in the analysis. The likelihood function for estimating the unknown variables (δ) in the Tobit model with censoring point 'a = 0' and 'a = 1' can be identified as indicated below (Maddala, 1992):.

[10] This model was first used in the economic literature by Tobin (1958). It is also introduced as a censored normal regression model.

$$L = \prod_{y_i \rangle a} \frac{1}{\sigma} f\left(\frac{y_i - \delta z_i}{\sigma}\right) \prod_{y_i \leq a} f\left(-\frac{\delta z_i}{\sigma}\right) \qquad \text{Equation 5.2}$$

By maximising this likelihood function (L) with respect to δ and σ, the estimation for the parameters can be derived in the Tobit models. The characteristics incorporated in the regression model, proxy variables and expected relationships are summarised in Table 5.2. The estimation process can be performed using 'EViews 5' statistical software. The use of a Tobit regression model allows estimation of parameters by coping with the heteroskedastic problems in estimated limited variables. It offers insight into the probable influence of those characteristics.

Two separate Tobit regression models are estimated based on technical efficiency scores estimated for the local banks' sample using the intermediation approach and the assets approach as outlined in Chapter Four. As stated early in this chapter, data availability for branches of foreign operations limited the analysis to only the local banks. Furthermore, analysis was limited to estimated technical efficiency scores, since CRS-DEA has better discriminatory power than the VRS-DEA.

5.3.2 Determinants of banks' efficiency in Sri Lanka

This section introduces a range of microeconomic and macroeconomic factors and their expected relationships with estimated technical efficiency scores. To address Proposition II, a number of hypotheses are developed based on the theories related to each factor. Theories related to the factors, related hypotheses and corresponding evidence found in this study are presented separately in the section 5.4.

As previously stated, prior studies have tested the influence of three categories of variables on technical efficiency. The empirical evidence highlighted above showed that banking industries in some countries were able to report productivity improvements due to favourable microeconomic and macroeconomic factors, even under a rigid regulatory environment. Existence of favourable characteristics in the market may provide DMUs with a better opportunity for efficiency gains through reforms. On the other hand, unfavourable characteristics may diminish the efficiency

improvement even under a deregulated environment. Thus, it is important to investigate various factors and the nature and significance of their influence on firms' efficiency. Following previous research, this study concentrates on three types of variables in regression analysis: (1) microeconomic characteristics such as assets quality, capital adequacy, collateral value (ratio of fixed assets), interest margin, leverage, liquidity, operational risk and profitability; (2) macro economic characteristics, stock market capitalization, inflation ratio, per capita income and GDP growth; and (3) qualitative characteristics such as line of business (commercial banks), ownership (privately-owned banks), relative experience (old banks) and one variable to represent major political change in 1994.

Firms' specific (microeconomic) variables are given precedence over other variables since those variables are specific to individual banks. Macroeconomic variables are introduced to the model to control environment-related influences which all banks equally enjoy. In regression analysis, a qualitative variable is used to proxy regulatory conditions which banks face. Overall, the analysis concentrates on 14 explanatory variables. Predicted relationships and proxies used for representing each variable are briefly defined in Table 5.2. Detailed discussion of each factor is provided within the results of the regression analysis. Information about firm-specific explanatory variables was obtained from the published annual reports of banks. Information about macroeconomic variables was obtained from various issues of CBSL annual reports.

Table 5.2: Variables and definitions

Characteristic	Proxy variable	Hypothesised Relationship
Dependent variables		
TE(I)	Technical efficiency in intermediation	
TE(A)	Technical efficiency in asset transformation	
Independent variables – Firm-specific (microeconomic)		
Assets quality	Problem loan provision to total loan portfolio	Negative
Capital strength	Equity capital to total assets	Positive
Collateral value	Fixed assets to total assets	Positive
Gross interest margin (GIM)	Gross interest margin to total assets	Negative
Liquidity	Liquid assets to total assets	Negative
Profitability	Return on total assets	Positive
Purchased funds	Total purchased funds to total assets	Positive
Operational risk	Loan to assets ratio	Negative
Size	Natural logarithms of total assets	Positive
Independent variables – macroeconomic		
Stock market capitalization	% change in total market capitalisation compared to the previous year	Negative
GDP growth	GDP growth rate	Positive
Inflation ratio	% change in Consumer Price Index	Negative
Independent variables – Qualitative		
Commercial banks	Dummy; equals 1, if the bank is a commercial bank	Positive
Privately-owned banks	Dummy; equals 1, if the bank is a privately-owned bank	Positive
Old banks	Dummy; equals 1, if the bank is incorporated and commenced business before 1977	Positive
Political change	Dummy; equals 1, all observations during the period 1995-2003	Positive

5.4 Results and Discussion

5.4.1 An overview

Tables 5.3 and 5.4 present descriptive statistics and correlation coefficients for the independent and dependent variables used in the regression analysis. The mean values and the standard deviations of each variable show that there are no outliers among the explanatory variable which may affect the estimated regression coefficients. The mean value of the variable which represents collateral value shows that banks have invested relatively low amounts of total funds in fixed assets with high collateral value. Further, the descriptive statistics show that banks have maintained relatively high liquidity positions while investing a large portion of their assets in loans and advances (operation risk). However, the recorded mean value for profitability has shown that banks in Sri Lanka gain a low return on total assets. Further, the mean value of the capital ratio indicates that banks have mainly relied on deposit mobilisation for funding their operations.

Table 5.3 Descriptive statistics of firm-specific variables

Variable	Mean	Std. Dev.
TE(Intermediation) [TE(I)]	93.1%	[8.9%]
TE(Asset transformation) [TE(A)]	94.2%	[5.8%
Assets quality	4.5%	[4.1%]
Capital strength	6.9%	[7.3%]
Collateral value	2.4%	[1.15%]
Gross interest margin (GIM)	34.7%	[11.2%]
Liquidity	15.3%	[8.7%]
Profitability	0.8%	[0.79%]
Purchased funds	10.2%	[7.43%]
Operational risk	54.4%	[17.6%]
Size (ln[total assets])	10.15	[1.47]
Stock market capitalization	24.6%	[27.7%]
GDP	4.6%	[1.1%]
Inflation	10.1%	[2.3%]

Table 5.4: Correlation coefficient of variables tested[11]

Variable	TE(I)	TE(A)	Assets quality	Capital ratio	Collateral value	GIM	Liquidity	Profitability	Purchase funds	Risk	Size	Stock market capitalization	GDP growth	Inflation	Commercial banks	Privately-owned banks	Old banks
TE(A)	0.093																
Assets quality	-0.544	-0.363															
Capital ratio	0.269	-0.082	-0.330														
Collateral value	0.043	-0.307	0.012	0.483													
GIM	0.003	-0.250	0.152	0.695	0.450												
Liquidity	0.119	-0.243	-0.104	0.279	0.589	0.195											
Profitability	0.438	-0.072	-0.197	0.389	0.231	0.310	0.247										
Purchased funds	-0.027	-0.506	0.432	0.035	0.359	0.322	-0.063	0.027									
Risk	-0.068	-0.097	0.184	0.182	0.640	0.450	0.369	0.168	0.339								
Size	-0.405	-0.129	0.477	-0.565	-0.378	-0.285	-0.398	-0.059	0.037	-0.230							
Stock market capitalization	0.216	0.143	0.091	-0.210	-0.068	-0.161	0.127	0.074	-0.050	-0.029	-0.083						
GDP growth	0.040	0.023	0.006	0.039	-0.016	0.059	0.300	0.332	-0.210	-0.089	-0.030	0.089					
Inflation	0.158	0.087	0.062	-0.062	0.012	-0.207	0.361	0.279	-0.176	-0.064	-0.101	0.483	0.226				
Commercial banks	-0.230	-0.395	0.438	0.067	0.692	0.349	0.533	0.174	0.449	0.825	0.048	0.013	0.038	0.053			
Privately-owned banks	0.354	0.019	-0.539	0.395	0.549	0.294	0.455	0.229	0.095	0.613	-0.645	-0.050	-0.085	-0.104	0.336		
Old banks	-0.148	-0.087	0.339	-0.308	-0.349	-0.270	-0.208	0.093	-0.123	-0.305	0.689	0.079	0.135	0.164	-0.123	-0.631	
Political change	-0.195	-0.127	-0.089	0.170	0.028	0.216	-0.371	-0.272	0.219	0.090	0.075	-0.503	-0.490	-0.646	-0.033	0.139	-0.221

[11] This table presents Pearson correlation coefficients which are estimated using data analysis tools in Microsoft-Excel software.

Estimated correlation coefficients between explanatory variables are presented in Table 5.4. The table shows very little correlation between variables. Only the relationship between operational risk and commercial banks shows a correlation coefficient greater than 0.800. Overall, the low correlation between the variables implies that there is no risk in multicolinearity in the regression analysis (Gujarati, 2003).

Table 5.5 presents Tobit regression results. The relatively high values of the estimated Tobit R^2s (which are the counterparts of OLS R^2) indicate that both models were able to explain the influence of the variables on TE. Further, high estimated log likelihood values also confirm the models' ability to explain TE. As explained by Gujarati (2003), the violation of the normality assumption in limited dependent variable models may be quite severe. Bera, Jarque and Lee (1984) pointed out that the maximum likelihood estimation may be inconsistent under non-normality. This study applied the Jarque-Bera (JB) test of normality to examine whether distributions of residuals are normal. The JB test of normality is an asymptotic or large sample test (Gujarati, 2003). The estimated JB test statistic for the first regression model [TE(I)] is not able to provide sufficient evidence to support the assumption that residuals of the regression estimates are normally distributed. However, the recorded JB test statistic for the second model [TE(A)] shows that residuals of the regression are normally distributed.

Variables representing risk, market capitalization and commercial banks provide statistically significant evidence for both models. Estimated coefficients for profitability, product quality, liquidity and purchased funds are statistically significant only with the TE(I). Variables such as capital adequacy, privately-owned banks and old banks show significant relationships with the estimated TE(A). All other variables fail to provide sufficient evidence for the existence of statistically significant relationships under a 90% confidence level with either of the dependent variables.

Table 5.5 Tobit regression results

Explanatory variables	**TE(I)**	**TE(A)**
Assets quality	**-1.770*** [-1.82]	-0.219 [-0.50]
Capital strength	0.480 [0.57]	**0.383*** [1.72]
Collateral	-3.046 [-1.03]	-0.021 [-0.02]
GIM	-0.475 [-1.15]	-0.246 [-1.44]
Liquidity	**0.967*** [1.90]	-0.017 [-0.09]
Profitability	**6.641***** [3.00]	-0.892 [-0.75]
Purchased funds	**1.737***** [3.94]	-0.115 [-0.91]
Operational risk	**0.824**** [2.26]	**0.853***** [5.46]
Size	-0.021 [-0.63]	0.016 [1.07]
Stock market capitalization	**0.254***** [3.22]	**0.072**** [2.30]
GDP growth	-0.265 [-0.16]	0.481 [0.64]
Inflation	-1.361 [-1.47]	0.053 [0.12]
Commercial banks	**-0.577***** [-2.53]	**-0.453***** [-3.90]
Privately-owned banks	-0.070 [-0.76]	**-0.088**** [-2.06]
Old banks	0.067 [0.96]	**-0.070***** [-2.49]
Political change	-0.046 [-1.02]	-0.031 [-1.41]
Intercept	**1.339***** [3.49]	**0.909***** [5.03]
R-squared	0.75	0.62
Adjusted R-squared	0.70	0.55
Log likelihood	203.84	242.31
Avg. log likelihood	1.96	2.181
Akaike info-criterion	-3.57	-4.04
Schwarz criterion	-3.11	-3.60
Jarque-Bera	32.93	3.06

['z' values are in the parentheses. '***' indicates significant coefficients under 1% confidence level, '**' indicates significant coefficients under 5% confidence level,'*' indicates significant coefficients under 10% confidence level]

To examine the robustness of the estimated coefficients, four alternative regressions[12] have been performed omitting the non-commercial banks from the original sample and limiting the regression only for explanatory variables which record significant relationships with TE(I) and TE(A). These results are not dissimilar to the results derived from the original regressions. The remainder of this section presents and discusses the regression results related to individual explanatory variables.

5.4.2 Firm-specific variables

Assets Quality: The ratio of problem loans to total assets has been used to represent assets quality. Problem loan provision can be regarded as an indicator of the quality of loan assets. Berger and De-Young (1997) presented three hypothetical relationships between operational efficiency and problem loans, namely; bad luck hypothesis, bad management hypothesis, and skimping hypothesis[13]. Both the bad luck and bad management hypotheses predict a negative relationship between operational efficiency and problem loan provision. However, the skimping hypothesis, which relates the cost of managing loan assets with problem loans, predicts a positive relationship. This study relies on the bad management hypothesis and predicts that there is a negative association between problem loan provision and operational efficiency. The empirical findings support a significant negative relationship between TE(I) and assets quality only at the 10% confidence level. This result indicates that banks with well managed loan portfolios experience higher TE(I) than those with a need for high loss provisions. This result supports Isik and Hassan (2003). However, the estimated coefficient for assets quality in the TE(A) is not statistically significant and fails to support the hypothesised relationship.

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12 See Appendix 7.

13 The bad-luck hypothesis predicts that problem loans arise due to exogenous factors such as weather disasters that are impossible to control through managerial decisions. The bad management hypothesis predicts that bad management of loan origination and monitoring affects problem loans (Berger & De-Young 1997). The skimping hypothesis says that:

> 'a bank maximising long-run profits may rationally choose to have lower costs in the short-run bear the consequences of greater loan performance problems and possible costs of dealing with these problems in the future' (Berger & De-Young 1997, p. 853).

Capital Strength: Prior studies have considered capital adequacy as a prime requirement for the smooth operation of banking firms. Moreover, maintaining a minimum capital ratio is a major prudential regulatory requirement in the banking industry which aims to reduce gambling incentives that put bank equity at risk (Hellmann, Murdock and Stiglitz, 2000). Further, a bank's capital strength can be seen as an indicator of its ability to face risk related to insolvency. Claeys and Vennet (2003) stated that a strong capital base implies a lower default risk of the bank. Consequently, banks with healthier capital strength incur lower funding costs than banks with low capital strength. On the other hand, since capital is considered to be one of the most expensive forms of liabilities in terms of expected return, holding capital above the regulatory minimum is a credible signal of creditworthiness on the part of the bank. Thus, this study predicts a priori that the relationship between capital strength and TE will be positive.

Testing of the estimated coefficient for capital strength in the first regression fails to show a statistically significant relationship with TE(I). In the second TE(A) model, there is a statistically significant positive relationship with capital ratios (but only at the 10% confidence level) showing that managers in banks with a high capital ratio are more efficient in TE(A) than those in banks with low capital ratios. The result supports other findings—Grigorian and Manole (2002); Naceur and Goaied (2001); Darrat, Topuz and Yousef (2002); and Havrylchyk and Scharrnstrabe (2004)—which confirms that banks with a sound capital base are able to operate better than poorly capitalised banks.

Collateral (Fixed assets ratio) : Fixed assets to total assets ratio is an indicator that shows the extent of collateral which a bank can provide to its deposit holders by using its long-term assets. Generally, fixed assets include assets such as properties and freehold which carry higher collateral value. Increases in such assets reduce the funds available for funding operational activities. On the other hand, banks with a higher level of fixed assets may provide higher creditworthiness and consequently those banks may gain the confidence of deposit holders. Those investments can be regarded as an apparent insurance to deposit holders against risk of loan losses.

Therefore, the study predicts a positive relationship between fixed assets ratio and firm efficiency. However, estimated coefficients for the fixed assets ratio in both regressions are not significantly different from zero. Therefore, the results do not show that there is any relationship between collateral strength and TE.

GIM: GIM represents the ratio of net interest income (total interest income – total interest expenses) to total interest income and indicates the total value added to the interest paid on deposits and other sources of funds. The size of the interest margin may have a direct link with the operational efficiency of the firm. Technically efficient banks may reduce the margin of interest to share the efficiency benefits with their customers to gain a competitive advantage in the market. Thus, a priori, the relationship between TE and GIM is assumed to be negative. However, neither regression is able to provide evidence that the estimated coefficients are significantly different from zero. Thus, it could not be shown that GIM has a direct link with operational efficiency.

Regulatory restrictions on interest rate determination[14] may have limited banks' capacity to renew their interest rates on a competitive basis with changes in the operational environment. Consequently, the regulation may have restricted banks' ability to share the efficiency benefits with their customers. In addition, factors such as government taxes, lack of competition in the banking market and higher intermediation costs may have affected the statistically insignificant relationship between GIM and banks' efficiency.

Liquidity: Liquidity refers to the ability of credit institutions to fund increases in productive assets and meet short-term operational obligations. Further, the stochastic dimension of liquidity suggests that liquidity crises may exist under different circumstances. The unexpected utilisation of credit lines, unforeseen deposit withdrawals, untimely loan redemption and/or interest payments, liquidity need resulting from asset price developments, and failed or delayed payments by sellers

[14] As stated in Chapter Two, banks in Sri Lanka used two policy rates (Government Treasury bill rates and National Savings Banks Deposits rates) as the basis for interest rate determination. Banks are not allowed to significantly deviate from key policy rates.

of credit risk protection (ECB, 2002) are some such circumstances. To prevent liquidity crises, banks maintain a buffer of liquid assets on the asset side (Heffernan, 1996). However, provisioning a buffer of liquid assets to face shocks may reduce the amount of income-generating assets of the bank and it also may contribute negatively to firm performance. On the whole, the study predicts a negative relationship between TE and liquidity. The regression results shows a statistically significant positive relationship between TE(I) and liquidity at the 10% confidence level and reject the hypothesised relationship. This result suggests that banks with a better liquidity position are more technically efficient in the intermediation function than the banks with poor liquidity positions. Conversely, the estimated coefficient for liquidity in the TE(A) model is not statistically significant.

Profitability: In line with prior studies, this study applied return on total assets as a proxy for banks' profitability. Profitability, in general, indicates a firm's ability to earn an excess over its total expenditure. Efficiency also shows the quality of the management and demonstrates how management is effective in producing maximum outputs using a minimum level of inputs. The results of the first regression provide statistically significant evidence to support the proposition that there is a significant positive relationship between TE(I) and profitability. It shows that more profitable banks are more efficient than others. Accordingly, the result shows that performance in the intermediation process has a direct link with banks' profitability. Higher efficiency in intermediation lowers the cost of bank operations which, in turn, leads to higher profitability. Accordingly, managers in profitable banks have more incentive to efficiently perform in the intermediation process than those in the less profitable banks. The findings of the regression based on TE(I) supports the findings of Darrat, Topuz and Yousef (2002), Maghyereh (2004), and Casu and Molyneux (2003) that profitability is positively related to bank efficiency. The second regression, which tests determinants of TE(A), is not able to provide statistically significant evidence to support the association between banks' profitability and the assets allocation process.

Purchased Funds: Traditionally, banks are concerned with two main payment functions, namely, deposit mobilisation and funding loans. Banks mainly use deposits to produce their lending products. Purchased funds which are borrowed from other financial institutions and/or from individuals can be regarded as a substitute for funds generated from deposits (Heffernan, 1996). Generally, banks use purchased funds to satisfy the minimum capital requirements that are recommended by regulatory authorities (Carey, 2002). On the other hand, purchased funds can be considered as an alternative source of funds which can be used to satisfy excess demand for lending products. Since purchased funds increase the availability of loanable funds, this study has predicted a positive relationship between technical efficiency and purchased funds. The regression results provide statistically significant evidence to support the predicted positive relationship between TE(I) and purchased funds. However, the recorded relationship between TE(A) and purchased funds is not statistically significant.

Operational Risk: Operational risk can be regarded as another major variable that determines banks' operational efficiency. Prior studies in both banking and non-banking sectors have used earnings' variability as a proxy for operational risk. However, going beyond prior studies, this study applies the total loans to total assets ratio as an alternative measure to proxy operational risk. Loan to assets ratios can be considered a measure of the risk-taking nature of the banks' management. Profit-seeking banks may tend to put their funds in risky lending portfolios to capture higher interest income. Consequently, high loan to assets ratios may lead to wider interest margins and to large loan losses. Furthermore, the amount of loans granted is directly related to the loan administration costs, because loans need to be originated, serviced and monitored (Heffernan, 1996), and recovered. This leads to a reduction in the net interest margin. However, if a bank applies a mark-up pricing strategy to set its lending rates, the increased cost in maintaining a large loan level may adversely affect future lending potential. On the other hand, risk takers may prefer to find more productive investments while reducing the other overhead costs. Keeping a significant portion of funds in income generating assets may improve the

firm's operational efficiency. Hence, a positive relationship between operation risk and firm efficiency can be expected.

Both TE(I) and TE(A) have recorded statistically significant positive relationships with operational risk which are consistent with the predicted relationship. These results show that risk-taking banks have achieved comparatively higher efficiency than banks less aggressive in taking risk. It supports the findings of Darrat, Topuz and Yousef (2002) and Burki and Niazi (2003) and rejects the findings of McKillop, Glass and Ferguson (2002) and Havrylchyk and Scharrnstrabe (2004). The major implication of these results is that the banks' ability to put more funds into productive resources may improve operational efficiency. Regulatory restrictions may lead to control of banks' lending capacity and may undermine their operational efficiency.

Size: Prior studies in banking predicted a strong positive association between firm size and efficiency (Isik and Hassan, 2003). These studies used two methods for controlling the size effect in regression analysis, namely, clustering banks based on different size groups (large banks, small banks, and medium sized banks) (Isik and Hassan, 2003), and introducing a proxy to represent firm size such as total turnover and total assets (Darrat, Topuz and Yousef, 2002). This study used total assets (converted into natural logs) of individual banks to represent their size. The estimated coefficients for total assets in both models are not statistically significant. Thus, the study does not provide evidence for a relationship between TE and size.

5.4.3 Macroeconomic variables

Country-specific microeconomic variables are included to capture the impact of the external environment on banking operations. In order to control country-specific macroeconomic conditions, the growth in stock market capitalisation (to identify competitive threats made by other capital market participants), inflation (to account for changes in price level) and GDP growth rate (to capture the influence of general economic growth) are included in the regression model. However, only the growth

in stock market capitalisation shows a statistically significant relationship with estimated efficiency scores.

Changes in stock market capitalisation may influence banks' efficiency in three ways. First, savers may withdraw their deposit investments and may invest their savings in the stock market, thereby reducing the funds available for investments. Second, investors in the market may tend to use borrowings from banks for their investments and make profits from improved markets. Third, banks themselves may capitalise on profit-making opportunities in the stock market by investing their excess cash in active portfolios. The result indicates that the adverse effect of the withdrawal of deposits in favour of the stock market is over-shadowed by the lending opportunities arising from the same developments. Consequently, improvements in capital markets on one side assist banks to smooth the intermediation function and give more opportunities to diversify their investments. Further, the short-term investment opportunities arising in the stock market assist banks in keeping temporary cash surpluses in active portfolios. Ultimately, extra income generated from investments, as well as new lending opportunities, may have enhanced banks' efficiency. These results reject Grigorian and Manole's (2002) argument that developments in security markets and non-bank financial institutions have reduced the performance of banks, and confirm Fat and Hua's (1998) findings that stock market performance is closely related to bank efficiency. These findings indicate that the expansion of stock market activities is not hindering but, rather, widening the profit-making opportunities of banking firms.

5.4.4 Qualitative variables

The influence of four qualitative characteristics—namely, the line of business (commercial), ownership form (privately-owned), experiences (old) and political change—is tested. The regression results relating to qualitative characteristics are detailed below.

Commercial banks: Estimated coefficients for the dummy variable, which represents the line of business, produce statistically significant negative relationships in both regressions. These results indicate that the commercial banking sector is less

efficient than the savings banking sector. Until the late 1990s, the savings banking sector was dominated by state-owned banks. The Sri Lankan government has used the state-owned savings bank (NSB) to promote national savings, offering various incentives such as income tax and wealth tax relief. NSB offered its banking services island-wide through post offices, providing greater access to depositors. On the other hand, commercial banks have established their bank branches mostly in urban areas in the country. Further, the savings banks are permitted to provide a limited range of products which basically covers accepting customer deposits and granting loans products. Conversely, commercial banks have offered more freedom with various deposit and lending products. The results of the study found statistically significant evidence that the commercial banks were less efficient than the savings banks in both in TE(I) and TE(A). The main reasons for reporting higher efficiency by savings banks may be the easy access to savings banks and the public confidence created by high government intervention in the sector.

Privately-owned banks: Privately-owned and state-owned firms are operated with different objectives that are closely aligned between the types of ownership. The impact of private ownership of banks is tested ignoring the functional orientation (either savings or commercial) of those banks. Theories[15] such as public interest theory, private interest theory (Kroszner and Strahan, 1999), and the development view and political view (La-Porta, Lopez-de-Silanes and Shleifer, 2002) have predicted that state ownership of firms has unfavourably affected their performance. La-Porta, Lopez-de-Silanes and Shleifer (2002) pointed out that the direct involvement of the state sector in economic activities, not only in the banking industry but also in any other industry, might undermine the performance and growth of that industry. Accordingly, those theories pointed out that the non-transferable and widely dispersed ownership structure of public firms reduces the incentive of state-ownership to monitor the performance of management. Conversely, private ownerships provide incentives to enhance the firms' efficiency

[15] See Chapter 2 Section 2.

and, thereby, to maximise the firms' wealth. To investigate this issue, this study predicts that privately-owned banks are more efficient than the state-owned banks.

The study does not provide evidence for a statistically significant relationship between TE(I) and privately-owned banks. However, the testing of the estimated coefficient in the second model shows a statistically significant negative relationship between TE(A) and privately-owned banks. This result rejects the predicted relationship that the privately-owned banks (commercial and savings) are more efficient than the state banks (commercial and savings). These findings confirm findings of Isik and Hassan (2003) in Turkey and Sathye (2000) in India. Havrylchyk and Scharrnstra (2004) suggested interpreting the coefficient of state banks with caution and argued that the data used for the estimation of efficiency in state banks may be distorted by non-compliance with accounting regulations. This argument may not be valid to banks in Sri Lanka, since it is mandatary for all banks to apply the Sri Lankan Accounting Standard—regardless of ownership.

The input and output specification used in the assessment of TE(A) included loans, advances and other earning assets as outputs. Other earning assets include the investments made in government securities. The investments in government securities are allowed to be deducted from deposits which are required to be maintained in the CBSL as the statutory reserve requirement (SRR). Deposits maintained in the CBSL as the SRR are not considered as income generating assets and not included as liquid assets. Since state-owned banks have invested a considerable portion of their total assets in government securities, they need to maintain a smaller proportion of assets in the CBSL as SRR relative to the privately-owned banks. Thus, the recorded relationship may have been influenced by the regulation relating to the SRR.

Old banks: Previous studies have predicted that relatively greater experience in the market helps the old banks to perform better than the new banks which have relatively little experience (Isik and Hassan, 2003). Mester (1996) highlighted that new banks incur relatively higher start-up costs required to build customer

confidence, which increases their operational cost. Therefore, this study predicts that old banks are more efficient than new banks. The estimated coefficient for old banks in TE(I) is not statistically significant. However, TE(A) provides statistically significant evidence that the old banks are less efficient than the new banks in the asset transformation process rejecting the predicted relationship. The main reason for the recorded superior performance by the new banks may be the new technologies which those banks use.

Political change: During the study period, two main political parties ruled the country. These two parties had different views in relation to the open economy. The party that ruled from 1977 to 1994 believed solely in market forces and had little reliance on government intervention. They encouraged privatisation as a means of reducing government intervention in the market. The second party that came to power in 1994 has put less reliance on privatisation. A dummy variable was introduced to the regression model to identify the impact of political transition and the changed view on banks' efficiency. However, the variable does not provide evidence for a statistically significant relationship.

5.5 Conclusion

The objective of this chapter was to investigate the determinants of efficiency of local banks in Sri Lanka. Following previous studies, this chapter used a truncated normal Tobit regression model for identifying the factors and significance of their influence. A set of macroeconomic and microeconomic variables and three dummy variables have been introduced to the regression models as potential explanatory variables of technical efficiency of banks in Sri Lanka. Two technical efficiency indices based on the intermediation approach and the assets approach were used as dependent variables.

While the two models gave relatively high Tobit R^2 values, only a few variables included in the models were able to produce statistically significant coefficients. Only three variables—operational risk, line of business and stock market capitalisation—have statistically significant coefficients in both regressions. In

addition, none of the variables was estimated with the predicted sign. The variable representing commercial banks was predicted to be positive, but was estimated as negative. The other two variables were a priori thought to be negative, but were estimated as positive coefficients.

Variables representing profitability, liquidity and purchased funds are statistically significant in the TE(I) model and have positive relationships. The assets quality shows a negative relationship with TE(I). With the exception of liquidity, directions of the estimated relationships of all other variables are consistent with the a priori hypotheses. In the TE(A) model, the additional statistically significant variables are capital strength, privately-owned banks and old banks. Even though privately-owned banks recorded higher average efficiency in all measures, investigation of determinants revealed that those banks were less efficient in asset transformation than the state-owned banks. The influence of variables such as capital strength, risk and size are in the direction hypothesised, but the estimated coefficients of the other variables show inverse relationships to the hypothesised. Overall, these results suggest that the determinants of efficiency in different functions in banking, such as intermediation and asset transformation, are dissimilar and influences on determinants vary for different functions.

This chapter presented the findings of the Tobit regression analysis on factors affecting the estimated technical efficiency of banks in Sri Lanka. It has highlighted the macroeconomic and microeconomic factors that have affected the technical efficiency of the banking industry. The next chapter investigates how these efficiency scores have influenced the operational performance of banks in Sri Lanka.

CHAPTER SIX

MARKET STRUCTURE, EFFICIENCY AND PERFORMANCE

6.1 Introduction

The deregulation of the financial services sector, development in management information systems (MIS) supported by information and communication technology (ICT), and globalisation have changed the structure, size and scope of the banking industry in Sri Lanka. The emergence of new banks (both local and foreign), the expansion of branch networks, the integration of business services and the expansion of the activities of other forms of financial services institutions have changed the market structure of the banking industry. Such changes in the banking industry may have impacted on both the degree of competition and the operational efficiency of banks.

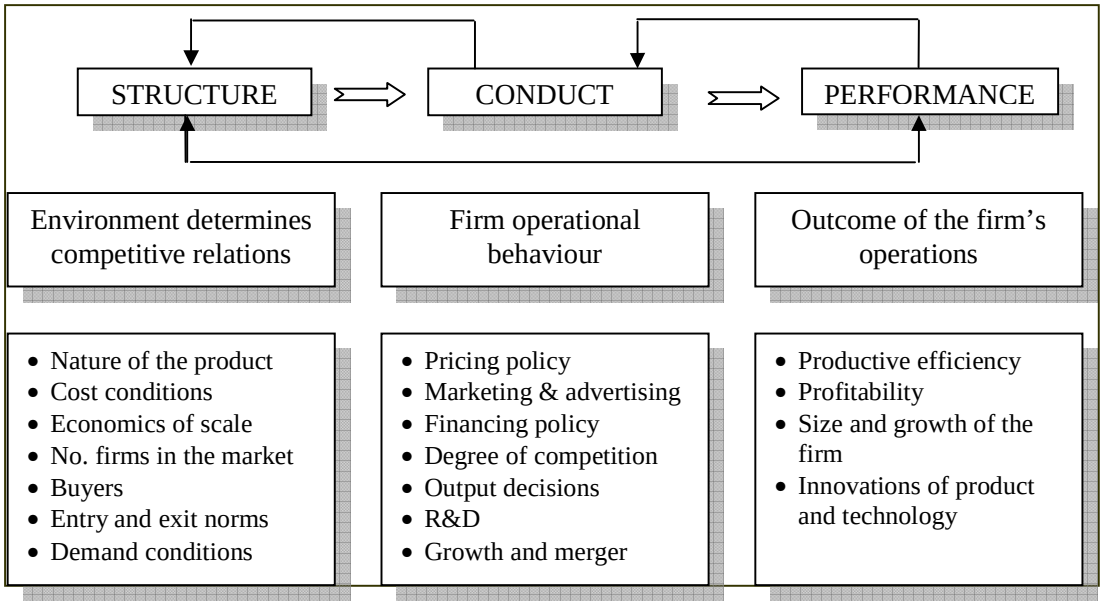
Research on banking and financial institutions has identified three strategies that may help to create healthy competition in a larger and more liberal market (Lloyd-Williams, Molyneux and Thornton, 1994). The first strategy is to encourage mergers among banks to increase bank size in order to pursue economies of scale. Accordingly, three factors may stimulate mergers: (1) creating large banks with market dominance; (2) deterring potential hostile acquisitions and takeovers; and (3) making the banking market more efficient. The second strategy involves sharing common resources/facilities such as ATMs and branch networks with other banks in the industry. The third strategy seeks to enhance the productivity and

efficiency of institutions in the industry. The strategy that is most appropriate to the banking industry is an empirical question that requires the attention of policy makers. Thus, Proposition III suggests that "improvements in efficiency have influenced the banks' operational performance than changes in the structure of the market". This chapter empirically investigates Proposition III to determine the appropriateness of the strategies described above for the banking industry in Sri Lanka, using the framework developed by Berger and Hannan (1993).

This chapter consists of five sections, commencing with this introduction. The next section presents a brief review of literature related to market structure and bank efficiency, with particular reference to the banking industry. The third details the empirical framework used in this chapter. The penultimate section presents the outcomes and implications of the analysis. The final chapter presents the conclusions of the analysis.

6.2 Market Behaviour

In the literature, both structural and non-structural approaches have been used to investigate the behaviour of the banking industry. Structural approaches are mainly based on traditional industrial organisation theory, which focuses on the efficient structure (EFS) hypothesis and the SCP hypothesis (Figure 6.1 illustrates basic elements of the theory behind structural approaches). Research based on structural approaches assumes that market concentration weakens market competition by fostering collusive behaviour among firms. Conversely, non-structural approaches assume that factors other than market structure and concentration may affect competitive behaviour, such as barriers to entry/exit and the general contestability of the market (Panzar and Rosse, 1987; Rosse and Panzar, 1977). Non-structural approaches have been developed in the context of the new empirical industrial organisation (NEIO) literature.



[An extension of Worthington, Briton & Rees (2004, p. 211)]

Figure 6. 1. The structure-conduct-performance theory

6.2.1 EFS hypothesis vs SCP hypothesis

The EFS hypothesis states that the aggressive behaviour of efficient firms in the market leads to an increase in those firms' size and market share. This behaviour allows efficient firms to concentrate on earning higher profits while further enhancing their market shares. Those firms can maximise profits either by maintaining the present level of price and firm size, or by reducing price and expanding the firm size (Lloyd-Williams, Molyneux and Thornton, 1994). Berger and Hannan (1989) stated that firms in markets with a large dispersion of efficiency within the market create an unequal market share and a high level of concentration. Accordingly, the EFS hypothesis states that the positive relationship between profit and concentration results in lower cost achieved through superior operational management and an efficient production process (Goldberg and Rai, 1996). Thus, proponents of the EFS hypothesis argue that differences in efficiencies among DMUs within markets create high levels of concentration. The high concentration ratio in the market creates greater than average efficiency in these markets, yielding a positive profit concentration relationship (Berger and Hannan, 1989).

As mentioned previously, deregulation and MIS, including ICT and globalisation, have changed the nature of competition in the banking industry. The improved level of competition has forced banks to be more efficient. As explained in the EFS hypothesis, there is no need to encourage mergers in the banking industry, since efficient banks can improve their market share by providing more cost-effective banking services and weak banks will either exit the industry or face an acquisition or merger. Therefore, the EFS hypothesis suggests that public policy makers should focus on the identification and implementation of strategies leading to enhancing productivity and efficiency.

On the other hand, the SCP hypothesis simply states that the more a bank grows, the more efficient it becomes. The SCP hypothesis propounds that concentration is a source of greater profitability, rather than the consequence of more efficient firms increasing their share of the market (Berger et al., 2004). According to the SCP hypothesis, market concentration fosters collusion among large firms in the industry, which subsequently leads to higher profits. Hence, the SCP hypothesis suggests that changes in market concentration may have a positive influence on a firm's financial performance (Goldberg and Rai, 1996). Furthermore, the SCP hypothesis recognises the consequent positive relationship between market concentration and performance as a result of the anti-competitive behaviour of firms with a large market share (Berger and Hannan, 1989).

The Relative Market Power (RMP) hypothesis, which is a special case of the SCP hypothesis, proposes that only firms with large market shares and a range of differentiated product lines are able to exercise market power to gain superior profits over non-competitive price-setting behaviour (Berger, 1995). The basic argument underlined by the SCP hypothesis supports the collusive power of the market and encourages the strategies that enhance market concentration. Consequently, if SCP holds in the banking industry, such strategies can be promoted.

The EFS and SCP hypotheses diverge on the basis that the causality of market concentration and performance is viewed differently. According to the SCP

hypothesis, market concentration is exogenous; however, according to the EFS hypothesis, it is endogenous and dependent on bank efficiency. This means that each hypothesis provides a contrasting view for policy makers. According to the SCP hypothesis, anti-trust legislation would be socially beneficial. However, if the EFS predominates, such policies that penalize or impair mergers would be socially costly.

As explained by Berger and Hannan (1989), the EFS and SCP hypotheses offer similar observations about the relationship between concentration and performance (profitability). The difference between these two theories mainly centres on ways of interpreting the relationship. Some studies have challenged the acceptability of the positive relationship predicted between market concentration and profitability of SCP. Smirlock (1985) pointed out that there is no relationship between concentration and profitability, but between profitability and market share. He found strong evidence to support the relationship between market shares (which were used as proxies for firms' efficiency) and profitability, and showed that market concentration is not a sign of collusive behaviour but the superior efficiency of leading firms.

Berger and Hannan (1994) pointed out four sources of anti-competitive behaviour that may have arisen as a consequence of high market concentration, namely:

1. A dominant firm in a market, able to set the prices in excess of competitive levels, may have lower pressure on managers to maintain operating costs at or near their competitive level;
2. Managers' self-interested behaviour may lead to riskier financing decisions (which may be detrimental to the shareholders' expectations) to reduce variation in earnings to protect their positions;
3. Increase in the political cost associated with obtaining and maintaining existing market power; and
4. The retention of inefficient managers or the maintenance of inefficient practices that allow managers to live a 'quiet life' to pursue other objectives or maintain market power gains.

Berger & Hannan's (1994) study has presented an alternative to the EFS and SCP, called the 'quiet life' hypothesis. It assumes that the managers of firms with relatively large market shares may not attempt to improve the efficiency of the use of resources since they can make adequate profits using their price-setting power (Punt and Rooij, 1999). This hypothesis predicts that large firms in the market use their market power to be 'quiet' in the market and earn profits without improving efficiency.

Early EFS studies used market shares as a proxy for a firm's efficiency instead of direct efficiency measures (Molyneux and Forbes, 1995). However, the firm's market share did not represent the overall productivity and efficiency level of the firm. The first application of direct efficiency measures by Berger and Hannan (1995) captured the impact of all factors affecting a firm's performance.

6.2.2 Measures of market concentration

Variables such as the buyer and seller cost relationship, the degree of product differentiation, market concentration, market share and entry conditions have been used in previous studies to represent market structure (Ashton, 1999). However, the majority of SCP studies have used a concentration ratio to represent market structure. Previous empirical analyses have applied two methods for estimating market concentration:

1. **'k' bank concentration ratio (CR_k);** CR_k takes the total market share of the k^{th} largest bank in the market ('k' denotes the number of banks considered in measuring the concentration ratio). Accordingly, this ratio ignores relatively small banks in the market and uses only a select number of firms in that market (Bikker and Haaf, 2002). CR_k indicates the percentage of a market or an industry accounted for by dominating firms only (Worthington, Briton and Rees, 2004). This ratio can be estimated in different ways, such as the percentage of employment, percentage of production and percentage of sales.

1. **Herfindahl-Hirshman Index (HHI)[1];** HHI defines concentration as aggregates of weighted market shares of individual firms in the market, and stresses the importance of larger banks by assigning them a greater weight than smaller banks. It counts all banks and weights them according to their market share and thereby avoids an arbitrary cut-off level (Bikker and Haaf, 2002).

The literature identifies two major criticisms of the use of concentration ratios to proxy market structure (Hannan, 1997). First, the concentration ratio is dependent on the size and number of firms in the market. Second, it ignores the influence of non-bank financial institutions in the context of banking concentration. Nevertheless, concentration indices such as HHI use weighted averages of market shares, which account for both the size distribution and the number of banks. Therefore, this ratio has often been used as a simple proxy of the market structure in previous research.

6.2.3 Previous applications

The theoretical basis of market structure and performance emerged more than 50 years ago. However, most of the empirical studies that used this theory were limited to a few developed countries in North America and Europe. Gilbert (1984) summarised 44 such studies, which were based on the US banking industry. Whilst they are important for understanding the theory behind the market structure, they have less empirical validity in relation to developing countries because there are significant differences between the banking industries in developing countries and in developed countries.

Previous empirical studies have used either price information (Berger and Hannan, 1989) or profitability information to proxy firm performance (Molyneux and Forbes, 1995). In a multi-product environment, the use of a single measure of price to

[1] $HHI = \sum_{i=1}^{N} \left(\frac{v_i}{V} \right)^2$, N = number of firms, v_i = market share of ith firm, V =total market share

represent a firm's overall performance is not appropriate in the context of banking. Conversely, profitability measures can be introduced as a comprehensive performance indicator since they integrate both cost and revenue into one measure. In some studies, increased market concentration was found to be associated with higher prices and greater than usual profits. Smirlock (1985) found that higher profits in concentrated markets could be the result of greater operational efficiency. Berger (1995) found some evidence that the efficiency hypothesis holds true in US banking.

A positive relationship between bank concentration and return on equity (ROE) was found by Short (1979) in a study based on a sample of banks from Canada, Western Europe and Japan. Moore (1998) examined the impact of advanced communication technology on the ability of banks to serve distant customers. Advanced technology helped bank managers to serve distant customers using alternative banking methods such as tele-banking and Internet banking. Moore examined the changes in the relationship between the concentration ratio and profitability using both univariate and multivariate regressions, and found that even though the technology had changed, bank concentration had positively affected performance. Molyneux and Forbes (1995) found evidence to support the traditional SCP in European banking. Lloyd-Williams, Molyneux and Thornton (1994) examined the applicability of the SCP and efficient market paradigm to analyse the Spanish banking structure using the concentration ratio and market share of an individual firm to represent its efficiency. The result indicated a positive relation between the concentration and the return on assets (ROA) which was used to proxy for performance, thus supporting the applicability of the SCP hypothesis to the Spanish banking industry.

Several empirical studies have employed different methodologies to test the SPC hypotheses. Thus, differences in variables used and hypotheses tested have made comparisons difficult. Berger and Hannan's (1993) research framework provided a comprehensive methodology for testing potential relationships between market structure and performance under both SCP and efficient market hypotheses. They proposed to test four hypotheses, namely, the traditional SCP hypothesis, the RMP

hypothesis, the X-efficiency (technical efficiency) hypothesis and the scale efficiency hypothesis to investigate whether market concentration affects performance or efficiency affects market concentration.

Berger and Hannan's framework investigated the hypothesis that best explains a particular market environment. Using the Berger and Hannan approach, Goldberg and Rai (1996) examined the structure-performance relationship of banks in European countries. Their study did not find a significant positive relationship between concentration and profitability. However, there was evidence in favour of the RMP hypothesis for all banks located in countries that have highly concentrated banking industries. Using a similar approach, Fu and Heffernan (2005) examined the market structure of the Chinese banking market. Their results found evidence supporting the RMP hypothesis. Even though Fu and Heffernan found a positive significant coefficient for efficiency variables, they did not find a positive relationship between market share and efficiency, which was one of the necessary conditions for the hypothesis.

The SCP framework has been widely used in the literature on industrial organisation in examining market structures. However, it does not account for other factors that influence firms' profitability and concentration. Further, SCP studies ignore the long-run equilibrium in the market. Therefore, the evidence from market concentration studies may be insufficient to support firm conclusions about the relationship between market behaviour and competition.

6.3 Methodology

To empirically investigate Proposition III, this study uses a framework similar to the empirical framework proposed by Berger and Hannan (1993). Accordingly, four hypotheses are identified for testing the validity of their applications in a developing country such as Sri Lanka.

H1: **SCP:** The dominant firms with collusive power have the ability to influence the price-setting process in the market, which allows them to gain superior

profit over the other firms. The SCP predicts a positive relationship between market concentration and firm performance. This hypothesis uses a concentration ratio to proxy the collusive market power of dominating firms.

H2: **RMP:** Firms with relatively bigger market shares and differentiated product lines have a superior market power and use it to set market prices and thereby earn an above-average profit. Therefore, market share and firm performance may have a positive relationship.

H3: **Technical efficiency (TE):** Technically efficient firms with superior management and/or business processes are able to operate at a lower cost and subsequently gain a high profit and market share. The high technical efficiency allows respective firms to achieve a higher market share at the expense of less efficient firms. Therefore, profitability is expected to have a positive relationship with variables such as technical efficiency, market share and concentration.

H4: **Scale efficiency (SE):** The differences in performance among firms are not due to variations in management styles and business processes but because of the difference in levels of economies of scale. Thus, SE predicts that firms that are operating under an optimum scale produce goods and services at relatively lower cost and are able to make a high profit, which leads to a high market share.

The SCP and RMP hypotheses test the influence of two market structure variables on firms' performance. In particular, the SCP hypothesis examines how collusive behaviour affects firm performance. The RMP hypothesis examines how individual firms' market power affects their performance. To accept either of these hypotheses, the estimated coefficient for respective variables (concentration and market power) should be positive and significantly different from zero.

The TE and SE hypotheses examine the validity of the efficient-structure paradigm. The proponents of the EFS hypothesis argue that both superior performance and high market share result in the operational efficiency of individual decision-making units in the market. Accordingly, efficiency variables are incorporated as

independent variables to the revenue equations. Consequently, these hypotheses predict that the influence of market structure on firm performance is not significant and is economically meaningless.

6.3.1 Empirical model

The following reduced-form profit equation has been employed to determine which of the stated hypotheses best explains firm performance. Coefficients for the unknown variables are estimated using the ordinary least-square (OLS) regression using EViews version 5.1.

$$p_i = \alpha + \beta_{con} CONC + \beta_{ms} MS + \beta_{EFF} TE + \beta_{SEFF} SE + \sum_{i=1}^{n} \lambda_i Z_i + \varepsilon_i^7 \qquad \text{Equation 6.1}$$

where; p_i is the measure of performance (profitability/net interest margin) of the i^{th} bank, β is the estimated coefficient for concentration, market share, technical efficiency and scale efficiency, *TE* is technical efficiency, *SE* is scale efficiency, Z_i is a vector representing the control variables, λ is an estimated coefficient for control variables, *MS* is the market share of the i^{th} bank, $CONC_i$ is the concentration of the market, which is measured using HHI and ε is the random error.

If the SCP hypothesis holds, the expected coefficient of Equation 6.1 for variables representing 'concentration' should be positive and statistically significant. If the RMP hypothesis holds, the variable representing 'market share' should have a statistically significant positive coefficient. If either of these hypotheses holds, other control variables, including efficiency variables, may have a significant effect on profitability.

In contrast, if the EFS holds, the following observations are expected:.

TE>0, SE>0, CON=0 and MS=0

Since efficient firms are expecting to have a relatively low cost advantage, leading to higher profit, a statistically significant positive relationship between firm

performance and efficiency is expected. A necessary condition to hold the EFS hypothesis is that there should be a positive relationship between efficiency and market structure. Hence, the following models are specified (these two equations use the same variables as in Equation 6.1).

$$MS_i = \alpha + \beta_{EFF} TE + \beta_{SEFF} SE + \sum_{i=1}^{n} \lambda_i Z_i + \varepsilon_i^2 \qquad \text{Equation 6.2}$$

$$CON_i = \alpha + \beta_{EFF} TE + \beta_{SEFF} SE + \sum_{i=1}^{n} \lambda_i Z_i + \varepsilon_i^3 \qquad \text{Equation 6.3}$$

If the above models are able to generate statistically positive coefficients for TE and SE variables, a sufficient condition for the relationship between the efficiency and the market structure is met.

6.3.2 Selection of variables

Different measures of performance have been used in the previous empirical literature. For instance, both profitability indicators and price indicators have been applied to proxy bank performance (Gilbert, 1984). Following Goldberg and Rai (1996), Smirlock (1985) and Yu and Neus (2005), this study uses profitability and net interest margin (NIM) as proxies for banks' performance.

Previous studies have mainly used two measures, namely return on assets (i.e. the ROA) (Goldberg and Rai, 1996; Yu and Neus, 2005) and the return on equity (i.e. the ROE) (Smirlock, 1985; Yu and Neus, 2005) to represent the profitability of banks. In principle, ROA reflects the ability of a bank's management to generate profits from assets, although it may be biased due to off balance sheet transactions. ROE indicates the return to shareholders on their equity and equals ROA times the total assets to equity ratio or the equity multiplier, which measures financial leverage. Banks with lower leverage (higher equity) report higher ROA, but lower ROE. Since an analysis of ROE disregards the greater risks associated with high financial leverage often determined by regulation, ROA emerges as the key ratio for

the evaluation of bank profitability (Sundararajan et al., 2002). Thus, this study applies ROA as an appropriate measure of banks' profitability.

This study also uses NIM as a proxy for banks' performance. NIM also can be regarded as a direct measure of performance that shows the residual interest income generated on efficient management decision making (Goldberg & Rai 1996). The NIM was estimated by dividing the net interest income (the difference between total interest income and interest expenses) by total assets.

Equations 6.1, 6.2 and 6.3 incorporate three sets of explanatory variables. The first set constitutes proxies for market concentration and market power, which are used to examine the influence of market structure on banks' performance. The second set is used to represent efficiency variables and the third set of variables is specified to control the influence of variables other than market structure and efficiency.

Banks are regarded as multi-product firms that use multiple inputs. As stated in Chapter Three, the literature provides no consensus as to which input generates which outputs. Consequently, finding a single variable to represent the banking market is a difficult task. Total deposits held (Goldberg and Rai, 1996; Smirlock, 1985), total loans granted and total assets held are some of the variables that can be used as proxies for market capacity. This study identifies total assets held by all banks in the industry to represent the size of the banking market. This is appropriate given that the total assets represent the combined outcome of all banking activities and off balance sheet transactions which are still evolving in the banking sector in Sri Lanka. Accordingly, this study uses percentages of the total assets held by individual banks to measure market power and aggregates of weighted market shares of individual banks in the market (HHI) to measure market concentration.

Following Berger and Hannan (1993), this study applies direct efficiency measures, which are estimated in Chapter Four, to proxy TE (X-efficiency) and SE. The study measures the efficiency of Sri Lankan banks, focusing on two major functions of banks, namely, the intermediation function and asset transformation function. Since

the intermediation function is more closely related to the market of the banking industry, this analysis is limited to the intermediation role. Therefore, the estimated technical and scale efficiency scores based on input and output variables with the intermediation approach are used to proxy TE and SE in the analysis in this chapter.

In addition to the variables described above, a set of variables is included to capture the impact of firm-specific and macroeconomic variables on banks' profit. Capital strength has been incorporated to represent a bank's capacity for diversification. Since a high capital ratio increases a bank's credit-worthiness, it may provide more strength to the bank's management to diversify its assets portfolio. Thus, the study predicts a positive relationship with the bank's performance. Since investment in liquid assets reduces banks' productive assets, a negative relationship between the liquidity ratio and performance is expected. To control the risk-taking behaviour of profit-seeking banks, the loan to total assets ratio is included. Since a high loan to assets ratio acts to increase the cost of monitoring and other loans administration costs, a negative relationship between performance and loans to assets ratio is expected. The product quality variable (which measures the extent of the effect of problem loans on the total loan portfolio) is included for controlling the impact of well-managed loan portfolios. The ownership structure of banks may also limit the decision-making capabilities of banking institutions, especially in state-owned banks (Goldberg and Rai, 1996; Molyneux, 1999). Most previous studies have shown that privately owned banks have relatively more freedom to set firms' operational policies and procedures and have expected a positive relationship with banks' operational performance. Further, two variables, commercial banks and old banks, are included to control the influence of the major business focus and the relative experience in the market. GDP growth and inflation have been incorporated as macroeconomic variables. Since GDP growth and inflation affect numerous factors related to the demand and supply of deposit and loan products, this study predicts positive relationships with the ROA and NIM.

6.3.3 Data

The third phase of the study relied on two sources of data, as in the case of the second phase. Information regarding all variables, except firm efficiency, was gathered from an unbalanced panel data set spread over a sixteen-year cross-sectional time period from published financial statements of local commercial banks. Three-year moving averages of all data related to variables are estimated to be in line with the estimated efficiency scores with the three-year moving windows used previously.

6.4 Results and Discussion

Tables 6.1 and 6.2 summarise the descriptive data and Pearson correlation coefficients of test data, respectively. The standard deviation shows the small statistical dispersion in data used for estimating equations. This confirmed that there are no outliers that may affect the estimation of coefficients using OLS. Further, the estimated correlation coefficients showed very little correlation among variables included in the model, except in three cases: SE(I) and TE(I); ownership and market power; and operational risk and commercial banks. As explained by Gujarati (2003), in a regression that has high R^2 values with individually significant regression coefficients for the explanatory variables, such relationships may not pose any serious multicolinearity problems. However, the study has performed two alternative regressions to test the robustness of original regression results. Since the outcome of the alternative regression related to NIM is not different from the original results, that result is recorded as an appendix. Additionally, since original regression results based on ROA differ from complementary regression results, these results are presented in Table 6.3 with other results.

Table 6.1 Variables and their definitions

Variable	Definition	Mean
Profitability (ROA)	Return on total assets (ROA)	0.008 [0.008]
NIM	Net interest margin to total assets	0.037 [0.011]
Market power (MP)	Total assets share in the market	0.112 [0.104]
Concentration ratio (HHI)	HHI (Total assets)	0.202 [0.030]
SE(I)	BCC DEA estimated scores in first phase	0.945 [0.079]
TE(I)	CCR DEA estimated scores in first phase	0.931 [0.090]
Risk	Loan and advances to total assets	0.544 [0.176]
Capital strength	Total equity capital to total assets	0.069 [0.073]
Assets quality	Total problem loan provision to total loan portfolio	0.045 [0.041]
Liquidity	Total liquid assets to total assets	0.544 [0.176]
Inflation	Change in Colombo consumer price index	0.101 [0.023]
GDP growth	National accounts	0.046 [0.011]
Privately-owned banks	Dummy; equals 1, if the bank is a privately-owned bank	
Old banks	Dummy; equals 1, if the bank is incorporated and commenced business before 1977	
Commercial banks	Dummy; equals 1, if the bank is a commercial bank	

[Standard deviations are within parentheses]

.

Table 6.2: Pearson correlation coefficient

	NIM	**ROA**	**MP**	**HHI**	**SE(I)**	**TE(I)**	**Risk**	**Capital strength**	**Assets quality**	**Liquidity**	**Inflation**	**GDP Growth**	**Private**	**Old**
ROA	-0.081													
MP	-0.137	-0.060												
HHI	0.005	0.274	0.234											
SE(I)	-0.067	0.356	-0.468	0.112										
TE(I)	-0.132	0.438	-0.383	0.161	0.972									
Risk	0.311	0.168	-0.351	-0.077	-0.036	-0.068								
Capital strength	-0.102	0.389	-0.417	-0.065	0.267	0.269	0.182							
Assets quality	0.146	-0.197	0.690	0.051	-0.550	-0.544	0.184	-0.330						
Liquidity	0.291	0.247	-0.344	0.465	0.145	0.119	0.369	0.279	-0.104					
Inflation	-0.077	0.279	0.158	0.639	0.129	0.158	-0.064	-0.062	0.062	0.361				
GDPG	-0.029	0.332	0.131	0.574	0.020	0.040	-0.089	0.039	0.006	0.300	0.226			
Privately-owned	0.140	0.229	-0.884	-0.153	0.413	0.354	0.613	0.395	-0.539	0.455	-0.104	-0.085		
Old	-0.233	0.093	0.712	0.251	-0.244	-0.148	-0.305	-0.308	0.339	-0.208	0.164	0.135	-0.631	
Commercial	0.447	0.174	-0.039	0.063	-0.195	-0.230	0.825	0.067	0.438	0.533	0.053	0.038	0.336	-0.123

Table 6.3 presents the regression results related to Equations 6.1, 6.2 and 6.3. Four separate OLS regressions are performed on Equation 6.1 by incorporating ROA and NIM as dependent variables. All equations seemed consistent with *a priori* expectations and fit the panel data set reasonably well. All the regressions show reasonable 'adjusted R^2' values and significant 'F' statistics. With the exception of the equation with ROA as the dependent variable, the normality test performed using the Jarque-Berra test is not able to provide satisfactory evidence to support the claim that residuals are normally distributed.

The second column of Table 6.3 presents the regression results based on ROA. The variable representing market power (MP) shows a positive relationship with ROA and a negative relationship with NIM, but recorded relationships in both regressions are not statistically significant. Similarly, the concentration variable (HHI) also indicates an opposing relationship with no apparent significance. These findings reject the SCP and the RMP hypotheses in relation to the Sri Lankan banking industry. Accordingly, this result indicates that the collusive power of large banks and high market power enjoyed by individual banks have not improved the operational performance of the banks.

Further, the estimated coefficient for TE(I) shows a statistically significant positive relationship with ROA, supporting the EFS, which predicts that the more technically efficient firms are able to maintain superior operational performance than the less technically efficient banks. However, the variable SE has showed a statistically significant inverse relationship with the ROA, suggesting that the scale of operation is not a pre-condition for superior profit.

The estimated coefficients for Equation 6.1, which is based on NIM, are not able to provide evidence to support either the SCP hypothesis or the EFS hypothesis. Furthermore, the recorded statistically significant negative relationship between NIM and MP is not in line with the predicted relationship. Thus, the RMP hypothesis is rejected.

Table 6.3: Regression results

Explanatory variables	ROA (Equation 6.1)	NIM (Equation 6.1)	Market power (Equation 6.2)	Concentration (Equation 6.3)	ROA1[2] (Equation 6.1)	ROA2[3] (Equation 6.1)
MP	0.025 [1.45]	-0.082*** [-2.70]			0.031** [2.27]	0.043*** [3.29]
HHI	-0.031 [-0.91]	0.077 [1.26]			-0.072** [-2.15]	-0.069** [-2.01]
SE(I)	-0.099*** [-3.06]	0.024 [0.42]	-0.845*** [-5.05]	-0.080 [-0.96]	-0.080** [-2.47]	
TE(I)	0.116*** [4.04]	-0.019 [-0.37]	0.751*** [5.07]	0.112 [1.52]	0.103*** [3.58]	0.034*** [4.76]
Risk	-0.008 [-1.01]	-0.013 [-0.87]	-0.130*** [-2.99]	0.063*** [2.89]	0.018*** [4.30]	0.020*** [4.91]
Capital strength	0.035*** [4.59]	-0.033** [-2.40]	-0.040 [-0.95]	-0.043** [-2.03]	0.031*** [4.00]	0.034*** [4.33]
Assets quality	-0.041* [-1.56]	-0.043 [-0.91]	0.511*** [3.62]	-0.056 [-0.80]	-0.056** [-2.18]	-0.075*** [-3.00]
Liquidity	-0.024** [-2.02]	-0.001 [-0.07]	-0.219*** [-3.99]	0.150*** [5.48]	0.004 [0.52]	0.004 [0.47]
Inflation	0.089*** [3.15]	-0.149 [-1.51]	0.288** [2.02]	0.398*** [5.62]	0.086*** [2.91]	0.085*** [2.82]
GDPG	0.223*** [4.04]	-0.055 [-1.09]	0.553** [2.03]	0.847*** [6.27]	0.241*** [4.21]	0.235*** [4.01]
Ownership	0.007* [1.93]	-0.020*** [-3.23]	-0.111*** [-6.67]	-0.027*** [-3.20]		
Old banks	0.002 [1.44]	-0.004 [-1.49]	0.036*** [4.66]	0.002 [0.40]	0.001 [0.77]	0.002 [1.02]
Commercial banks	0.011*** [2.77]	0.029*** [3.94]	0.103*** [5.10]	-0.023** [-2.33]		
Constant	-0.029*** [-3.20]	0.040** [2.49]	0.209*** [4.42]	0.074*** [3.14]	-0.031*** [-3.32]	-0.045*** [-6.09]
R^2	0.609	0.397	0.923	0.711	0.564	0.541
Adjusted R^2	0.563	0.327	0.916	0.683	0.522	0.500
F-statistic	13.305	5.625	123.810	25.327	13.305	13.421
Jarque-Bera	3.036	565.756	118.701	20.799	4.766	4.377

['t' values are in parentheses, '***' indicates significant coefficients under 1% confidence level, '**' indicates significant coefficients under 5% confidence level and '*' indicates significant coefficients under 10% confidence level]

[2] ROA1 excludes explanatory variables which are not considered as structural variables (such as commercial banks and privately-owned banks) and have demonstrated higher correlation coefficients (more than 0.800) with other explanatory variables.

[3] ROA2 excludes all explanatory variables which have demonstrated higher correlation coefficients (more than 0.800) with other explanatory variables.

Column four and column five of Table 6.3 present the results recorded for Equations 6.2 and 6.3 respectively. Evidence found in these regressions confirms that the EFS holds in the Sri Lankan banking industry. As mentioned previously, a necessary condition for EFS to hold is that technical efficiency must be positively related to market concentration and market power. Thus, the positive relationship of TE with MP implies that efficient firms can gain a higher market share, which subsequently leads to high concentration in the market. Further, the results confirm that technically efficient firms can enjoy both higher profitability, as well as higher market share, than less efficient banks.

Estimated coefficients for control variables provide mixed evidence. For instance, in Equation 6.1, firm-specific variables such as capital strength and commercial banks have shown significant relationships in both (ROA and NIM) regressions. Variables such as risk and old banks do not provide significant evidence to support a relationship with either ROA or NIM. Capital strength shows a statistically significant positive relationship with ROA and a negative relationship with NIM. The other firm-specific variables such as assets quality and liquidity have shown negative relationships with ROA. These results indicate that high investment in liquid assets, as well as high provision for problem loans resulting from low quality loan portfolios, have a negative effect on banks' profit, which is more aligned with the theoretical expectations. Further, the variable representing ownership indicates that the privately-owned banks earn relatively higher profits while charging lower interest margins than state-owned banks. This result shows that privately-owned banks are in a better position to manage operational costs and subsequently earn higher profit than state banks. GDP growth and inflation have shown a similar relationship with the ROA and the NIM. These results indicate that economic growth, as well as inflation, may act to improve banks' profit. On the other hand, the regression based on NIM does not provide evidence to support the relationship with GDP growth and inflation. Further, the estimated coefficients for commercial banks in both regressions show that commercial banks have a higher ROA and NIM than savings banks.

The regression based on Equation 6.2 shows that market power is positively related to TE(I), product quality, inflation, GDP growth, commercial banks and old banks and negatively related to SE(I), operation risk, liquidity and ownership. Since state-owned banks have a significant portion of banking assets in the country, it is obvious that privately-owned banks have a negative relationship with MP. However, the graphical analysis presented in Chapter Two revealed that privately-owned banks were able to improve their stake in the banking market during the study period. The regression results also indicate that not only improvements of technical efficiency, but also degrading the product quality (which results in the high ratio of problem loans), may act to increase a bank's market share. However, the findings in Equation 6.1 show that the product quality has a negative influence (under 10% confidence level) on the ROA of the banks by increasing the cost of bad loans.

The results of the regression based on the concentration ratio are presented in the fifth column of Table 6.3. The results show that market concentration is positively related to variables such as risk, liquidity, inflation and GDP growth and negatively related to variables such as capital strength, privately-owned banks and commercial banks.

The regression results, which exclude explanatory variables that recorded high correlation coefficients with other explanatory variables, are presented in the last two columns of Table 6.3[4]. The results of the regression ROA1 (which excludes non-structural explanatory variables) and ROA2 (which excludes all explanatory variables with high correlation coefficients) show a statistically significant positive coefficient for both variables which represent the MP and the TE(I). This finding is different from the original regression results, which support the TE version of EFS. Since the variable representing MP is statistically significant, both EFS (TE and SE) hypotheses are rejected. Further, the coefficient recorded for the variable representing MP supports the RMP hypothesis, which predicts that market share has a positive effect on banks' profit. Among the other control variables, variables

[4] The results of the supplementary regressions which are based on NIM are not different to the original regression results. Thus, those results are presented in Appendix 8.

representing risk and liquidity have provided results different from the original findings. Contrary to expectations, both regressions record statistically significant negative coefficients for HHI and SE(I) and reject the SCH and SE hypotheses.

6.5 Conclusion

In summary, this chapter has examined the main structural and performance features of the banking industry in Sri Lanka based on Proposition III. The study used four hypotheses proposed by Berger and Hannan (1993) and two performance measures, namely ROA (profitability) and NIM. Generally, empirical results are not consistent with the SCP hypothesis. Confirming the major arguments raised by Molyneux (1999) against the profit-concentration relationship, this study totally rejects the existence of the traditional SCP hypothesis in the banking industry in Sri Lanka. The study's findings also reject Goldberg and Rai's (1996) findings which showed a significant profit-market power relationship. Empirical results confirmed Proposition III that the efficient operation of banking firms is vital for higher operational performance. Furthermore, these results indicate that banks can earn superior performance only by improving their operational efficiency. However, the supplementary regressions, which omit some variables with the original regression equations, show that these results are more sensitive to the selection of variables.

CHAPTER SEVEN

CONCLUSION AND POLICY IMPLICATIONS

7.1 Introduction

This research examined trends in the efficiency and productivity of the banking industry in Sri Lanka during a 16-year period from 1989 to 2004. It covered three research issues, namely, whether efficiency and productivity of the banking industry in Sri Lanka has improved after introducing financial reforms, what are the determinants of Sri Lankan banks' efficiency, and how does the market structure of the banking industry and the banks' efficiency influence the banks' operational performance (ROA and NIM). Through addressing these three research issues, this study provides empirical evidence from the Sri Lankan banking industry to supplement the existing body of knowledge in efficiency and productivity, market structure and performance from a developing country perspective.

The study was presented in five main chapters, which followed the introductory chapter (Chapter One). Chapters Two and Three presented two literature reviews on financial services sector reforms in Sri Lanka and their influence on the banking industry, and on concepts and measurements of efficiency and productivity and their application in the banking industry. Chapter Four analysed efficiency and productivity of the banking industry in Sri Lanka. Chapter Five investigated determinants of technical efficiency of banks. Chapter Six investigated the influence of market structure and efficiency on banks' operational performance. The remainder of this chapter presents the main findings of the study, policy implications and recommendations, limitations of the research, recommendations for further research and the overall conclusion of the study.

7.2 Main Findings

Four objectives[1] of the study have been systematically addressed within five chapters of this thesis. This section summarises the main findings of each of the preceding five chapters.

7.2.1 Analysis of efficiency and productivity

Chapter Four addressed the first objective of the study which aimed to investigate banks' efficiency and productivity improvements gained during the post-liberalisation period. The window analysis of estimated efficiency and productivity scores in both intermediation and asset transformation models showed a negative trend in the first half of the study period. However, mid-year mean efficiency (intermediation) scores of different forms of banks show some interesting evidence on the impact of reforms. Those results indicate a negative trend in efficiency (intermediation) in the first half of the study and a positive trend in the second half. Further analysis of estimated efficiency scores shows that new banks have higher average efficiency than old banks in both approaches. Privately-owned commercial banks recorded a relatively higher average efficiency than state-owned commercial banks in both intermediation and asset transformation. The savings bank sector (which is dominated by state-owned NSB) recorded higher average efficiency scores than the commercial banking sector. The major findings of the efficiency analysis are as follows:

1. There is not sufficient evidence to refute that financial reforms have contributed to improve efficiency of Sri Lankan banks in the short-term. However, the recorded efficiency (intermediation) trends in different types of banks suggest that banks may gain efficiency improvements from reforms in the long-term.
2. Window analyses of estimated efficiency scores in both intermediation and asset transformation have recorded a sharp drop in efficiency in the year

[1] See section 1.4

2001. This drop suggests that the financial repercussions created by the fiscal deficit may have adversely affected banks' efficiency.

3. In both the intermediation and asset transformation approaches, the state-owned commercial banks recorded lower average efficiency scores than the privately-owned commercial banks, indicating that state-owned commercial banks are the main contributor to low efficiency in Sri Lankan banks.
4. The efficiency gap between privately-owned commercial banks and state-owned commercial banks lessened during the second half of the study period. This provides evidence that the limited autonomy offered to the state-owned commercial banks through the commercialisation program in 1994 has affected an improvement in the efficiency of those commercial banks.
5. New commercial banks, which include predominantly medium and small-scale banks, show higher average technical and scale efficiency scores in both intermediation and asset transformation than old banks. This result suggests that old banks have not fully utilised their production capacity, implying that non-optimal scale of operations is a major contributor to technical inefficiency of Sri Lankan banks.

Empirical investigation of productivity improvements gained by banks in Sri Lanka during the 16 year period from 1989-2004 has provided mixed evidence. With the exception of state-owned commercial banks and old commercial banks, all other banks have recorded a regress in total factor productivity in intermediation during the study period. However, the asset transformation process shows productivity improvement mainly from frontier shift. The estimated MPIs indicate that even though banks in Sri Lanka have invested in advancement of technologies in asset transformation, no productivity gains have been achieved from improvement of efficiency. This is evident particularly in the case of state–owned commercial banks and old commercial banks.

The second objective of the study was to undertake a comprehensive review of the literature related to financial reforms and their impact on the banking industry in Sri

Lanka and efficiency and productivity change (concepts and measurements) and their application in the banking industry. Two literature reviews and their findings are presented in Chapter Two and Chapter Three respectively of this dissertation.

7.2.2 Determinants of technical efficiency

The third objective of the study was to investigate the determinants of technical efficiency of banks in Sri Lanka. The study results (see Chapter Five) show that TE(I) has:

- positive relationships with variables such as profitability, operational risk, purchased funds, liquidity (but only at the 10% confidence level) and market capitalisation;
- negative relationships with product quality (but only at the 10% confidence level) and line of business (commercial banks);
- no relationship with the other variables tested.

On the other hand, regression based on TE(A) provided evidence for:

- positive relationships with capital strength (but only at the 10% confidence level), operational risk, and stock market capitalisation;
- negative relationships with line of business, ownership (private banks) and old banks;
- no relationship with other variables tested.

Recorded relationships of operational risk and product quality with TE(I) show that achieving a trade-off between operational risk and product quality is a pre-condition for having high technical efficiency in intermediation. Further, positive relationships recorded by market capitalisation show that the improved competition as a result of developments in the financial market has improved the TE in the banking industry. These results suggest that policies aimed at improving efficiency in other financial institutions in the sector may bring similar gains in the banking industry. The recorded relationships between capital strength and TE(A), and between purchased

funds and TE(I), indicate the significance of expanding the banks' capital base. The evidence recorded on state-ownership in the investigation of determinants of TE is not consistent with evidence found in the analysis of estimated efficiency scores in intermediation. The finding suggests that state-owned banks are more efficient than the privately-owned banks in asset transformation. However, this finding may have been influenced by regulation related to the SRR.

7.2.3 Market structure, efficiency and operational performance

The fourth objective of the study was to investigate the influences of market structure and efficiency on banks' operational performance. This analysis was limited to the intermediation role, which is directly related to the external operation of banks. The study uses both ROA and NIM to represent banks' operational performance. The regression based on NIM does not provide evidence to support any of the predicted relationships. However, the estimated coefficients for ROA show that the banks' profitability is positively related to the TE(I) and not related with the HHI and the MP, thus supporting the EFS. This result suggests that banks' operational performance can be improved only by gaining efficiency improvements.

However, the recorded correlation coefficients for some explanatory variables indicate that the estimated coefficients of the original regression may have been affected by the multicolinearity. Thus, two supplementary regression analyses have been performed, excluding some variables which record high correlation coefficients with other explanatory variables. The estimated coefficients of regression based on NIM provide similar results to the original regression, although the ROA model records positive relationships for both variables which represent MP and TE(I). These results indicate that banks with high MP may have higher profit than the banks with low MP, thereby supporting the RMP hypothesis. Further, positive relationships recorded by TE(I) with ROA and MP indicate that efficient banks can have a greater MP—which may lead to higher operational performance. Overall, the study findings suggest that the collusive power does not have a significant impact on the operational performance of Sri Lankan banks.

7.3 Policy Implications and Recommendations

Development in the financial services sector is considered a prime requirement for a country's economic development (McKinnon 1973; Shaw 1973). Thus, as part of the development strategy, the government of Sri Lanka commenced regulatory reforms to the financial services sector in 1977 (Dunham & Jayasuriya 2005; Kelegama, 1989). Those reforms aimed to enhance the capital accumulation process by improving efficiency and productivity of the financial services sector. These reforms brought various benefits to the banking industry (see Chapter Two). However, the analyses of efficiency, productivity and market structure show that the banking industry in Sri Lanka was not able to capitalise on the opportunities created by the reforms by gaining sufficient efficiency and productivity gains.

Overall, banks in Sri Lanka have recorded a low level of improvement in efficiency and productivity gains especially in the case of intermediation during the study period. If these trends continue, the Sri Lankan banking sector may deviate from developments in the international banking industry. With globalisation of the sector's operations, the local banks will suffer from competition coming from international competitors. Furthermore, recorded low efficiency and unused capacity of banks may lead to an increase in the operational cost of banks in the future which may, in turn, result in large interest rate rises. Thus, policy makers should give priority to promoting policies and strategies which may enhance efficiency improvements and productivity gains in the sector in general. Those strategies must target all small and large banks, irrespective of their ownership structure and business focus. Further, the findings of the investigation of determinants of technical efficiency suggest that the future reforms should focus on:

- overall competitiveness of the financial services sector (including all segments in the sector such as the banking industry, debt markets, stock market, and all other financial and information intermediaries) to enhance the inter-industry market competition;

- removal of operational differences in different forms of authorised deposit-taking institutions such as savings banks, development banks and commercial banks to enhance competition in the banking industry;
- strengthening the capital bases of banks to control the risk-taking behaviour of banks' management; and
- formulating strategies for achieving a trade-off between operational risk and product quality.

The empirical analysis which examines the influence of market structure and efficiency on operational performance of banks suggests that collusive power in the banking industry does not have any impact on operational performance. However, the relative market power and operational efficiency which individual banks hold have a significant effect on operational performance. Thus, policy makers need to focus on polices and strategies which strengthen the operational efficiency (and improve the market competition) and relative market power of individual banks. Accordingly, in order to bolster efficiency and productivity gains in the banking industry in Sri Lanka, this study suggests policy concentration on areas such as speed of reforms, banks' operational environment, and institutional framework. The remainder of this section focuses on these proposed policy areas.

7.3.1 Speed of reforms

Speed of reforms encompasses the sequences and timing of reforms. As explained by Lal (1986), the sequence of economic liberalisation should be: (1) the reduction of fiscal deficit accompanied by removal of capital market distortions; (2) the floating of the exchange rate; and (3) the introduction and implementation of a phased program for removing commodity market distortions. Previous reforms in Sri Lanka have attempted to cover all these three phases in economic liberalisation. Hoj et al. (2006) pointed out that reforms must be consistent with governments' objectives outside the field of economic efficiency. Therefore, it is necessary to have strong political will to face the political difficulty of creating the necessary pro-

reform consensus in the electorate and/or overcoming strong opposition to reform (Hoj et al. 2006).

Conflicting economic goals such as stabilisation and development, as well as lack of strong political will, have adversely affected the success of reforms in Sri Lanka. Reforms introduced in the late 1970s aimed to free the market completely from government intervention. However, latter reforms have given more precedence to stabilisation goals than to development goals (Dunham & Kelegama 1997). Accordingly, policy makers relied on ad-hoc policy adjustment which gave more emphasis to short-term, rather than long-term, economic consequences. The recorded efficiency trends show how those circumstances have affected the banks' efficiency improvements and productivity changes.

This study recognises that issues related to the speed of reforms have adversely affected banks' efficiency and productivity gains. Thus, this study suggests a phased program for further reforms in the financial services sector which addresses all problems faced during the last 27 year period. Such program can be used to:

- recognise, define and establish the objectives, tasks, priorities and timing of further reforms;
- identify potential challenges in implementation of the reforms;
- formulate strategies for overcoming such challenges; and
- inform all constituencies which may be affected by the proposed reforms.

The program should include:

- removal of all restrictions in determination of interest rates (which are currently linked to the two policy interest rates, namely, NSB deposit rates and return on government securities), all forms of credit restriction on banks, and taxes which increase the cost of banking transactions (such as debit tax and various forms of stamp duties); and
- further relaxation of entry and exit barriers (which currently require the consent of CBSL) by providing more room for foreign banks to expand their

operations within the country (these may provide greater competition and more information about advanced banking technologies).

7.3.2 Banks' operational environment

Analysis of estimated efficiency scores and investigation of determinants of technical efficiency have identified a number of factors which may affect banks' efficiency. The results suggest that the autonomy of decision-making enjoyed by banks' boards of management, irrespective of the form of ownership, have impacted on banks' efficiency improvements and productivity gains. This has been highlighted by the reduction of efficiency gaps between the privately-owned commercial banks and the state-owned commercial banks with the introduction of the commercialisation program in late 1994. Thus, this study suggests that further commercialisation should be undertaken in state-owned banks, with reduced political interference. The study results also highlight the necessity of freeing state-owned banks completely from government control. Further, the study proposes reducing the dependency on state-owned banks for financing fiscal deficit since it may have adversely affected not only those banks' efficiency, but also the market competition in the banking industry by crowding out private investment.

TE(A) shows a significant negative relationship with the old banks, indicating that the new banks are more efficient in asset transformation than the old banks. Furthermore, analysis of efficiency scores found significant differences in estimated efficiency scores (both in intermediation and asset approaches) between new and old banks. On the other hand, the analysis of productivity improvement indicates that old banks attempted to improve their productivity through improving their production frontier. It is suggested that old banks have focused on reducing the differences in operational environments of new and old banks by mainly focusing on advancement of the production technologies they use. However, old banks were not able to improve their productivity from efficiency gains. Thus, these findings suggest that there is a need to formulate strategies, not only to speed-up the

upgrading of existing product-delivering technologies used in old banks, but also to enhance the current efficiency level.

Developments in other industries in the financial services sector have increased the degree of competition in the sector. Gaining efficiency improvements is the most appropriate approach to facing increased competition. Cost advantages gained through efficiency improvements assist banks in reducing their intermediation margin by being able to offer their products at a lower price than their competitors. The recorded relationship between TE and stock market capitalisation can be considered as an indicator of the impact of developments in other institutions in the financial services sector on banks' technical efficiency. Further, such developments in the other industries may allow banks to focus on new business opportunities. Thus, any reforms aimed at expanding activities in the financial services sector are important for further development in the banking industry.

7.3.3 Institutional framework for financial reforms

Lack of a well-defined institutional framework for policy reforms may also impact on regulatory reforms in Sri Lanka. Currently, the CBSL is responsible for regulation and supervision of financial institutions. The CBSL also provides statutory protection to deposit holders of the authorised deposit taking institutions. Contemporary researchers point out that maintaining both supervisory and regulatory roles under government control may reduce the impartiality of outcomes (Barth, Caprio & Levine 2004). Hence, those studies suggest transferring the banks' supervision to private institutions which are independent from direct government control (Barth, Caprio & Levine 2004). As Barth, Caprio & Levine pointed out, private sector supervision may improve the soundness of both the supervisory and regulatory functions. Therefore, this study proposes the following changes to the institutional framework of the financial services industry:

1. Governments must limit intervention in the banking industry to formulating and implementing policies and procedures which may be helpful to the smooth operation of the banking industry.

2. The CBSL should give priority to identifying, formulating and implementing sound banking regulatory practices.
3. Prudential supervision is a prime requirement to constrain risk-taking behaviour in a liberalised financial environment. Thus, there is a need to allow an independent agency to supervise financial institutions.
4. Deposit insurance aims to protect deposit holders in the case of the bankruptcy of a bank, and to provide an environment that is conducive to the smooth operation of banks and general stability in the financial sector. Thus, this study proposes establishing a separate institution for deposit insurance, which is responsible for introducing deposit insurance mechanisms to protect the deposit holders of authorised deposit taking institutions.
5. Banks—even state-owned banks—and other institutions operating in the financial services sector should adopt management structures that ensure they are primarily autonomous profit centres. Those institutions might be able to respond to the market passively to satisfy the market needs in intermediation and asset transformation. Regulatory intervention in their activities should be limited to ensure solvent, safe and fair operations.

7.4 Limitations of the Study

A number of factors have limited the empirical analysis of this study. Accordingly, all measures have been taken within the study to restrict any cause that may result in bias in the study due to the limitations explained below.

This study is based on secondary data, mainly collected from banks' annual reports. Therefore, the data may be subject to measurement and allocation errors which are common to traditional accounting reports.

This study aimed to evaluate the impact of financial reforms which commenced in 1977. However, the accounting disclosures made in the banks' annual reports before 1989 were limited to minimum disclosure requirements stipulated by the regulatory institutions. Thus, this study has to be limited to the period from 1989 to 2004.

The study used non-parametric DEA to estimate productivity efficiency of banks in Sri Lanka. Discriminatory power of DEA is mainly dependent on the sample size and the number of inputs and outputs considered in the efficiency assessment. Since there are only a small number of banks in the Sri Lankan banking industry, this study used three-year moving windows for constructing production frontiers for efficiency assessment. The estimated efficiency scores based on three-year windows may have been influenced by the technological improvements reported during the window period.

DEA measures efficiency scores by pair-wise comparisons of DMUs in the sample. Benchmarking units for efficiency assessment are identified from the sample under review. These benchmarks are endogenous and have very little value in comparability with benchmarks created from another sample. Therefore, comparisons of estimated efficiency and productivity scores with other studies may not be appropriate. Branches of foreign banks can be considered as a major force in the banking industry in Sri Lanka. However, available information from those banks does not provide all required information for this study. Thus, the study is limited to local banks.

7.5 Future Research

Efficiency, productivity, market structure and competition are some important aspects of banking operations in a country. This study covered only efficiency, productivity and market structure. Accordingly, this study suggests future research should concentrate on several areas related to banks' efficiency and productivity.

Estimated efficiency scores using DEA for one sample may not be compared with the estimated efficiency scores for another sample. Further, the estimated scores may not reflect the true efficiency level of the DMUs under review. Thus, this study suggests that measuring efficiency and productivity change using cross-country data may lead to a better understanding of the performance of the banking industry in Sri Lanka. Such a study may provide information about comparable efficiency scores for banks in Sri Lanka with other countries in the sample.

Furthermore, this study focused only on financial aspects of the banks' performance. In a small banking industry, some behavioural aspects may severely affect efficiency and productivity of banks. Hence, studying non-financial factors which may influence the banks' efficiency and productivity gains may be more important.

Some recent studies (Fried, Schmidt and Yaisawarng, 1999; Drake, Hall and Simper, 2006 and Dietsch and Lozano-Vivas, 2000) suggest using a three-stage procedure for estimating efficiency scores. Those studies suggest decomposing impact of environment effect form estimated efficiency scores. However, this study has been based on the two-stage procedures for investigating factors influencing the technical efficiency. Thus, it is proposed to conduct future research based on the three-stage procedure.

This study has been limited to the impact of financial reforms on the efficiency and productivity change in the banking industry in Sri Lanka. However, various forms of government intervention in the industry may have greatly affected the banks' efficiency and productivity gains. Thus, this study stresses the significance of investigating the impact of such interventions on the operational performance of the banking industry.

The Sri Lankan financial services sector consists of a few industries. An inter-industry analysis on efficiency and productivity change may provide information about the influence of financial reforms. Hence, this study suggests undertaking an inter-industry analysis on efficiency and productivity change in the financial services sector would be useful future research.

7.6 Conclusion

Financial liberalisation has resulted in a significant change in the infrastructure and operational environment of the banking industry in Sri Lanka. As discussed in Chapter Two, financial services sector reforms widened the overall activities of the banking industry. During this period the banking industry emerged as a main economic agent that facilitates the transformation of financial assets in the capital

market. However, further analysis in the study found that banks were not able to capitalise on the favourable environment created by financial reforms through efficiency and productivity improvements. The analysis of factors affecting the technical efficiency of banks in Sri Lanka shows that the impacts of those factors on the different aspects of banking operations are not similar. The overall study findings suggest that policy reforms on their own may not be enough to improve the efficiency and productivity gains of the banking industry. The introduction of financial reforms may affect efficiency and productivity gains if individual banks are able to capture the opportunities created by such reforms and if the government is able to attain and sustain microeconomic stability in the country.

Appendix 1: Applications of DEA in the financial services sector

Researcher (Year)	Sample	Issues addressed	Findings
Deregulation			
Alam (2001)	US 1980-89 166 Banks	Branching restrictions	• Banks take a considerable time to respond to regulatory reforms.
Ali and Gstach (2000)	Austria 1990-97 216 Banks	Foreign banks	• All banks recorded a declining trend in estimated technical efficiency scores. • Performance gaps between best performing banks and the other banks have been widened. • Small banks performed better than big banks
Avkiran (1999)	Australia 1986-95 25 banks	Bank mergers and outcome of deregulation	• Mergers were not able to gain in productivity improvements • Acquiring firms were not always able to maintain the pre-merger productivity gains
Avkiran (2000)	Australia 1986-95 10 banks	Deregulation	• Interest expenses were identified as an important source of inefficiency • Regional banks were in the IRS and trading banks were in the DRS
Berg, Forsund and Jansen (1992)	Norway 1980-89 152 banks	Deregulation	• There was a productivity regress during the pre-deregulated period and rapid growth in productivity during post-deregulation. • Deregulation has lessened dispersion of productivity levels within the industry
Canhoto and Dermine (2003)	Portugal 1990-95 20 banks	Relative efficiency of new domestic banks	• Deregulation affected efficiency improvements • New banks are more efficient than old banks
Denizer, Dinç and Tarimcilar (2000)	Turkey 1970-94 29-53 banks	Productivity improvements	• Estimated efficiency indicated a declining trend in post deregulations. • There were no significant differences in estimated efficiency among different types of banks
Elyasiani and Mehdian, (1990a)	USA 1980-85 191 banks	Technological change	• 12.98% non-neutral technology change has been reported
Elyasiani and Mehdian (1995)	USA 1979, 1986 300 banks	Deregulation	• Small banks were more efficient than large banks in the pre-deregulated periods and equally efficient in the post-deregulated period.
Isik and Hassan (2003a)	Turkey 1981-90 41-56 banks	Deregulation	• Efficiency improvements were reported mostly owing to management practices rather than improved scale. • New environment created through deregulation reduced the efficiency gap between private and public banks.

Isik and Hassan (2003b)	Turkey 1988-96 52-55 banks	Deregulation	• State-owned banks and foreign banks outperformed privately-owned banks in terms of cost and technical efficiency where as state-owned banks dominated both in terms of allocative efficiency. • Publicly traded banks recorded relatively high efficiency. • No evidence found to support that bank size has a significant effect on estimated cost efficiency.
Maghyereh, (2004)	Jordan 1984-2001 8 banks	Productivity improvements	• Deregulation improved bank efficiency indicating a faster push of productivity growth in large banks.
Noulas (2001)	Greece 1994-98 19 banks	Deregulation	• Privately-owned banks positively responded to the deregulation. • No evidence was found for significant gap between state-owned and privately-owned banks.
Sathye (2001)	India - All	Productive efficiency gained on reforms	• The efficiency of privately-owned banks was paradoxically lower than that of state-owned banks and foreign banks.
Sturm and Williams (2004)	Australia 1988-2001	Foreign bank entry	• Foreign banks were more efficient, however, those banks were not able to convert recorded efficiency into profit • The main source of technical inefficiency was excessive scale of operation.
Webb (2003)	UK 1985-95 7 banks	Performance of retail banks	• The main source of inefficiency is the scale of operation • Small banks suffered from technical inefficiency • Large banks were in the DRS
Policy issues			
Batchelor and Gerrard (2002)	Singapore 1997-2001 3 banks	Local take over	• Productivity improvement in banks primarily resulted from technological change • Local take-over has a positive influence on technological change
Barr et al. (1999)	USA 1984-98	Performance evaluation approaches	• Traditional measures of bank performance and DEA scores has a close relationship
Bauer et al. (1998)	USA 638 banks 1977-88	Consistency of efficiency scores among different methods	• Efficiency estimations based on parametric approaches are closely related. However, there are big differences in estimated efficiency scores using parametric and non-parametric approaches. • Non-parametric approaches report relatively low average efficiency.
Casu and Girardone (2002)	Italy 1995 110 banks	Performance comparison	• Result suggests bank group is less efficient when compared to the parents' banks and subsidiary banks. • Estimated efficiency scores showed a higher variation of efficiency between banking group of companies, and parents and subsidiary companies • Banks' size plays a very little role in determining banks' efficiency

Drake and Hall (2003)	Japan 1997 149 banks	Problem loans	• Small banks were in the economics of scale. • Technical efficiency was improved with bank size. • Problem loans was an important source of inefficiency especially for the smaller regional banks
Elyasiani and Mehdian (1990b)	USA 1980-85 144 banks	Rate of technology change	• Size (total assets or total revenue) has positive effect on bank efficiency. • Large banks were able to gain efficiency improvements on scale of operation
Fried, Lovell and Yaisawarng (1999)	USA 1988-95 6000 credit unions	Mergers	• Merger has a mixed effect on the estimated efficiency
Fukuyama (1995)	Japan 1989-91 155 banks	Policy issue	• During the economic crises, the estimated average efficiency report a stable trend • Bank size (revenue) inversely correlated with the estimated efficiency
Jackson Fethi and Inal (1998)	Turkish 1992-1996 38 banks	Policy analysis	• Productivity improved on deregulation
Noulas (1997)	Hellenic 1991-92 20 banks	Productivity growth	• Productivity growth was reported by both state-owned (mainly on technological progress) and privately-owned (mainly on catching-up) banks.
Worthington (2001)	Australia 1993-1997 323 credit unions	Merger	• Merged credit unions recorded higher productivity improvements than non-merged credit unions
Sathye (2001)	Australia 1996 29 banks	Merger	• Domestic banks were more efficient than the foreign banks • Market power and size variables were negatively associated with the bank efficiency.
Methodological issues			
Asmild et al. (2004)	Canada 1981-2000 5 main banks	Window analysis with MPI	• Decomposition of frontier shift and catching-up effects of the MPIs estimated using window based DEA are not accurate.
Brown (2001)	Australia 1992-95 credit unions 326	Sample stratification	• Stratification of the sample improves discriminatory power of inefficient units from efficient units.
Cinca, Molinero and Garcia (2002)	Spain 2000 47 banks	Review on input output specifications	• DEA estimated efficiency scores was influenced by input and output specifications used. • Better estimation of relative efficiency can be derived on average value of the estimated efficiency scores under different combinations of input output specification.

Favero and Papi (1995)	Italy 1991 174 banks	Scale efficiency and influence of input-output specifications	• Productive specialisation, size and location are identified as determinants of banks' efficiency.
Huang and Wang (2002)	Taiwan 1982-97 22 banks	Comparison of estimated efficiency on different approaches	• DEA and other two parametric methods used for estimation of efficiency scores recorded similar distribution patterns. • Parametric and non-parametric methods gave slightly different results in ranking of DMUs • Parametric methods showed a highly persistence distribution across periods and a close correlation with traditional measures.
Leong and Dollery (2002)	Singapore 1993-99 35 banks	Tested Barr et al (1999) approach	• A longitudinal approach has been applied to examine relationship between estimated efficiency scores and other performance indicators. • A positive relationship between estimated efficiency and traditional measures of bank efficiency was found
Leong, Dollery and Coelli (2002)	Singapore 1993-99 35 banks	Consistency of DEA estimated efficiency scores with other methods	• DEA estimated efficiency scores were consistent with best practice conditions, model specification condition, and market condition. However the results did not comply with the time consistency condition.
Pastor (1999)	Spain 1985-95 165-132 banks	Risk	• A sequential DEA procedure was proposed to decompose the banking risk into internal and external components in order to obtain efficiency measures free from risk.
Resti (1997)	Italy 1988-92 270 banks	Performance	• Differences of efficiency scores estimated using econometric and mathematical programming approaches are not significant when the same data-set and conceptual framework used. • Estimated efficiency scores using ADEA (VRS and CRS) and SFA were shown a high positive correlation.
Saha and Ravisankar (2000)	India 1992-95 25 public banks	Performance	• Public sector banks have improved their efficiency • More efficient banking units listed in stock market were able to recorded higher stock return within a short period after IPO.
Tortosa-Ausina (2002)	Spain	Sensitivity of estimated efficiency productivity scores	• Estimated productivity and efficiency scores are more sensitive to specifications of input/output
Tortosa-Ausina (2003)	Spain 1986-97 77 banks	Non-traditional activity and bank efficiency	• Inclusion of non-traditional activities in efficiency analysis contributes to improve the estimation of efficiency scores of some clusters of DMUs under review. • The results depend on the bank size, type of the firm, and the time

Weill (2004)	5 EC countries 1992-98 588 banks	A comparison of frontier techniques	• All five countries have given un comparable average efficiency scores for three frontier approaches (DEA, SFA and DFA) • Except with DEA, estimated efficiency using parametric approaches are positively correlated • All three methods provide consistent efficiency scores with the standard measures of performance
Managerial performance			
Ayadi, Adebayo and Omolehinwa (1998)	Nigeria 1991-1994 10 banks	Quality of bank management	• Old banks are more efficient • Main sources of inefficiency is the poor management of bank resources • Deregulation creates threats to safety of the banking system demand for close supervision of banking firms
Berg et al. (1993)	Nordic Countries		• Both in country specific production frontiers and common frontiers (constructed using pooled data from all countries) were recorded that a large number of Swedish banks were on the frontier having higher efficiency scores. • The results showed that efficiency spreads between banks were most important in Finland and Norway and least important in Sweden.
Bergendahl (1998)	4 Nordic Countries 1992/1993 48 banks	Benchmarking	• DEA is a best approach to identify benchmark for inefficient bank
Chen (2002)	Taiwan 1997-1998 44 banks	Managerial performance	• Three specifications were applied to stand for operating, marketing and financial efficiency of banking firms. • Significant differences are observed in estimated efficiency scores • State banks [and large] exhibited superior performance in profitability and private sector banks [and small banks] exhibited operational capability.
Drake (2001)	UK 1984-1995 10 banks	Productive performance	• Reported improvements in productivity throughout the period • Main sources of inefficiency is the scale diseconomies • Over the period, UK banks reported a positive productivity growth over the period due to the frontier shift and negative catch-up
Darrat, Topuz and Yousef (2002)	Kuwait 1994-1997 8 banks	Productivity improvements	• Mainly technical and allocative inefficiencies are caused by inefficiency of banking system • Small banks are more efficient • Capitalization and profitability are positively related to banks' inefficiency

Drake and Simper (2003)	UK 1995-2001 20 institutions[1]	Ownership change	• Conversion of mutual building societies to public limited companies brought only temporary benefits in efficiency and productivity gains
Grabowski, Rangan and Rezvanian (1993)	USA 1989 7,721 banks [2]	Organization structure	• Branch banking firms are more efficient than the banks belonging to the holding companies. • Statistically significant differences were reported among scale efficiency, allocative efficiency and pure technical efficiency. • The efficiency improvements are mainly reported on technical sources
Grigorian and Manole (2002)	Transition[3] countries 1995-1998 17 banks	Sources of productivity	• Banking system with few large well capitalised banks are likely to generate better efficiency and higher rate of intermediation • The influence of prudential tightening on efficiency varies across different prudential norms • Transferring banks' ownership from state to local (not to foreigners) does not make statistically significant efficiency improvements.
Hasan, Lozano-Vivas and Pastor (2000)	European countries 1993 612 banks	Cross country differences	• Research findings suggested that a [un]favourable environment condition could be an exogenous [good] bad competitive strategy for the home country banks.
Miller and Noulas (1996)	USA 1984-1990 201 large banks	Technical efficiency	• Majority of banks indicate DRS. • Large and more profitable banks report less inefficiency.
Mukherjee, Ray and Miller (2001)	USA 1984-1990 201 large banks	Productivity growth	• 4.5% productivity change was reported during 1984-1990 mainly on technical change. • Bank size and product specialisation was positively related with the efficiency change while equity to total assets ratio was negatively related.
Noulas (1997)	Hellenic 1991-92 20 banks	Post-deregulation analysis	• State-owned banks reported relatively high productivity change • Technical efficiency has improved in privately-owned banks and declined in the state-owned banks
Sherman and Ladino (1995)	USA 33 branches of a bank	Benchmarking	• The study found that DEA can easily accommodate for some of the traditional bank monitoring techniques with relatively low cost. • DEA can be used to analytically review complex transaction
Yue (1992)	USA 1992/1993 60 banks	Managerial performance	• Recorded technical efficiency is purely a result of excessive use of inputs

[1] sample consisted of 8 credit unions, 3 converted credit unions into PLC and 9 banks
[2] this sample consisted of 3,627 banks affiliated to multi-bank holding company and 4,094 banks with branch banks.
[3] Former communist countries

Zanios et al. (1999)	Bank of Cyprus Branch network	Benchmarking	• DEA is a powerful tool which can account impact of the external environment that the managers have less control • DEA measurements can be used to provide constructive recommendation for improvements
Cross country studies			
Berg et al (1993)	3 Nordic countries 779 banks	Cross country	• Country differences in estimated efficiency scores and dispersion of those scores existed
Casu and Molyneux (2003)	5 EUCs 1993-96	Cross country	• There was no evidence to support that convergence to a single market has caused improvement in banks' productivity in the region. • The efficiency distribution among the EU countries appears to be mainly determined by country specific factors.
Grigorian and Manole (2002)	Transition[4] countries 1995-1998 17 banks	Cross country	• Large banks and foreign banks recorded relatively high efficiency scores • Per capita income has a positive relationship with estimated efficiency • Developments in security market and non-bank financial institutions have negatively affected the performance of banks.
Lozano-Vivas, Pastor and Pastor (2002)	10 EUCs 1993 612 banks	Cross country	• Cross country variations in estimated efficiency have been affected by the environmental variables.
Pastor (2002)	France, Italy, Spain and Germany 1988-1994	Cross country variations	• Average cross country efficiency estimations were relatively low. • DEA scores which were not adjusted for risk are substantially different from the risk adjusted scores.
Other application			
Fat and Hua (1998)	Singapore 1992-1996 30 banks	Stock market reaction	• Stock market performance closely associated with the estimated efficiency scores.
Kantor and Maital (1999)	USA Mideast bank 250 branches	Activity-based cost accounting and DEA	• Combines use of activity-based costing and DEA for activity-based management provides managers with detailed quantitative performance benchmarks for the specific business activities of their firms or divisions.

[4] Former communist countries

Appendix 2: Applications of DEA in financial services sector; Input and output specification

Researcher	Issues addressed	Approach used	Input	Output
Deregulation				
Alam (2001)	Branching restrictions	Intermediation (different combination of input-output has been used)	Physical capital, labour, purchased funds, demand deposits, other deposits, core deposits, and loanable funds (Dollar value)	Securities, real estate loans, commercial and industrial loans, instalments loans, total loans (Dollar value)
Ali and Gstach (2000)	Foreign banks	Intermediation /Value added	Labour, physical capital, purchased funds, interbank deposits, equity	Customer deposits, inter bank loans, small loans, securities
Avkiran (1999)	Bank mergers and deregulation	Intermediation	Staff number, deposits, interest expenses and non-interest expenses	Net loans, net interest income and non-interest income
Canhoto and Dermine (2003)	Efficiency of new domestic banks	Intermediation	Number of employees and physical capital	Loans, deposits, securities, and interbank assets/ liabilities
Denizer Dinc and Tarimcilar (2000)	Productive improvements	Stage 1: Production Stage 2: Intermediation	Total personnel expenses, interest and fees Total deposits, income from non-banking sources and non-personnel operating expenses	Total deposits and income from non-banking sources Total loan and banking income
Elyasiani and Mehdian (1990a)	Technological change	Intermediation	Deposits (saving and time), labour, capital	Real estate loans, commercial and industrial loans, other loans and investment
Elyasiani and Mehdian (1995)	Deregulation	Intermediation	Time and savings deposits, demand deposits, capital and labour	Investment real estate loans, commercial and industrial loans, and other loans
Isik (2003)	Deregulation	Intermediate Value-added approach	Labour (number of full time employees), capital (book valve of fixed assets), banking funds Labour, capital and funds	Short-term loans, long-term loans, other earnings assets Short-term loans, long-term loans, other earnings assets and risk adjusted off-balance sheet activities
Isik and Hassan (2003a)	Deregulation	Intermediation	Labour, loanable funds, and capital	Short-term loans, long-term loans, other earnings assets and risk adjusted off-balance sheet activities

Maghyereh (2004)	Productivity improvements	Intermediation	Labour, capital and deposits	Loans and liquid assets, investments and other income
Noulas (2001)	Deregulation	User cost	Interest expenses and non-interest expenses	Interest revenue and non-interest revenue
Sathye (2001)	Productive efficiency gained on reforms	Intermediation	Net worth, borrowing, operating expenses, number of employees, number of banks	Deposits, net profits, advances, non-interest income interest spread
Tortosa-Ausina (2003)	Non-traditional activity and bank efficiency	Intermediation approach (1) Restricted (2) Unrestricted	Labour, funding and physical capital Same as above	Loans and other earnings Loans, other earnings, and non-traditional activity
Policy issues				
Barr, Seiford and Siems (1994)	Bank failure	Production approach	Full-time equivalent employees, salary, premises and fixed assets, other non-interest expenses, total interest expenses and purchase funds	Core deposits, earning assets, and total interest income
Batchelor and Gerrard (2002)	Local take over	Intermediation approach	Labour, net fixed assets, and total deposits	Loans and advances, investment securities, and liquid assets
Bauer et al.(1998)	Methodological/ policy issues	Production	Labour, physical capital, small denomination time and savings deposits, and purchased funds	Demand deposits, real estate loans, commercial and industry loans and instalments loans
Berger (1997)	Problem loans and cost efficiency	Intermediation approach	Operating expenses	Commercial loans, real estate loans, transaction deposits and fee-based income
Casu and Girardone (2002)	Performance comparison	Intermediation	Labour costs, deposits and physical capital	Total loans and other earning assets
Dietsch and Vivas (1996)	Impact of environmental variables	Value added approach	Labour, physical capital, deposits	Loans, produced deposits, other productive assets including short term investment
Drake and Hall (2003)	Mergers, problem loans	Intermediation approach	General and administrative expenses fixed assets, retail and wholesale deposits and problem loans	Total loan and bills discounted, liquid assets and other investment and other income
Elyasiani and Mehdian (1990b)	Rate of technology change	Intermediation	Deposits, labour (number of employee), and capital	Loans and investments
English et al. (1993)	Bank mergers	Assets approach	Labour, capital, deposits and borrowings	Investment income, real estates income consumer loans, and commercial loans

Fried, Lovell and Yaisawarng (1999)	Bank mergers	Alternative	All operating expenses	Nos. deposit, deposit interest rate, nos. loan, loan interest rate, transaction volume and service variety
Fukuyama (1995)	Policy issue	Intermediation	Labour, capital and funds from customers	Returns from loans and returns from investments
Jackson, Fethi and Inal (1998)	Policy analysis	Value added	Number of employees, sum of non-labour operating cost, depreciation expenditure and material expenditure	Loans, demand deposit and time deposits
Kohers, Huang and Kohers (2000)	Policy issue/ Merger and stock prices	Intermediation	Labour, physical capital, time and saving deposits, and purchased funds	Demand deposits, time and saving deposits, real estate loans, other loans and net non-interest income
Noulas (1997)	Productivity growth	Intermediation	Physical capital, labour and deposits	Liquid assets, loans and advances, and investments
Worthington (2001)	Merger	Intermediation	Physical capital, at call deposits, notice-of-withdrawal deposits, interest and non-interest expenses	Personal loans, commercial loans, residential loans, investment, and interest and non-interest income
Methodological issues				
Brown (2001)	Outcome of firm mergers	Alternative	Operating costs	Loans, deposits, average interest paid, average interest received
		Alternative	Operating costs	Housing loans, non-housing loans, deposit not at call, average interest paid and received
Cinca, Molinero and Garcia (2002)	Review on input-output specifications	Alternative (different combinations)	Number of employees, fixed assets and deposits	Operating income, deposits and loans
Favero and Papi (1995)	Scale efficiency and influence of input-output specifications	Assets	Labour (number of employees), capital (book vale of fixed assets and premises), loanable funds, and net funds from other banks [and financial capital]	Loans to other banks and non-financial institutions, investment and security and non-interest income
Fethi, Jackson and Weyman (2002)		Intermediation	Number of employees, total interest expenditure, depreciation expenditure and material expenditure	Loans and demand deposits
Fukuyama and Weber (2002)	Methodological issues	Assets	Labour, physical capital, and funds from customers	Loans and security investments
Huang and Wang (2002)	Comparison of methods	Intermediation	Deposits and borrowed money, labour and net physical capital	Investment, short term loans, and long term loans

Leong and Dollery (2002)	Methodology	Intermediation	Deposits and fixed assets	Loans and risk weighted assets
Leong Dollery and Coelli (2002)	Methodology	Model A Model B Model C	Interest expenses and operating expenses Deposits and fixed assets Deposits and fixed assets	Interest income and other income loans Risk weighted assets
Resti (1997)	Methodological/ Performance	Value added	Labour (staff expenses), and capital (non-staff expenses and depreciations)	Loans and deposits
Saha and Ravisankar (2000)	Methodological/ Performance	Production	Interest expenses, establishment expenses, non-establishment expenses and fixed assets	Deposits, advances, investments, non-interest income, spread and total income
Cross country studies				
Athanassopoulos, Soteriou and Zanios (1997)	Cross country difference of efficiency gain	Production approach	Labour cost, number of computer terminals, branch size	Savings, checking, business and loan accounts
Berg et al.(1993)	Cross country comparison	Alternative approach	Labour and capital	Total loans, total deposits and number of branches
Casu and Molyneux (2003)	Cross country	Intermediation	Total cost and total customer and short-term deposits	Total loans and other earnings assets
Lozano-Vivas, Pastor and Pastor (2002)	Cross country comparisons/ Methodological		Personnel expenses and non-personnel expenses and a set of environmental variables	Loans, deposits, and other earnings assets
Pastor (2002)	Cross country variations	Value added	Personnel expenses, and non-personnel operating costs (with environmental and risk variables)	Loan, deposits, other earning assets
Managerial performance				
Athanassopoulos and Giokas (2000)	Branch performance	Production approach	Labour hours, branch size, computer terminals, and operating expenses	Number of transactions, (credit, deposits and foreign exchange)
Ayadi, Adebayo and Omolehinwa (1998)	Performance measurements	Intermediation	Interest paid, and personnel and other expenses	Total loans, interest income and non-interest income
Barr et al. (1999)	Efficiency performance/ Methodological	Integrated	Salary expenses, premises and fixed assets, other non-interest expenses, interest expenses	Earning assets, interest income and non-interest income

Bergendahl (1998)	Benchmarking	Production	Personnel cost, cost of materials, and credit loss cost	Lending, deposits and gross revenue
Chen (2002)	Managerial performance	Alternative approach	Operation efficiency Bank staff, assets and deposits Marketing efficiency Loans, investments and exchange Financial efficiency Interest revenue, non-interest revenue, service quality and performing loans	 Loan, investments and exchange Interest revenue, non-interest revenue, service quality and non-performing loans Profit and equity
Drake (2001)	Productive performance	Production Intermediation	Fixed assets, nos. employees Fixed assets, no. employees and deposits	Loans, liquid assets & investments, other income and deposits Loans, liquid assets & investments and other income
Drake and Simper (2003)	Ownership change	Alternative	Employee expenses, non-interest expenses and loan loss provisions	Net interest income, net commission income and total other income
Darrat, Topuz and Yousef (2002)	Productivity improvements	Intermediation	Labour, capital, and deposits	Loans and investments
Golany and Storbeck (1998)	Performance evaluations	Production approach	Teller hours, operating expenses, market size, economic status of the area, competitive activity	Loan (direct, indirect, commercial and equity), deposits (checking, savings and deposit certificates), average number of accounts per customer, customer satisfaction
Grabowski, Rangan and Rezvanian (1993)	Managerial issues	Intermediate	Labour, capital and loanable fund	Commercial and industrial loans, consumer loans, real estate loans, demand deposits and investment security
Grigorian and Manole (2002)	Sources of productivity	Alternative	Labour, fixed assets, and interest expenditure	Revenues, net loans and liquid assets
McAllister and McManus (1993)	Scale efficiency	Value added approach	Purchased funds, savings deposits, fixed assets, and labour	Real estate loans, commercial and industrial loans, instalment loans, demand deposits and savings deposits

Miller and Noulas (1996)	Technical efficiency	Intermediation	Transaction deposits, non-transaction deposits, total interest expenses, and total non-interest expenses	Commercial and industrial loans, consumer loans, real estate loans, investments and total non-interest income
Mukherjee, Ray and Miller (2001)	Productivity growth	Intermediation	Transaction deposits, non-transaction deposits, equity labour, and capital.	Commercial and industrial loans, consumer loans, real estate loans, investments and total non-interest income
Pal, Mukherjee and Nath (2000)	Performance	Production	Deposits, net profits, advances, non-interest income and interest spread	Net worth, borrowing, operating expenses, number of employees and number of banks
Sherman and Ladino (1995)	Benchmarking	Alternative	Teller, platform, managerial personnel, office space, branch operating cost	Deposits (withdrawals and cheques chased), bank cheques traveller's cheques, bonds (sold, redeemed and coupon), loans (mortgage and consumer) and new accounts (time savings, certificates of deposits)
Yue (1992)	Managerial performance	Intermediary	Interest expenses, transaction deposits, non-transaction deposits, non-interest expenses	Interest income, non-interest income and total loans
Zanios et al. (1999)	Benchmarking	Production	Clerical staff, managerial staff, computer terminals and working space	Number of current accounts, savings accounts, foreign currency and commercial accounts, credit application and service hours
Other application				
Fat and Hua (1998)	Share market performance	Alternative	Non-interest expenses, interest expenses, and financial capital	Annual average increase in total assets and total income from interest and non-interest activities

Appendix 3: Coefficients of variation (Input and output data)

Window	Interest Expenses	Personnel Expenses	Establishment Expenses	Advances	Deposits	Number of Employees	Interest Income	Other Income	Other Loanable Funds	Earning Assets
1990	0.95	1.19	0.96	1.13	0.92	1.04	0.91	0.86	1.36	1.66
1991	0.88	1.13	0.96	1.01	0.87	1.00	0.86	0.82	1.45	1.53
1992	0.82	1.09	0.95	0.93	0.79	0.97	0.82	0.90	1.52	1.46
1993	0.78	1.07	0.91	0.89	0.76	0.93	0.79	0.95	1.45	1.34
1994	0.85	1.08	1.00	0.97	0.84	0.98	0.85	1.00	1.40	1.42
1995	0.91	1.09	1.14	0.98	0.89	1.03	0.90	1.09	1.37	1.43
1996	0.98	1.18	1.31	1.03	0.97	1.10	0.98	1.23	1.40	1.52
1997	0.98	1.19	1.34	1.02	0.96	1.10	0.97	1.22	1.38	1.47
1998	1.02	1.21	1.31	1.03	0.98	1.14	1.00	1.29	1.44	1.51
1999	1.02	1.22	1.05	1.03	0.96	1.14	0.99	1.27	1.62	1.52
2000	1.04	1.22	0.88	1.07	0.98	1.16	1.02	1.23	1.65	1.49
2001	1.02	1.21	0.87	1.04	0.98	1.16	1.01	1.10	1.51	1.47
2002	1.02	1.21	0.85	1.01	0.99	1.15	0.99	1.00	1.27	1.41
2003	0.99	1.21	0.84	0.97	0.99	1.13	0.96	1.05	1.02	1.44
Pooled sample data	1.08	1.36	1.09	1.17	1.14	1.09	1.08	1.25	1.56	1.69

Appendix 4: Window analysis – (Mean estimated efficiency scores in individual window periods)

(a) Technical efficiency in intermediation

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Win_1990	0.989	0.985	0.944													
Win_1991		0.995	0.973	0.948												
Win_1992			0.995	0.957	0.977											
Win_1993				0.955	0.975	0.992										
Win_1994					0.920	0.900	0.923									
Win_1995						0.905	0.926	0.934								
Win_1996							0.902	0.879	0.898							
Win_1997								0.880	0.878	0.951						
Win_1998									0.886	0.939	0.911					
Win_1999										0.941	0.893	0.924				
Win_2000											0.917	0.931	0.916			
Win_2001												0.969	0.890	0.949		
Win_2002													0.795	0.836	0.889	
Win_2003														0.822	0.869	0.902

(b) Pure-technical efficiency in intermediation

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Win_1990	1.000	0.994	0.994													
Win_1991		1.000	0.999	0.971												
Win_1992			1.000	0.982	1.000											
Win_1993				0.983	0.992	1.000										
Win_1994					0.987	0.987	0.989									
Win_1995						0.987	0.987	0.998								
Win_1996							0.983	0.982	0.989							
Win_1997								0.976	0.971	0.995						
Win_1998									0.973	0.989	0.968					
Win_1999										0.989	0.964	0.993				
Win_2000											0.976	0.989	0.976			
Win_2001												0.994	0.961	0.988		
Win_2002													0.886	0.900	0.905	
Win_2003														0.888	0.899	0.909

(c) Scale efficiency in intermediation

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Win_1990	0.989	0.990	0.950													
Win_1991		0.995	0.974	0.976												
Win_1992			0.995	0.975	0.977											
Win_1993				0.971	0.983	0.992										
Win_1994					0.930	0.913	0.934									
Win_1995						0.917	0.938	0.936								
Win_1996							0.917	0.893	0.906							
Win_1997								0.898	0.900	0.954						
Win_1998									0.907	0.948	0.939					
Win_1999										0.951	0.925	0.930				
Win_2000											0.936	0.941	0.938			
Win_2001												0.974	0.927	0.961		
Win_2002													0.822	0.852	0.900	
Win_2003														0.855	0.892	0.915

(d) Technical efficiency in asset transformation

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Win_1990	0.942	0.951	0.981													
Win_1991		0.944	0.948	0.939												
Win_1992			0.961	0.941	0.966											
Win_1993				0.939	0.959	0.990										
Win_1994					0.947	0.955	0.985									
Win_1995						0.905	0.939	0.950								
Win_1996							0.870	0.922	0.968							
Win_1997								0.923	0.962	0.943						
Win_1998									0.920	0.889	0.953					
Win_1999										0.904	0.945	0.956				
Win_2000											0.926	0.925	0.965			
Win_2001												0.914	0.948	0.960		
Win_2002													0.869	0.880	0.865	
Win_2003														0.886	0.872	0.852

(e) Pure-technical efficiency in asset transformation

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Win_1990	0.975	0.968	0.993													
Win_1991		0.965	0.971	0.981												
Win_1992			0.997	0.956	1.000											
Win_1993				0.948	0.982	0.992										
Win_1994					0.978	0.964	1.000									
Win_1995						0.957	0.988	1.000								
Win_1996							0.930	0.975	0.994							
Win_1997								0.970	0.992	0.977						
Win_1998									0.961	0.943	1.000					
Win_1999										0.947	0.975	0.986				
Win_2000											0.959	0.959	0.999			
Win_2001												0.958	0.987	0.991		
Win_2002													0.904	0.900	0.898	
Win_2003														0.906	0.905	0.897

(f) Scale efficiency in asset transformation

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Win_1990	0.966	0.981	0.988													
Win_1991		0.976	0.976	0.958												
Win_1992			0.964	0.982	0.966											
Win_1993				0.989	0.976	0.999										
Win_1994					0.968	0.990	0.985									
Win_1995						0.947	0.951	0.950								
Win_1996							0.928	0.945	0.974							
Win_1997								0.950	0.969	0.965						
Win_1998									0.958	0.944	0.953					
Win_1999										0.955	0.969	0.970				
Win_2000											0.966	0.964	0.965			
Win_2001												0.952	0.959	0.969		
Win_2002													0.881	0.895	0.884	
Win_2003														0.903	0.890	0.876

Appendix 5: Mean estimated efficiency scores

(a) Intermediation process

	Win_ 1990	Win_ 1991	Win_ 1992	Win_ 1993	Win_ 1994	Win_ 1995	Win_ 1996	Win_ 1997	Win_ 1998	Win_ 1999	Win_ 2000	Win_ 2001	Win_ 2002	Win_ 2003	Average	St-dev
Technical efficiency																
All Banks	0.972	0.972	0.976	0.974	0.915	0.922	0.893	0.903	0.912	0.920	0.921	0.936	0.916	0.936	0.934	0.029
Saving	0.977	0.979	0.988	1.000	0.988	1.000	0.983	0.920	0.930	0.965	0.956	0.989	0.967	0.984	0.973	0.024
Commercial	0.972	0.971	0.975	0.970	0.902	0.909	0.882	0.901	0.899	0.911	0.909	0.924	0.901	0.925	0.925	0.032
State-owned	0.949	0.932	0.933	0.921	0.756	0.781	0.669	0.713	0.748	0.815	0.850	0.944	0.882	0.909	0.843	0.095
Privately-owned	0.983	0.991	0.995	0.994	0.976	0.973	0.953	0.964	0.949	0.943	0.926	0.919	0.907	0.929	0.957	0.029
Old	0.969	0.965	0.966	0.961	0.874	0.884	0.823	0.845	0.854	0.888	0.905	0.936	0.894	0.914	0.906	0.048
New	0.977	0.983	0.991	0.988	0.960	0.957	0.941	0.957	0.944	0.934	0.912	0.915	0.907	0.933	0.950	0.028
Pure-technical efficiency																
All Banks	0.996	0.990	0.994	0.991	0.987	0.991	0.984	0.981	0.977	0.982	0.981	0.981	0.979	0.974	0.984	0.026
Saving	1.000	1.000	0.991	1.000	1.000	1.000	1.000	1.000	0.978	0.978	1.000	1.000	1.000	1.000	0.997	0.007
Commercial	0.995	0.988	0.994	0.990	0.985	0.989	0.982	0.978	0.974	0.980	0.976	0.977	0.974	0.969	0.981	0.028
State-owned	0.999	0.973	0.983	0.974	0.985	0.997	0.973	0.944	0.942	0.953	0.957	0.998	0.997	1.000	0.977	0.037
Privately-owned	0.993	0.996	1.000	0.998	0.986	0.986	0.985	0.990	0.984	0.989	0.982	0.971	0.967	0.961	0.982	0.023
Old	0.999	0.986	0.992	0.987	0.991	0.997	0.984	0.968	0.970	0.977	0.979	0.999	0.996	0.991	0.987	0.028
New	0.987	0.993	1.000	0.996	0.975	0.975	0.980	0.988	0.977	0.984	0.974	0.960	0.956	0.954	0.974	0.026
Scale efficiency																
All Banks	0.977	0.982	0.982	0.982	0.926	0.930	0.905	0.917	0.931	0.935	0.938	0.954	0.936	0.962	0.945	0.079
Saving	0.977	0.979	0.997	1.000	0.988	1.000	0.983	0.920	0.953	0.988	0.956	0.989	0.967	0.984	0.981	0.022
Commercial	0.977	0.982	0.980	0.979	0.915	0.919	0.896	0.917	0.920	0.927	0.930	0.946	0.925	0.955	0.939	0.085
State-owned	0.949	0.957	0.948	0.945	0.767	0.783	0.686	0.749	0.788	0.851	0.884	0.946	0.885	0.909	0.860	0.118
Privately-owned	0.990	0.995	0.995	0.996	0.989	0.987	0.966	0.973	0.964	0.953	0.943	0.946	0.937	0.967	0.967	0.042
Old	0.970	0.978	0.974	0.973	0.881	0.887	0.833	0.866	0.875	0.906	0.922	0.938	0.897	0.922	0.916	0.103
New	0.989	0.990	0.991	0.992	0.983	0.982	0.958	0.967	0.965	0.948	0.936	0.953	0.948	0.978	0.964	0.045

(b) Asset transformation process

	Win_ 1990	Win_ 1991	Win_ 1992	Win_ 1993	Win_ 1994	Win_ 1995	Win_ 1996	Win_ 1997	Win_ 1998	Win_ 1999	Win_ 2000	Win_ 2001	Win_ 2002	Win_ 2003	Average	St-dev
Technical efficiency																
All Banks	0.958	0.944	0.956	0.963	0.962	0.931	0.920	0.942	0.921	0.935	0.939	0.941	0.951	0.943	0.942	0.057
Saving	0.996	1.000	1.000	0.993	0.993	1.000	1.000	1.000	0.995	1.000	1.000	1.000	1.000	1.000	0.994	0.010
Commercial	0.951	0.934	0.949	0.958	0.957	0.920	0.910	0.935	0.905	0.921	0.928	0.930	0.940	0.931	0.932	0.058
State-owned	0.971	0.941	0.933	0.929	0.958	0.894	0.895	0.892	0.855	0.896	0.894	0.895	0.928	0.882	0.912	0.069
Privately-owned	0.942	0.931	0.956	0.972	0.957	0.933	0.915	0.949	0.921	0.930	0.938	0.940	0.944	0.944	0.940	0.051
Old	0.970	0.956	0.955	0.953	0.962	0.913	0.914	0.907	0.861	0.887	0.901	0.910	0.922	0.904	0.922	0.060
New	0.914	0.891	0.935	0.967	0.947	0.934	0.907	0.963	0.948	0.956	0.950	0.946	0.955	0.949	0.943	0.052
Pure-technical efficiency																
All Banks	0.979	0.973	0.984	0.974	0.981	0.982	0.966	0.980	0.968	0.969	0.972	0.979	0.982	0.978	0.976	0.030
Saving	1.000	1.000	1.000	0.993	0.993	1.000	1.000	1.000	0.996	1.000	1.000	1.000	1.000	1.000	0.998	0.004
Commercial	0.975	0.968	0.982	0.971	0.979	0.979	0.962	0.977	0.960	0.963	0.968	0.974	0.979	0.973	0.972	0.031
State-owned	0.992	0.991	0.972	0.954	0.982	0.998	0.976	0.992	0.994	0.984	0.936	0.966	0.994	0.992	0.980	0.026
Privately-owned	0.967	0.956	0.987	0.979	0.977	0.969	0.957	0.972	0.949	0.956	0.977	0.976	0.974	0.969	0.969	0.032
Old	0.982	0.983	0.984	0.970	0.977	0.989	0.978	0.973	0.959	0.952	0.949	0.979	0.990	0.980	0.975	0.028
New	0.960	0.938	0.976	0.972	0.982	0.957	0.946	0.981	0.962	0.975	0.983	0.970	0.970	0.969	0.968	0.034
Scale efficiency																
All Banks	0.978	0.970	0.971	0.988	0.981	0.949	0.949	0.961	0.952	0.965	0.965	0.960	0.967	0.964	0.965	0.045
Saving	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000	1.000	0.996	0.008
Commercial	0.975	0.965	0.966	0.986	0.978	0.941	0.943	0.957	0.943	0.957	0.959	0.954	0.960	0.956	0.959	0.046
State-owned	0.979	0.950	0.959	0.973	0.975	0.895	0.916	0.899	0.860	0.910	0.956	0.925	0.933	0.889	0.930	0.064
Privately-owned	0.973	0.973	0.970	0.992	0.980	0.963	0.952	0.976	0.971	0.972	0.960	0.962	0.968	0.973	0.969	0.033
Old	0.988	0.972	0.970	0.981	0.985	0.923	0.933	0.933	0.900	0.933	0.950	0.929	0.931	0.923	0.946	0.054
New	0.950	0.950	0.959	0.995	0.965	0.975	0.952	0.981	0.986	0.980	0.967	0.974	0.984	0.978	0.973	0.031

Appendix 6: Nature of return to scale

(a) Efficiency in intermediation

		2002-04	2001-03	2000-02	1999-01	1998-00	1997-99	1996-98	1995-97	1994-96	1993-95	1992-94	1991-93	1990-92	1989-91
All banks	IRS	0	0	3	0	1	1	0	0	0	0	0	1	2	0
	CRS	17	12	11	14	16	16	16	15	14	12	13	13	13	11
	DRS	19	23	20	19	15	14	13	13	11	11	8	7	6	10
Savings	IRS	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	CRS	5	2	4	5	4	5	3	2	3	2	3	2	2	2
	DRS	1	4	2	1	2	1	2	2	0	1	0	0	1	1
Commercial	IRS	0	0	3	0	1	1	0	0	0	0	0	0	2	0
	CRS	12	10	7	9	12	11	13	13	11	10	10	11	11	9
	DRS	18	19	18	18	13	13	11	11	11	10	8	7	5	9
Privately-owned commercial	IRS	0	0	3	0	1	1	0	0	0	0	0	0	2	0
	CRS	11	9	6	6	10	10	12	13	11	10	10	10	8	6
	DRS	13	14	13	15	9	8	6	5	5	4	2	2	2	6
State-owned commercial	IRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CRS	1	1	1	3	2	1	1	0	0	0	0	1	3	3
	DRS	5	5	5	3	4	5	5	6	6	6	6	5	3	3
Old commercial	IRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CRS	2	1	3	5	5	3	3	4	4	5	6	6	7	7
	DRS	10	11	9	7	7	9	9	8	8	7	6	6	4	5
New commercial	IRS	0	0	3	0	1	1	0	0	0	0	0	0	2	0
	CRS	10	9	4	4	7	8	10	9	7	5	4	5	4	2
	DRS	8	8	9	11	6	4	2	3	3	3	2	1	1	4

(b) Efficiency in asset transformation

		2002-04	2001-03	2000-02	1999-01	1998-00	1997-99	1996-98	1995-97	1994-96	1993-95	1992-94	1991-93	1990-92	1989-91
All banks	IRS	3	3	4	8	8	7	3	1	1	6	0	3	7	6
	CRS	19	18	15	14	14	12	15	21	14	16	14	12	10	11
	DRS	14	14	15	11	10	12	11	6	10	1	7	6	4	4
Savings	IRS	0	1	2	2	1	3	1	0	0	0	0	0	0	1
	CRS	6	5	4	4	5	3	4	3	3	3	3	3	3	2
	DRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Commercial	IRS	3	2	2	6	7	4	2	1	1	6	0	3	7	5
	CRS	3	2	2	6	7	4	2	1	1	6	0	3	7	5
	DRS	13	13	11	10	9	9	11	18	11	13	11	9	7	9
Privately-owned commercial	IRS	14	14	15	11	10	12	11	6	10	1	7	6	4	4
	CRS	13	13	11	8	8	8	10	15	9	8	7	5	3	7
	DRS	8	8	9	7	5	7	6	3	6	0	5	4	2	0
State-owned commercial	IRS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CRS	0	0	0	2	1	1	1	3	2	5	4	4	4	2
	DRS	6	6	6	4	5	5	5	3	4	1	2	2	2	4
Old commercial	IRS	0	0	0	0	0	0	0	0	0	2	0	1	3	1
	CRS	1	1	1	3	3	3	4	9	5	9	7	7	6	7
	DRS	11	11	10	9	9	9	8	3	7	1	5	4	3	4
New commercial	IRS	3	2	2	6	7	4	2	1	1	4	0	2	4	4
	CRS	12	12	10	7	6	6	7	9	6	4	4	2	1	2
	DRS	3	3	5	2	1	3	3	3	3	0	2	2	1	0

Appendix 7: Regression results – Determinants of technical efficiency

Explanatory Variables	Commercial banks only		All banks -Significant variables only	
	T(I)	T(A)	T(I)	T(A)
Assets quality	-1.542 [-1.50]	-0.031 [-0.07]	--1.172*** [-2.94]	
Capital strength	0.374 [0.42]	0.242 [1.11]		0.0355 [0.35]
Collateral	-4.766 [-1.44]	-0.991 [-0.88]		
GIM	-0.177 [-0.37]	-0.040 [-0.23]		
Liquidity	0.851 [1.59]	-0.150 [-0.79]		
Profitability	5.994*** [2.56]	-1.475 [-1.22]	6.408*** [3.78]	
Purchased funds	1.669*** [3.70]	-0.137 [-1.11]	1.530*** [1.13]	
Operational risk	0.826** [2.17]	0.858*** [5.62]	0.767*** [5.41]	0.998*** [5.92]
Size	-0.042 [-1.08]	-0.001 [-0.04]		
Stock market capitalization	0.220*** [2.62]	0.053* [1.78]	0.242*** [3.57]	-0.087*** [-2.80]
GDP growth	-0.468 [-0.26]	0.241 [0.33]		
Inflation	-1.086 [-1.09]	0.224 [0.52]		
Commercial banks			-0.3751*** [-3.49]	-0.619*** [-5.21]
Privately-owned banks	-0.030 [-0.30]	-0.057 [-1.36]		-0.083*** [-3.11]
Old banks	0.092 [1.21]	-0.048* [-1.73]		-0.053** [-2.49]
Political change	-0.048 [-1.01]	-0.032 [-1.51]		
Intercept	0.891 [1.53]	0.569** [2.48]	0.940*** [10.49]	1.045*** [8.60]
R-squared	0.75	0.60	0.70	0.58
Adjusted R-squared	0.70	0.53	0.68	0.55
Log likelihood	168.03	215.99	197.67	236.23
Avg. log likelihood	1.87	2.12	190	2.13
Akaike info-criterion	-3.36	-3.90	-3.63	-4.11
Schwarz criterion	-2.88	-3.46	-3.53	-3.92
Jarque-Bera	14.90	2.84	29.23	1.411

['Z' values are in the parentheses, '***' indicates significant coefficients under 1% confidence level,'**' indicates significant coefficients under 5% confidence level and '*' indicates significant coefficients under 10% confidence level]

Appendix 8: Regression results - Market structure, efficiency and operational performance

Explanatory variables	NIM1[5] (Equation 6.1)	NIM2[6] (Equation 6.1)
MP	0.012 [0.46]	0.015 [0.60]
HHI	0.028 [0.44]	
SE(I)	0.098 [1.62]	0.097 [1.60]
TE(I)	-0.089 [-1.66]*	-0.087 [-1.64]
Risk	0.010 [1.24]	0.010 [1.27]
Capital strength	-0.032 [-2.21**]	-0.033 [-2.31]**
Assets quality	0.022 [0.46]	0.018 [0.39]
Liquidity	0.045 [2.81]***	0.048 [3.31]***
Inflation	-0.066 [-1.21]	-0.055 [-1.14]
GDPG	-0.145 [-1.36]	-0.122 [-1.31]
Old banks	-0.005 [-1.60]	-0.005 [-1.61]
Constant	0.025 [1.46]	0.027 [1.61]
R^2	0.270	0.269
Adjusted R^2	0.199	0.204
F-statistic	3.797	4.186
Jarque-Bera	376.130	384.000

['t' values are in the parentheses, '***' indicates significant coefficients under 1% confidence level,'**' indicates significant coefficients under 5% confidence level and '*' indicates significant coefficients under 10% confidence level]

[5] NIM1 excludes explanatory variables which are not considered as structural variables (such as commercial banks and privately owned banks) and have demonstrated higher correlation coefficients (more than 0.800) with other explanatory variables.

[6] NIM2 excludes all explanatory variables which have demonstrated higher correlation coefficients (more than 0.800) with other explanatory variables.

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