SRIPATUM UNIVERSITY

RESEARCH REPORT

THAI BANK EFFICIENCY DURING ECONOMIC RECOVERY PERIOD AND ITS RELATION TO STOCK RETURNS

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ABSTRACT

This study examines efficiency of 10 Thai commercial banks and their relations to stock returns. The analysis is conducted between 2001 and 2007 using a non-parametric frontier technique, Data Envelopment Analysis (DEA), to estimate profit efficiency. Then, the relationship between bank efficiency and stock return is examined. This paper makes key contributions to literature. To the best of author knowledge, this is the first study that investigates profit efficiency of Thai banks after the 1997 Financial Crisis. In addition, an important issue whether changes in a bank's efficiency are reflected in stock prices is addressed.

The main finding reveals that on average the profit efficiency of Thai bank is in the moderately high level at 85%. The results from the productivity analysis suggest that, on average, there is little improvement. Although Thai banks experienced an improvement in technical efficiency, this was partially offset by a contraction in their technology. Nonetheless, the total productivity of the restructured banks increased gradually and stood at a higher level than when the recovery period begins.

Finally, this study shows that the relationship between changes in profit efficiency and stock returns appears that the profit efficiency measured can explain about 10% of stock returns movement. One of explanations may be that the information on bank efficiency might be outweighed by other market information during the recovery period.

Keywords; Bank Efficiency, Stock Values, Data Envelopment Analysis

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Chapter 1

Introduction

1.1 Significance and Background of Research

Over the past decade, one of the key themes of post-crisis economy restructuring in East Asia has focused on the banking sector to transform into a market-based economy. After the East Asian crisis in 1997, which was originated in Thailand, most of the bank regulators in the countries affected by the crisis implemented measures to both improve and strengthen their banking systems. These measures included liquidity support, blanket guarantee on banks' liabilities, removal of bad loans, nationalisation, mergers, and relaxation of foreign bank entry barriers. Although such measures may vary by country, a significant common goal is to improve bank efficiency to maintain a viable banking system. Nonetheless, the effectiveness of such policies for the crisis affected countries has attracted very little investigation.

After struggling with NPLs and liquidity problems for several years, Thai commercial banks can make higher profit and has regained people and investors' trust. In 2005, Thai commercial banks, dominating the financial sector in Thailand, collected total deposits of 6,196,052 million baht, accounting approximately for 76.62 percent of total deposits of Thai financial institutions. Since 2002, capital adequacy ratio for Thai banks have been raised and stood at above 10%, with banks' balance sheets improving. The institutions have been becoming keen to lend once again to consumers, and bank credit growth has been back in positive territory for the first time since 1998. Almost all commercial banks in Thai financial sector are capable of making higher profits during the period of 2001 - 2007. However, to the best of author's knowledge, no study measures profit efficiency and productivity of the Thai banks during the recovery period of 2001 to 2006 systematically.

This study seeks to explore profit efficiency of Thai commercial banks, particularly during the crisis recovery period. Previous studies of bank profit efficiency have typically focused only on developed countries (e.g., the U.S., and Japan), which cannot be used as proper yardsticks for a developing country such as Thailand. Since the U.S. banking industry consists of distinct local markets, which are quite unconcentrated by world standards (Berger & Humphrey, 1997), the evidence from research based on the U.S. cannot be used as an appropriate benchmark for Thailand (which have concentrated banking sectors).

In addition, this study raises an issue whether changes in a bank's efficiency is reflected in stock prices. Kirkwood and Nahm (2006) find that the efficiency of an Australian bank's operation has significant information about its excess returns that is not explained by market movements. However, no previous research provides insight information on the relationship between Thai bank efficiency measured and its response by stock market. This observation provides the opportunity to address such gaps in research.

1.2 Research Objectives

This research aims to fill the gaps identified earlier and to contribute to theoretical and empirical development of bank profit efficiency. The aim of this study is to address the significant question of whether or not profit efficiency of Thai banks during the recovery period has improved. To accomplish this goal, an integrated bank efficiency analysis is developed with the following key objectives:

1. To measure profit efficiency of Thai bank during the recovery period,
2. To identify and measure impact of economic factors those may affect Thai bank efficiency during economic recovery period, and
3. To identify relationship between the efficiency measured and its response by the stock returns.

1.3 Research Questions

To achieve the proposed objectives, the following questions need to be answered:

1. What is the level of profit efficiency of Thai bank during the recovery period of 2001 to 2007?

2. Have the total factor productivity of Thai banking system improved during the economic recovery period?
3. What is the relationship between the efficiency measured and its response by the stock returns?

1.4 Research Propositions

Two propositions, which are guided by literature, are formed and to be tested systematically.

Proposition 1: The level of profit efficiency of Thai bank in 2007 was higher than the efficiencies measured in 2001.

Proposition 2: The profit efficiency measured has a relationship with the bank stock returns.

1.5 Scope of Research

The scope of the study is limited to the selected commercial banks in Thailand after the Asian banking crisis of 1997. The analysis is conducted between 2001 and 2007 for 12 banks listed on the Stock Exchange of Thailand. The scope is guided by the observation that during the early 1990s, the East Asian economies were recognised as the most successful in financial integration, attracting capital flows from other free-markets, and providing the preferred model for emulation by other developing countries (World Bank, 1993). However, the 1997 disruption in financial systems caused repercussions, around the world, in many other financial markets shortly after the crisis emerged (Radelet & Sachs, 1998). This implies that the stability of Thai economy is significant on a global basis to the world economy.

The investigation is intended to assist policy makers regarding post-crisis recovery of the banking sectors in developing countries, with emphasis on measuring relative efficiency of banks, as this has been claimed as a possible cause of the banking crisis.

1.6 Research Contributions

This study contributes to the theory of bank efficiency, as well as exploring bank efficiency during the crisis recovery period. It is the first study that investigates profit efficiency of Thai bank after the 1997 Asian Financial Crisis. Second, to the best of the author's knowledge, this research is the first efficiency study which applies both parametric and non-parametric approaches to the Thai banking system. Third, no study of Thai banking efficiency has measured productivity indices during the crisis recovery period after 2001. Finally, this research addresses an important issue whether changes in a bank's efficiency are reflected in stock prices. The relationship between changes in profit efficiency and stock returns provide significant information about its excess returns that may not be explained by market movements.

1.7 Definition of the Key Concepts

Definitions are gathered through extensive literature survey and constitute a useful reference to understanding precisely the concepts examined throughout the study. While definitions in the literature vary, more commonly used definitions of these concepts are shown below:

Decision Making Unit (DMU): An organisational unit of interest that has control over the process to convert its resources into outputs (Avkiran, 2006). A DMU in this study is a commercial bank in Thailand.

Efficiency: Maximising outputs with given resources. Cooper, Seiford, and Zhu (2004: p. 3) provide a definition of efficiency in the context of Pareto-Koopmans that "Full (100%) efficiency is attained by any DMU if and only if none of its inputs and outputs can be improved without worsening some of its other inputs or outputs." However, since true possible levels of efficiency cannot be known theoretically, then the preceding definition is replaced by the term 'Relative Efficiency', where "A DMU is to be rated as fully (100%) efficient on the basis of available evidence if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs."

Profit Efficiency: The ratio of maximum profit in the sample to the actual profit of the unit investigated. It is also known as economic efficiency or overall efficiency (Berger & Mester, 1997).

Technical Efficiency: A measure of ability of a production process in converting inputs to outputs (Charnes, Cooper, & Rhodes, 1978; Farrell, 1957).

Chapter 2

Literature Review

2.1 Introduction

This chapter provides an overview of the theory of bank efficiency. Section 2.2 illustrates an overview of Thai banking system. Then, section 2.3 reviews the concept of bank efficiency, and efficiency estimation using frontier techniques, followed by a discussion of X-efficiency and the efficient frontier in section 2.4. Section 2.5 highlights bank efficiency and bank efficiency estimation using the efficient frontier and the shortcomings of the literature. Finally, section 2.6 reviews literature on bank efficiency around the crisis period.

2.2 Overview of Thai Banking System

Generally, the financial sector in Thailand comprises three sectors: commercial banks, finance and securities companies, and insurance companies. The financial sector in Thailand has long been dominated by commercial banks, as in many other Asian countries, whereas finance and securities companies and insurance companies have gained importance in recent years. In 2006, there are 12 commercial banks, 35 finance and securities companies and 20 insurance companies which are the members of the Stock Exchange of Thailand (SET). Total deposits at Thai financial institutions are 8,086,648 million baht. Commercial banks, dominating the financial sector in Thailand, collect total deposits of 6,024,720 million baht, accounting approximately for 76.62 percent of total deposits at financial institutions, whereas finance and securities companies and insurance companies approximately account for 0.99 percent and 5.93 percent of total deposits, respectively.

During the early 1990s, Thai economy as well as the East Asian economies were recognised as the most successful in financial integration, attracting capital flows from other free-markets, and providing the preferred model for emulation by other developing countries (World Bank, 1993). However, the 1997 disruption in financial systems caused repercussions, around the world, in many other financial markets shortly after the crisis emerged (Radelet & Sachs, 1998). This implies that the stability of East Asian economies is significant on a global basis to the world economy.

After new regulations of restrictions on the issue of new banking, called financial market deregulation, and the establishment of Bangkok International Banking Facilities (BIBF) were implemented in 1993, Thai banking system which was based on client-based relationship banking was replaced by a new market-oriented competitive banking situation which may lead to inexperienced banks lending inappropriately, and thus contributing to financial crisis. Commercial banks and finance and securities companies lent inappropriately to real estate business, leading to enormous NPLs in every commercial banks and bankruptcy of 56 finance companies after the eruption of 1997 crisis.

Since the devaluation of Thai baht in 1997, Thailand has faced the currency crisis and switched to the floating exchange rate currency base. There was the basket exchange rate or pegged currency in Thailand that provided on US dollar usually equal to twenty five baht, yet immediately after the crisis, the baht depreciated to reach the worst point at fifty five baht per one US dollar within a few months later. The business environment for financial institutions deteriorated even further. The corporate borrowers' repayment burden on Banks with foreign currency liabilities increased suddenly. Moreover, the corporations also came under enormous financial pressure, since they had substantial foreign currency exposures without the hedging against exchange rate. Thus, many commercial banks and finance and securities companies faced loss and bankruptcy. The inefficiency in financial sector was claimed to be a major factor in the currency crisis (Bird & Rajan, 2001; Bongini, Claessens, & Ferri, 2001; Bongini, Laeven, & Majnoni, 2002; Dekle & Klezer, 2001; Kane, 2000; Kho & Stulz, 2000; Lauridsen, 1998; Reynolds, Ratanakomut, & Gander, 2000; Tai, 2004).

Now, a decade after the crisis, there are several changes in Thai financial sector. Several privately owned banks no longer exist in the aftermath of the 1997 financial crisis. Some were merged with other Thai commercial banks, while others were acquired by foreign commercial banks. For instance, the assets of Bangkok Bank of Commerce were transferred to Krungthai Bank. Union Bank was merged with Krung Thai Thanakit (a subsidiary of Krung Thai Bank) to become Bank Thai. Laem Thong Bank was merged with a new state owned bank called Radanasin Bank, which was later acquired by United Overseas Bank Limited (UOB) of Singapore and then was renamed UOB Bank. Nakornthon bank was also acquired by Standard Chartered Bank of UK and then was renamed Standard Chartered Bank Public Company Limited. Moreover, Thai Danu Bank was acquired by DBS Bank of Singapore and then was renamed and merged with Thai Military Bank as TMB Bank. Accordingly, it is clear that there is a change in ownership of Thai financial sector, that is, many commercial banks became foreign.

However, Thai economy as well as Thai financial sector has been claimed by the government and the authorities to be recovered. After struggling with NPLs and liquidity problems for several years, Thai financial sector can now make higher profit and has regained people and investors' trust. Almost all companies in Thai financial sector are capable of making higher profits during the period of 2001 – 2006 after struggling with awfully low profit or even a negative profit (loss) in 1998. The situation of Thai financial sector has been better since 2001 when all companies could have continuously earned profit. Still, people and investors have been questioning the performance in Thai financial sector, though. The efficiency in Thai financial sector after the crisis is one of the most interesting issues of both Thai and foreign investors.

2.3 Theory of Bank Efficiency

In the literature, bank efficiency studies can be separated into those that examine scale and scope efficiency and those that examine X-efficiency or frontier efficiency. The scale and scope studies estimate an average practice cost function, which relates bank costs to output levels and input prices (Berger, Hanweck, & Humphrey, 1987; Berger & Humphrey, 1992b; Evanoff & Israilevich, 1991; Ferrier & Lovell, 1990; McAllister & McManus, 1993; Mester, 1993, 1996). These studies implicitly assume that there is no X-inefficiency, and that the banks are using the same production function technology (Berger & Humphrey, 1992b; Evanoff & Israilevich, 1991).

However, the conventional studies on scale and scope economies are beset by a number of problems. For example, McAllister and McManus (1993) suggest that the commonly used translog cost function specification gives a poor approximation when applied to banks of all sizes. They address this problem by replacing the translog with one of several non-parametric estimation procedures, such as the kernel regression technique. Another potential difficulty in the scale efficiency literature is that most studies do not use a frontier estimation method. Scale and scope efficiency, theoretically, apply only to the efficient frontier, and the use of data from banks not on the frontier could confound scale efficiencies with differences in X-efficiency. In addition, Berger, Hunter, and Timme (1993) assert that the most important origin of cost problems in the banking industry is X-inefficiency or differences in managerial ability to control costs for any given scale or scope of production.

2.4 X-Efficiency and the Efficient Frontier

In the 1990s, the research focus shifted to X-efficiency, which estimates deviations in performance from that of best practice firms on the efficient frontier, holding constant a number of exogenous market factors such as the prices faced in local markets (Allen and Rai, 1996; Berger & Mester, 1997; English, Grosskopf, Hayes, & Yaisawarng, 1993; Mester, 1996). Traditionally, estimated efficiency indicators are based on the alternative use of production, cost, or profit frontiers. Berger and Mester (1997) assert that these different concepts of efficiency used in financial intermediaries' literature are one of the sources of variation in measured efficiency. The frontier can be defined in each case, for a set of observations, assuming that it is not possible to find any other observation above the frontier (in the case of the production and profit frontiers) or below it (in the case of cost frontier). Which concept should be used depends on the question being considered. For example, Berger et al. (1993) mentioned that, on average, banks' cost in their U.S. based study were about 20% above the efficient frontier. This means that a bank, on average, has costs around 20% more than a 'best-practice' bank producing the same outputs. Most of the sources of the inefficiencies are caused by inappropriate operations, such as excessive use of labour in branch offices, and financial inefficiency, such as excessive interest paid for funds.

Pastor, Perez, and Quesda (1997, p. 396) give the definition of the production frontier as “the maximum attainable level of output, given a level of input, or the minimum level of inputs required to produce a given output.” Alternatively, the cost (profit) frontier is associated with the minimum (maximum) level of costs (profits) that can be obtained given a set of output quantities and input prices. The use of cost frontiers makes possible the study of the bank efficiency in both its technical and allocative components. In the case of cost frontier, the knowledge of input prices is necessary, whereas in the case of the profit frontier, both input and output prices are needed.

2.5 Bank Efficiency Estimation Using the Efficient Frontier

A number of different frontier techniques in the banking literature have been used in estimating the efficiency of financial institutions. These techniques can be divided into two broad categories: parametric frontier approaches and non-parametric frontier approaches. They are different in the way they deal with measurement error; the parametric approaches recognise the presence of measurement error and capture it in the error term, whereas the non-parametric approaches assume that there is no statistical noise.

2.1.1. Parametric Frontier Approaches

Three main parametric frontier approaches have been widely used in the literature: the Stochastic Frontier Analysis (SFA), the Distribution Free Analysis (DFA), and the Thick Frontier Analysis (TFA). The SFA, introduced by Aigner, Lovell, and Schmidt (1977) and applied to banks by Ferrier and Lovell (1990), specifies a particular form for the production or cost function, usually a translog form, and allows for random errors. It assumes that the error term consists of inefficiencies, which follow an asymmetric distribution, usually a half-normal or truncated distribution, as well as random errors that follow a symmetric distribution, usually the standard normal distribution. For example, a production function can be defined as:

$$\ln y_i = x_i \beta + v_i - u_i, \quad (i = 1, \ldots, N), \tag{2.1}$$

where y_i is total output, x_i is vector of inputs, v_i is the two-sided random error, and u_i is a non-negative random variable representing inefficiencies. This model is called the stochastic frontier production function because the output variables are bounded from above by the stochastic or random variable, $\exp(x_i\beta + v_i)$. The random error, v_i, can be positive or negative and therefore, the stochastic frontier outputs vary regarding the deterministic part of the frontier model, $\exp(x_i\beta)$ (Coelli, Rao, & Battese, 1998). The efficiency results depend critically on the skewness of the data; any inefficiency components that are more or less symmetrically distributed will tend to be measured as random error and any random error components that are more or less asymmetrically distributed will tend to be measured as managerial inefficiency.

The Distribution Free Analysis (DFA), applied to a bank study in Berger (1993), also assumes a functional form for the production or cost frontier, but separates the inefficiencies from random errors in a different way. Bauer and Hancock (1993) and Berger (1993) found that when the inefficiencies were unrestricted, they were more like symmetric normal distributions rather than the half-normal assumption in SFA (indicating the inefficiencies). This approach assumes that the inefficiency of each bank in a panel dataset is constant over time whereas the random errors tend to level out to zero over time. The inefficiency estimate of each bank is then measured as the difference between its average residual from the estimated cost function and that of the bank on the cost efficiency frontier. The distribution of inefficiencies can follow almost any form, as long as they are non-negative. However, if efficiency is changing over time due to technological change, regulatory reform, or the economic cycle, then DFA may describe the average deviation of each bank from the best average practice frontier, rather than the efficiency at any point in time (Berger & Humphrey, 1997).

The Thick Frontier Analysis (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 & Humphrey, 1991; Shaffer, 1993). The residuals for both functions are assumed to represent only random error, while the predicted difference between the two functions is assumed to represent X-efficiency differences. The TFA is intended to provide an estimate of the general level of overall efficiency, rather than provide point estimates of efficiency for individual firms. For example, Figure 2.1 shows the variation in average cost by bank size class. Differences between the most efficient (AC_{low}) and the least efficient quartile (AC_{high}) roughly represent inefficiency.

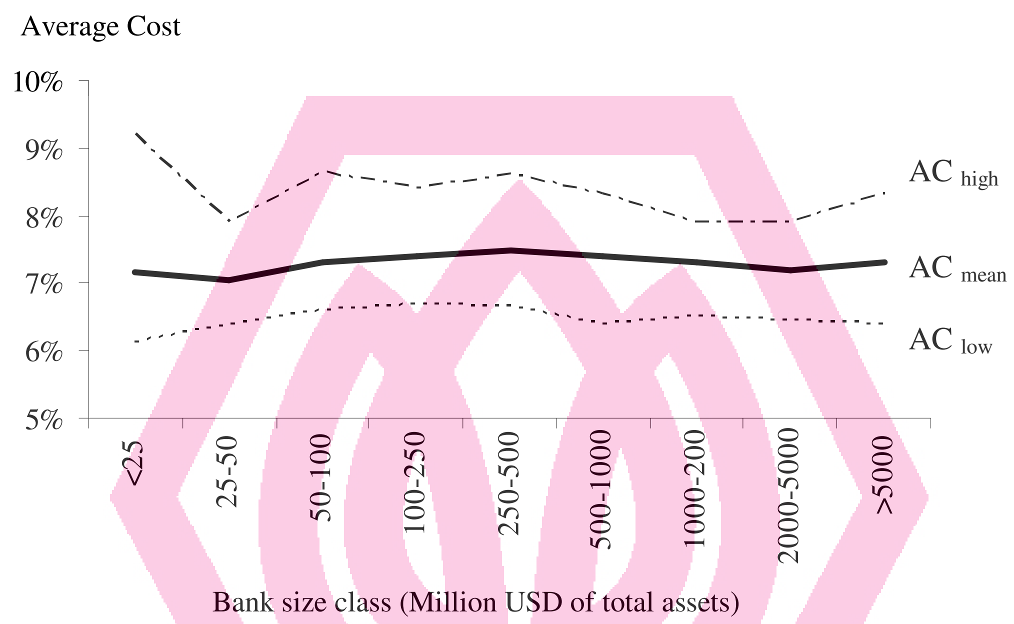

Figure 2.1 Thick Frontier Cost Efficiency

An advantage of TFA is that it reduces the effect of extreme points in the data when the extreme average residuals are truncated. The measured efficiency under the TFA, however, is indeed sensitive to the assumptions about which fluctuations are random and which represent efficiency differences. For example, the TFA may mistake one for the other if random errors follow a thick-tailed distribution and tend to be large in absolute value, while inefficiencies follow a thin-tailed distribution and tend to be small (Berger & Humphrey, 1997).

2.1.2. Non-Parametric Frontier Approaches

Non-parametric frontier approaches, such as Data Envelopment Analysis (DEA) by Charnes, Cooper and Rhodes (1978), and Free Disposal Hull (FDH) by Desprins, Simar, and Tulken (1984) impose no structure on the specification of the best-practice frontier. DEA is a linear programming technique where the set of best-practice or frontier observations are those for which no other decision making unit (DMU) or linear combination of units has as much or more of every output or as little or less of every input. The DEA frontier is formed as the piecewise linear combinations that connect the set of these best-practice observations, yielding a convex production possibilities set. Therefore, DEA does not require the explicit specification of the underlying production relationship. There are two widely used DEA models. The first, developed by Charnes et al. (1978) assumes constant returns to scale (CRS). The second, developed by Banker, Charnes, and Cooper (1984) assumes variable returns to scale (VRS). These models are respectively known as the CCR and BCC models.

The Free Disposal Hull (FDH) approach is a special case of the DEA model where the points on lines connecting the DEA vertices are not included in the frontier. Instead, the FDH production possibilities set is composed only of the DEA vertices and the free disposal hull points interior to these vertices. Because the FDH frontier is either congruent with or interior to the DEA frontier, FDH will typically generate larger estimates of average efficiency than DEA (Tulkens, 1993). Either approach permits efficiency to vary over time and makes no prior assumption regarding the form of the distribution of inefficiencies across observations except that undominated observations are fully efficient.

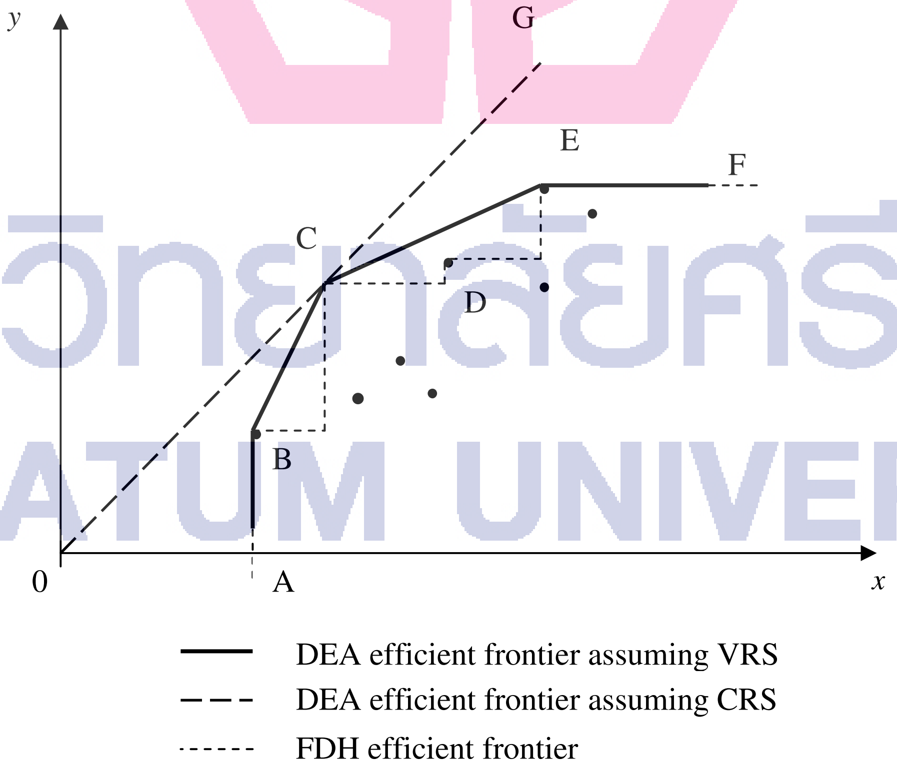

Figure 2.2 Shape of Efficient Frontiers Measured by DEA and FDH Methods

Figure 2.2 (adapted from Tulkens, 1993) illustrates the shapes of the efficient frontier for the one input-one output case. Where the FDH efficient frontier is the staircase line *ABCDEF*, the DEA frontier assuming VRS is the line *ABCEF*. The frontier *0CG* represents the DEA frontier assuming CRS.

A key drawback of the non-parametric approaches is that they generally assume no random error. There is assumed to be no measurement error in constructing the frontier, and no luck that temporarily gives a decision making unit better measured performance over other units. Any of these errors that did appear in an inefficient unit's data may be reflected as a change in its measured efficiency. What may be more problematical is that any of these errors in one of the units on the efficient frontier may alter the measured efficiency of all the units that are compared to this unit or linear combinations involving this unit.

2.6 A Survey of Bank Efficiency Studies

To date, only a few studies have investigated banks' efficiency around a banking crisis in Asian countries although there is a claim that bank inefficiency is a cause of banking crisis. Kwan (2003) examines the banking industry's per unit operating costs in seven East Asian economies, namely, Hong Kong, Indonesia, Malaysia, Philippines, Singapore, South Korea, and Thailand, from 1992 to 1999. Prior to the 1997 crisis period, the author finds that bank operating costs among these Asian countries were declining from 1992 to 1997, indicating that banks, on average, were improving their operating performance over time. Laeven (1999), however, argues that, on average, the increase in calculated efficiency before the East Asian banking crisis in 1997 was due to excessive risk-taking instead of a true increase in efficiency. This is because these countries experienced extremely high loan growths, but *ex-post* it was known that a substantial part of those loans were nonperforming, and therefore risky. The author also indicates that foreign-owned banks took little risk relative to other banks in the East Asian region, and those family-owned banks, were among the most risky banks.

Karim (2001), who used the stochastic frontier analysis to assess efficiency of banking industries in four South East Asian countries prior to the crisis in 1997, provides different results from the aforementioned studies. The author indicates that cost inefficiencies in South East Asian banks tend to increase over the year preceding the crisis, and suggests that the problem of bank failures may have been related to inefficiency.

Alam and Leightner (2001) analyses the dynamics of productivity of Thai banks over the period of 1989 to 1998, including the impact of the financial crisis of recent history. They find productivity increased substantially in the wake of Thailand's financial liberalisation (1992 to 1996); this was followed by a precipitous fall during the crisis (1996 to 1997). To test the robustness several specifications are undertaken: four models (differing with respect to whether or not risk and deposits are included as inputs), and two frontiers (one where banks and finance companies are treated separately, the other where the data are pooled) are analysed.

Turning to the post-crisis period, Kwan (2003) notes that Asian banks were incurring additional costs in dealing with their problem loans while output was simultaneously declining after the 1997 Asian banking crisis. Moreover, the proportion of labour costs to total costs is found to decline significantly between 1997 and 1999. This suggests that banks were adjusting their labour input upon falling demand but were less flexible in reducing physical capital input.

Chansarn (2005) investigates the productivity in Thai financial sector after the financial crisis (1998 – 2004) by looking at the total factor productivity (TFP) growth. Based on the sample of 12 commercial banks, 13 finance and securities companies and 20 insurance companies listed on the Stock Exchange of Thailand (SET) over the period of 1998 – 2204, the other reveals that the productivity in Thai financial sector, commercial bank sector and finance and securities company sector was diminishing over the period of 1998 – 2004, while the productivity in insurance company sector remained unchanged over the same period. However, the sharp decrease in productivity in these three sectors occurred only over the period of 1998 – 1999, while the productivity was decreasing very slightly over the period of 1999 – 2004.

Regarding relationship between efficiency and stock returns, Kirkwood and Nahm (2006) used Data Envelopment Analysis to evaluate cost efficiency of Australian banks in producing banking services and profit between 1995 and 2002. Empirical results indicate the major banks have improved their efficiency in producing banking services and profit, while the regional banks have experienced little change in the efficiency of producing banking services, and a decline in the efficiency of producing profit. They attempt to measure relationship between the changes in efficiency and stock returns. Results indicate that changes in firm efficiency are reflected in stock returns.

Sufian and Majid (2007) utilised the Data Envelopment Analysis (DEA) window analysis method to investigate the long-term trend in efficiency change of Singapore commercial banks during the period of 1993-2003. They found that listed Singapore commercial banks had exhibited an average overall efficiency of 95.4% and suggest that the small Singapore commercial banks have outperformed their large and very large counterparts. They further investigated relationship between cost efficiency and share price performance by employing panel regression analysis. The evidence seems to indicate that the changes in stock prices tend to reflect cost efficiency albeit with small degree of reaction. This suggests that stock of cost efficient banks to some extend outperform cost inefficient banks.

2.7 Chapter Summary

This chapter focuses on the development of the theoretical background of bank efficiency. It appears that research regarding bank efficiency in a developing country such as Thailand lags behind studies based on the U.S. and other developed countries. There is only a handful of research that focuses on bank efficiency in the time frame around a crisis period; and a study on the impact of the post-crisis restructuring on bank profit efficiency in Thailand is lacking.

Chapter 3

Research Methodology

3.1 Introduction

This chapter sets out the methodology to test the propositions discussed in the previous chapter by using non-parametric and parametric frontier approaches. Section 3.2 provides an overview of data. Section 3.3 justifies bank behaviour, and the choice of inputs and outputs in the empirical analysis is discussed in section 3.4. The methodology starts with a non-parametric frontier approach to measure profit, and technical efficiencies in Section 3.5. Section 3.6 illustrates a parametric approach to estimate bank profit efficiency in order to investigate the robustness of findings. Malmquist Productivity Index (MPI) is calculated to measure total factor productivity changes during 2001 to 2007 in section 3.7, then, relationships between the efficiency estimated and stock returns are tested using a Tobit regression in section 3.8. Finally, the relationship between the efficiency estimated and stock returns will be tested using the Sharpe-Lintner's CAPM.

3.2 Data

To answer the research questions, this study applies both non-parametric and parametric efficient frontier approaches to analyse the data. Thai commercial bank data, which experienced a severe banking crisis in 1997, were collected as an empirical case to determine efficiency level of the commercial banks during the recovery period.

3.2.1 Sample Selection

Although there are more than 12 banks operating in Thailand, only those surviving throughout the seven-year period (2001 to 2007) are included in the study. This facilitates focusing on changes in banks' operations during the recovery period of post-crisis restructuring. The minimum requirement of five years helps to distinguish reliably between statistical noise and bank inefficiency in the errors of estimated cost functions in the parametric analysis (Fries & Taci, 2005). In addition, to test the proposition for a relationship between efficiency and stock returns, only banks that have been listed in the Stock Exchange of Thailand are included in the sample.

The study sample comprised 12 commercial banks listed in the Stock Exchange of Thailand. Annual bank data from 2001 to 2007 are used to estimate technical and profit efficiencies. Although the date of completion of bank crisis restructuring is somewhat different for each bank, most of the restructuring efforts were completed by 2001, following which the restructured banks were fully exposed to market forces. Therefore, this study marks the year 2001 as the starting point of bank recovery period.

Unconsolidated financial data of commercial banks are mainly obtained from the Setsmart database, which provides a homogenous bank classification and reliable data. Additional data regarding bank regulations and policies are obtained from the official publications of the Bank of Thailand and the Ministry of Finance, whilst stock returns data are collected from the Stock Exchange of Thailand. The data are adjusted for inflation using the gross domestic product deflator (GDPD) from International Financial Statistics (IFS) published by IMF.

3.3 Bank Behaviour

Modelling the production and cost functions of banks, which have multiple services and products, raises a long-standing debate on the definition of the inputs and outputs of banks. There are two main schools of thought on bank behaviour, which have been widely used in the banking literature. The first is the intermediation approach, which views a bank as a mediator of funds between depositors and investors (Sealey & Lindley, 1977). Following this concept, deposits, labour and physical capital are regarded as inputs being converted into loans. The second is the production approach, which emphasises the role of banks as providers of services for account holders. With this view, banks are regarded as using inputs such as labour and capital to generate deposits and loans. While the production approach is probably better able to evaluate the efficiency of bank branches, the intermediation approach may be better for the evaluation of banks in their entirety (Cavallo & Rossi, 2002).

There are also other approaches to modelling bank behaviour. For example, under the value-added approach, high value creating activities such as making loans and taking deposits are classified as outputs, whereas labour, physical capital, and purchased funds are regarded as inputs (Avkiran, 2007; Wheelock & Wilson, 1995). Lastly, the user-cost approach regards an asset as an output if the financial returns are higher than the cost of funds. This is similar to a liability item which is classified as an output if the financial costs are less than the opportunity cost (Berger & Humphrey, 1992a).

Since one of the key aims of bank restructuring is to improve the banking system's capacity to provide financial intermediation between savers and borrowers (Dziobek & Pazarbasioglu, 1997), the intermediation approach is preferable in this study. This is similar to many other studies (e.g., Gilbert & Wilson, 1998; Isik & Hassan, 2002; Kraft & Tirtiroglu, 1998), which examine bank efficiency during a period of regulatory changes in developing and transition countries. The intermediation approach normally includes interest expense, which is a large proportion of any bank's total costs (Berger & Humphrey, 1991; Elyasiani & Mehdian, 1990). Section 3.4 below discusses the choice of inputs and outputs for the empirical tests that follow the intermediation approach.

3.4 Inputs and Outputs in the Core Profit Efficiency Model

Variables in the core profit efficiency model in the current study include interest expense and non-interest expense as inputs, while outputs are interest income and non-interest income. Effectively, banks' profit efficiency is measured because these are costs and revenues as per banks' profit and loss statements. Also, the concept of profit efficiency is considered superior to cost efficiency because, "Profit efficiency accounts for errors on the output side as well as those on the input side…" and that errors on the output side can be as large or larger (Berger & Mester, 1997, p.900).

The choice of interest income instead of the more common net interest income merits further comment (the latter is defined as interest income less interest expenses). Using net interest income in profit efficiency modelling can confound estimates. For example, referring back to the interest rate example given in the introduction, substituting interest income for net interest income could minimise the inbuilt bias regarding high interest rate risk whereby efficiency estimate could decline (as interest rates rise) even in the absence of any change in the average margin between deposit and lending rates. To understand this better, consider the influence of rising interest expense on the output side of the efficiency model when it effectively reduces the output variable net interest income. Swapping of the output variables removes the bulk of the impact of change in interest rates attributed to endogenous factors such as asset liability management decisions.

The inputs and outputs in the core profit efficiency model are broadly consistent with the intermediation approach to modelling bank behaviour. Consistent with the literature, this parsimonious input/output set is appropriate for covering the full range of resources used and outputs created, while providing adequate discriminatory power. Examples of other studies where these similar variables are used include: Yue (1992), Bhattacharyya et al. (1997), and Leightner and Lovell (1998).

3.5 Non-Parametric Approaches to Efficiency Measurement

In the first part of empirical testing, the relative efficiency of banking sectors in Asian developing countries will be examined using Data Envelopment Analysis (DEA) techniques. Data Envelopment Analysis, introduced by Charnes et al. (1978), is a linear programming technique where the set of best-practice or frontier observations are those for which no other decision making unit (DMU) or linear combination of units has as much or more of every output or as little or less of every input. This is known as the Pareto-Koopmans efficiency. The DEA frontier is formed as the piecewise linear combinations that connect the set of these best-practice observations, yielding a convex production possibilities set. Therefore, DEA does not require the explicit specification of the form of the underlying production relationship, which is theoretically unknown. Another advantage of DEA is that it performs well with a small number of observations (Evanoff & Israilevich, 1991).

However, a key drawback of DEA is that it assumes no random error. That is, DEA assumes there is no measurement error in constructing the frontier, and no luck that temporarily gives a decision making unit better measured performance over other units. Any of these potential errors that appear in a unit's data may be reflected as a change in its measured efficiency. DEA may be cast in either an output-maximising (e.g. profit maximisation) or an input-minimising (e.g. cost minimisation) role.

3.5.1 DEA Profit Efficient Frontier

To estimate the profit efficiency for each bank, the first step is to construct an efficient frontier by solving the following linear program (Chu & Lim, 1998).

$$\begin{aligned} \text{max} \quad & w = p_0 y - c_0 x \\ \text{subject to} \quad & x = X\lambda \le x_0, \\ & y = Y\lambda \ge y_0, \\ & L \le e\lambda \le U \\ & \lambda \ge 0 \end{aligned} \tag{3.1}$$

where x and y are a non-negative input and output vectors used by a bank, and ϕ is the calculated profit-maximising vector for bank i, given cost of input (c_0) and revenue of output (p_0). When the variable returns to scale (VRS) is applied, L as well as U are equal to 1, whereas L = 0 and U = ∞ in the case of constant returns to scale (CRS). The variable returns to scale assumption is preferred in this study because the imperfect competition environments in a developing country may cause a bank not to operate at optimal scale; hence, assuming constant returns to scale (CRS) may provide inaccurate inferences.

In the second step, based on an optimal solution from the above linear programming problem, the individual profit efficiency scores are given in Equation 3.2.

$$E_p = \frac{p_0 y_0 - c_0 x_0}{p_0 y^* - c_0 x^*} \tag{3.2}$$

where y_0, x_0 are vectors of observed values for DMU$_0$ and y^*, x^* are the optimal values from a profit maximising linear program. If the bank is profitable to any extent, that is, $p_0 y_0 > c_0 x_0$, then $0 < E_p \le 1$. If E_p = 1, DMU$_0$ is considered to be profit efficient.

3.5.2 DEA Technically Efficient Frontier

To measure technical efficiency based on the variable returns to scale assumption (TE_{VRS}), which is also known as pure technical efficiency (*PTE*), the BCC model (Banker et al., 1984) assuming output maximisation (output orientation) is applied. Pure technical efficiency scores for banks are calculated by solving the following input-oriented BCC linear program:

$$\begin{aligned} &\mathbf{min}_{\theta,\lambda}\,\theta \\ \text{subject to}\quad & -\mathbf{y_i} + \mathbf{Y\lambda} \geq 0, \\ & \theta\,\mathbf{x_i} - \mathbf{X\lambda} \geq 0, \\ & \mathbf{I1'\lambda} = 1, \\ & \boldsymbol{\lambda} \geq 0, \end{aligned} \tag{3.3}$$

where x ≥ 0 is an input vector, and y ≥ 0 is an output vector, used by a bank, X = [x1,…, xI] is an N x I matrix of input vectors, Y = [y1,…, yI] is an M x I matrix of output vectors, $\boldsymbol{\lambda}$ = [λ1,…, λI] is an I x 1 vector of peer weights, and there are I banks in the sample. The term **I1**= [1,…, I] is an I x1 vector, the convexity constraint for the variable returns to scale assumption.

3.5.3 Assigning Weights in DEA

In the standard DEA models such as the CCR (Charnes et al., 1978), the procedure does not require a priori knowledge on any of the input and output weights, so a decision making unit (DMU) has complete freedom to select the weights that are most favourable for its assessment to achieve the maximum efficiency score. This freedom of choice is based on an assumption that no input or output is more important than any other. However, the weights assigned by the optimisation process may not always be suitable in practice since inputs and outputs may not be equally important to management (Thanassoulis, Portela, & Allen, 2004). To become an efficient unit, a DMU may maximise only one of its outputs or minimise only one of its inputs, while assigning zero weights to the remaining inputs and outputs. Hence, this unit becomes a maverick or operates in different ways from its peer, and thus, is not a genuinely efficient DMU.

3.5.3.1 Cross-Efficiency Analysis

As mentioned earlier, a DMU can be rated as fully efficient even though a DMU may have been rated on only one of the variables. Under such circumstances, the researcher may introduce additional constraints to prevent such a maverick from becoming efficient. However, doing so may raise another issue in interpretation. For example, Allen, Athanassopoulos, Dyson, & Thanassoulis (1997) have shown that direct weights restrictions create problems in interpreting DEA results. Under weights restrictions, the efficiency measure obtained cannot be interpreted as a radial expansion of outputs or contraction of input levels. Therefore, this section suggests cross-efficiency analysis, which is based on the concept of peer evaluation, instead of a self-evaluation (Sexton, Silkman, & Hogan, 1986), as a precursor to deciding whether applying weights restrictions is needed.

In cross-efficiency analysis introduced by Sexton et al. (1986), the efficiencies determined for each DMU are calculated by using optimal weights for the other DMUs. Therefore, each DMU will have *n*-1 cross-efficiencies where *n* is the total number of DMUs. Table 3.1 (adapted from Doyle & Green, 1994) illustrates a cross-efficiency matrix using five DMUs.

Table 3.1 Matrix of Cross-Efficiencies for DEA Involving Five DMUs

Rating DMU	**Rated DMU**					**Averaged appraisal of peers**
	1	2	3	4	5	
1	$\mathbf{E_{11}}$	E_{12}	E_{13}	E_{14}	E_{15}	$\boldsymbol{A_1}$
2	E_{21}	$\mathbf{E_{22}}$	E_{23}	E_{24}	E_{25}	$\boldsymbol{A_2}$
3	E_{31}	E_{32}	$\mathbf{E_{33}}$	E_{34}	E_{35}	$\boldsymbol{A_3}$
4	E_{41}	E_{42}	E_{43}	$\mathbf{E_{44}}$	E_{45}	$\boldsymbol{A_4}$
5	E_{51}	E_{52}	E_{53}	E_{54}	$\mathbf{E_{55}}$	$\boldsymbol{A_5}$
	$\boldsymbol{e_1}$	$\boldsymbol{e_2}$	$\boldsymbol{e_3}$	$\boldsymbol{e_4}$	$\boldsymbol{e_5}$	
	Averaged appraisal by peers					

Reading down the columns in Table 3.1, a DMU is rated by multiplying its inputs and outputs with the weights of other units. On the other hand, reading along the rows shows the relationship of a DMU's weights applied to other DMUs' variables. The leading diagonal represents each DMU's efficiency score derived from the initial DEA computation. For example, the cross efficiency E_{12} is the cross efficiency of DMU_2 using DMU_2's variables and DMU_1 weights, while E_{22} represents its own variables and weights or the original efficiency score from DEA. Therefore, the average of column 2 (e_2) can be interpreted as an averaged appraisal of DMU_2 by its peers (i.e., average of cross-efficiency for DMU_2). In contrast, averaging along row 2 (A_2) shows the result of how other units perform by using DMU_2 weights. This is the so-called averaged appraisal of peers.

To detect maverick DMUs, the so-called maverick index (Doyle & Green, 1994), is calculated. The maverick index for bank k (M_k) can be explained as

$$M_k = \frac{(E_{kk} - e_k)}{e_k}, \text{ and } \quad e_k = \frac{\sum_{s \neq k} E_{sk}}{(n-1)}, \qquad (3.4)$$

where E_{kk} is the technical efficiency score of the bank k or self appraisal, and e_k refers to mean cross-efficiency or mean peer appraisal. The higher the index value, the more of a maverick is bank k. Since there is no standard cut-off point for determining which DMUs are mavericks, the value above two is preferred as a conservative rule of thumb (Avkiran, 2007; Hartman, Storbeck, & Brynes, 2001) and to be consistent with a benchmark for identifying outliers in section 3.5.4 later on. Therefore, banks with a maverick index value of two or higher are regarded as maverick DMUs.[1]

3.5.4 Slacks-Based Measure of Technical Efficiency

In the previous section, the traditional DEA models (the CCR and the BCC models) that measure technical efficiency in a scalar measure θ^* are presented. Since θ^* accounts for the proportionate change (radial) in input/output values, but neglects the existence of non-radial inefficiencies[2], a DMU may have the full efficiency score of 1 following the BCC model, although it has input excesses. Figure 3.1 illustrates the

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[1] However, note that the above procedure does not apply to the BCC technical efficiencies (TE_{VRS}). This is because the non-linear relationship between variables and scale effects in the model may result in negative cross-efficiency scores, making the interpretation problematic.

[2] Non-radial inefficiency is commonly known as 'slack'. Slacks refer to excesses in inputs (input slacks), or shortfalls in outputs (output slacks) (Tone, 2001).

example of radial and non-radial measures of efficiency using two inputs, x_1 *and* x_2, and one output *y*.

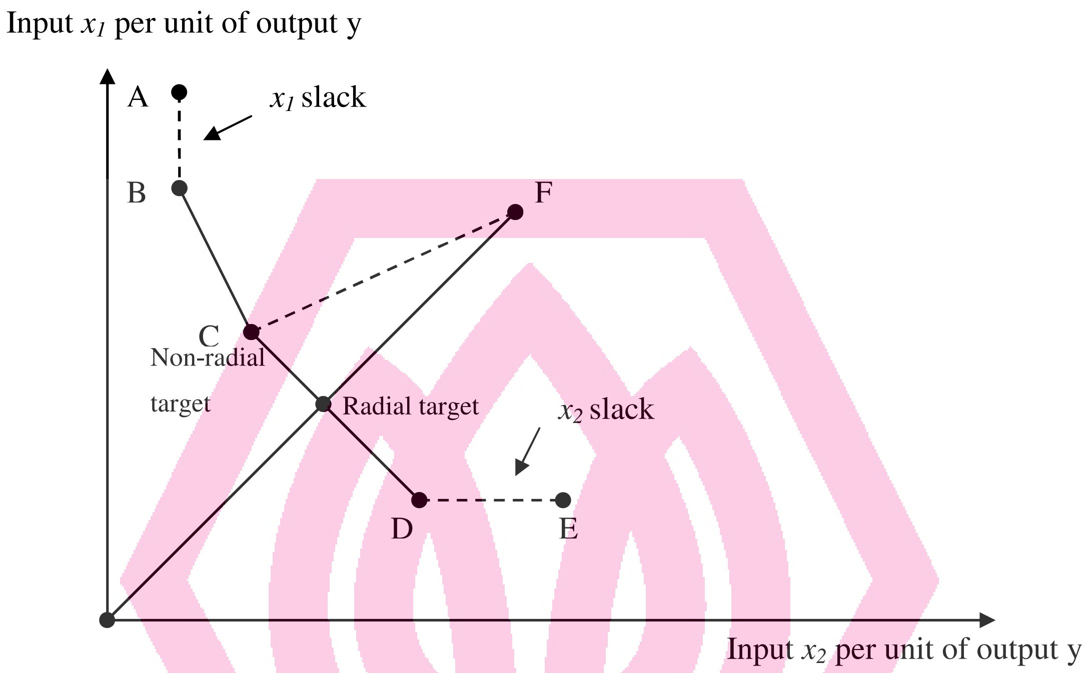

Figure 3.1 Radial and Non-Radial Efficiency (Input Orientation)

Consider the six DMUs in Figure 3.1 (adapted from Zhu, 2003). Following a radial DEA model (e.g., the BCC model), DMUs A, B, C, D and E are efficient, and DMU F is inefficient. However, when non-radial inefficiencies or slacks are accounted for, DMUs A and E are recognised as inefficient since they have non-zero slack on the input x_1, and the input x_2, respectively (i.e., DMU A can reduce the use of input x_1 to point B, while DMU E can reduce the use of input x_2 to point D). In addition, to obtain the efficiency score for DMU F, the radial DEA model selects a convex combination of DMUs C and D as the efficient target, whereas a non-radial DEA model selects DMU B as the efficient target.

Although Charnes, Cooper, Golany, Seiford, and Stulz (1985) developed the additive model of DEA, which deals directly with input excesses and output shortfalls, the model has no scalar measure like θ^* in the CCR model. To overcome this issue, Tone (2001) proposes a slacks-based measure (SBM), which identifies non-radial inefficiency in the scalar measure known as ρ.

To recall, following the BCC model, a DMU is rated as fully efficient if its radial efficiency score $\theta^* = 1$; that is, there is zero radial inefficiency. In such a case, the SBM score ρ^* can be equal to or less than 1. For example, if $\rho^* = \theta^* = 1$, it implies that there is zero radial and non-radial inefficiency. However, if $\rho^* < 1$ where $\theta^* = 1$, it refers to the situation where the DMU is radially efficient, but there are some non-radial inefficiencies. In general, $\rho^* \leq \theta^*$.

Since the radial measures discussed in the previous sections neglect the presence of slacks, and may overstate the efficiency measures, the input-oriented SBM model assuming variable returns to scale in Equation 3.5 is formulated to investigate whether there are any slacks that were not accounted for by the radial models.

$$\begin{aligned} \min \rho_{in} &= 1 - \frac{1}{N}\sum_{i=1}^{N} \mathbf{s}_i^- / \mathbf{x}_i^o \\ \text{subject to} \quad \mathbf{x}^o &= \mathbf{X}\boldsymbol{\lambda} + \mathbf{s}^-, \\ \mathbf{y}^o &= \mathbf{Y}\boldsymbol{\lambda} - \mathbf{s}^+, \\ \sum_{j=1}^{I} \boldsymbol{\lambda}_j &= 1, \\ \boldsymbol{\lambda} &\geq 0, \\ \mathbf{s}^- &\geq 0, \\ \mathbf{s}^+ &\geq 0 \end{aligned} \tag{3.5}$$

where $\mathbf{x}$ is a DMU's N x 1 vector of inputs, $\mathbf{y}$ is a DMU's M x 1 vector of outputs, $\mathbf{s}^-$ and $\mathbf{s}^+$ are vectors of input and output slacks, respectively, and $\mathbf{X}\boldsymbol{\lambda}$ and $\mathbf{Y}\boldsymbol{\lambda}$ represent benchmark input consumption and output production. Inputs and outputs for the unit evaluated are indicated by the superscript 'o' and the linear program is solved once for each unit in the sample. The term $\sum_{j=1}^{I} \boldsymbol{\lambda}_j = 1$ is the constraint to invoke variable returns to scale. A bank is evaluated as efficient if the optimal value for the objective function equals one ($\rho^* = 1$). That is, the efficient bank will have zero input slacks.

Besides the ability to identify slacks, another advantage of the SBM model is that it does not have to be oriented (unlike the CCR and BCC models that require a distinction between input orientation and output orientation). Therefore, it can combine two orientations together to deal with the reduction in inputs and the expansion in outputs at the same time; such a measure of SBM is called non-oriented.

Also, this model does not suffer from the infeasibility of linear programming solutions. Thus, the non-oriented SBM is used to identify potential outliers in the next section.

3.5.5 Potential Outliers in DEA

A disadvantage of using DEA as a frontier technique is its sensitivity to outlying observations. Although the data are first screened for potential univariate outliers with standard procedures, the non-oriented SBM model (Tone, 2002) is used to obtain super-efficiency scores in search of outliers. As mentioned earlier, this model does not suffer from the infeasibility of linear programming solutions, and it can simultaneously capture both input and output inefficiencies. It therefore provides more comprehensive inferences in identifying potential outliers than Andersen and Petersen's (1993) super-efficiency model, which is based on the input-oriented BCC model.

The variable returns to scale assumption (VRS) is applied in the non-oriented SBM model. As mentioned previously, the VRS assumption is superior to constant returns to scale (CRS) because the CRS assumption is only appropriate when all banks are operating at an optimal scale, which is unlikely in imperfect markets such as a developing country. Imperfect market competition, regulations, and other macro-economic factors may cause a bank to fail to operate at an optimal scale; hence, assuming constant returns to scale in the sample of this study is not appropriate in identifying potential outliers. Although no standard cut-off exists for determining which efficient DMUs are outliers, a conservative rule of thumb is preferred where banks with super-efficiency scores of two or higher are regarded as potential outliers in the analysis (Avkiran, 2007; Hartman et al., 2001). After removing the potential outliers, a dimensionality test that follows Hughes and Yaisawarng (2004) is executed.

3.5.6 Dimensionality Tests

Due to the nature of DEA, several factors including the relationship between sample size and number of model variables may affect the DEA score estimated. For example, adding more model variables for a given sample size yields higher efficiency scores for units in the sample, hence less discriminatory power. This is regarded as a dimensionality issue (Hughes & Yaisawarng, 2004; Seiford & Thrall, 1990). Ideally, DEA results should be independent of the dimension of the efficiency model and robust across alternative proxy variables, if the results are to be used for devising appropriate policy recommendations (Hughes & Yaisawarng, 2004).

The test procedure according to Hughes and Yaisawarng (2004) begins with a simulation of 110 samples. Each sample comprises three inputs and four outputs, as used in the actual data, generated by random numbers from a normal distribution; hence, there is no structural relationship among the numbers assigned to each simulated observation. Efficiency scores for all 110 simulated samples are calculated using Tone's (2001) slacks-based measure (SBM) model under the assumption of variable returns to scale, and then the percentage of efficient units is recorded. Since the numbers in the simulated sample are random, the efficiency scores computed from this procedure are the effect of dimensionality.

After 100 replications of this process, the mean proportion of efficient units in the sample is used to test the null hypothesis that the proportions of efficient units from simulated data and actual data are the same. This study postulates to find support for the alternative hypothesis that the mean proportion of efficient banks to emerge from DEA with actual data would be less than the average proportion of efficient units from the simulated samples. In other words, if the null hypothesis is rejected, then the DEA model is appropriate, and the efficiency scores capture the relative performance of banks in the actual data set and are not driven by dimensionality.

3.6 Total Factor Productivity: Malmquist Index

Measuring technical efficiency in the previous sections focused on quantifying how well banks convert inputs into outputs. However, using technical efficiency measures alone can be a misleading measure of productivity during a period of major environmental change (e.g., restructuring). This is because output growth between period one and period two may be due to changes in bank technology. Thus, another source of productivity improvement that should be studied is technological change. Technological change represents a shift of the efficient frontier due to technological innovation and it should be distinguished from gains in technical efficiency represented by units moving toward the frontier (Avkiran, 2006).

3.6.1 The Radial Malmquist Index

The Malmquist index introduced by Caves, Christensen, and Diewert (1982) is the most commonly used measure of productivity change. This index measures total productivity change between two data points by calculating the ratio of the distances of each data point relative to a common technology. Total factor productivity change can be decomposed into (1) technological change, which reflects the shift in the efficient frontier, and (2) technical efficiency change, which reflects the 'catch-up' effect or measures how close a DMU has moved to the best-practice between period one and two (Coelli, Rao, O'Donnell, & Battese, 2005).

In the literature, several methods have been used to calculate the distance functions. However, the study follows the DEA-like method introduced by Färe, Grosskopf, Norris, and Zhang (1994), as shown in Equation 3.6:

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)} \right]^{\frac{1}{2}}, \quad (3.6)$$

where the notation $d_0^t(y_t, x_t)$ represents the distance from the period t observation to the period s technology. The ratio outside the square brackets measures the 'catch-up' effect or the change in the output-oriented measure of Farrell (1957) technical efficiency between period s and t. Technological change is identified by the ratio in the square bracket. That is the geometric mean of the shift in technology between the two periods, evaluated at x_t and at x_s. Under the output orientation, a value of $m_0 > 1$ will indicate positive total factor productivity growth from period *s* to period *t* while a value less than one indicates a decline.

Figure 3.2 illustrates the measures inherent in Equation 3.6 using the example of a single output *y* and a single input *x*. The bank *i* in period *s* and *t* is operating at a level of productivity less than what is feasible under each period's technology. For example, bank *i* at time *s* could produce output y_p for input x_s; for the same input, it could produce output y_q at time *t*. Thus, bank *i* is technically inefficient in both periods.

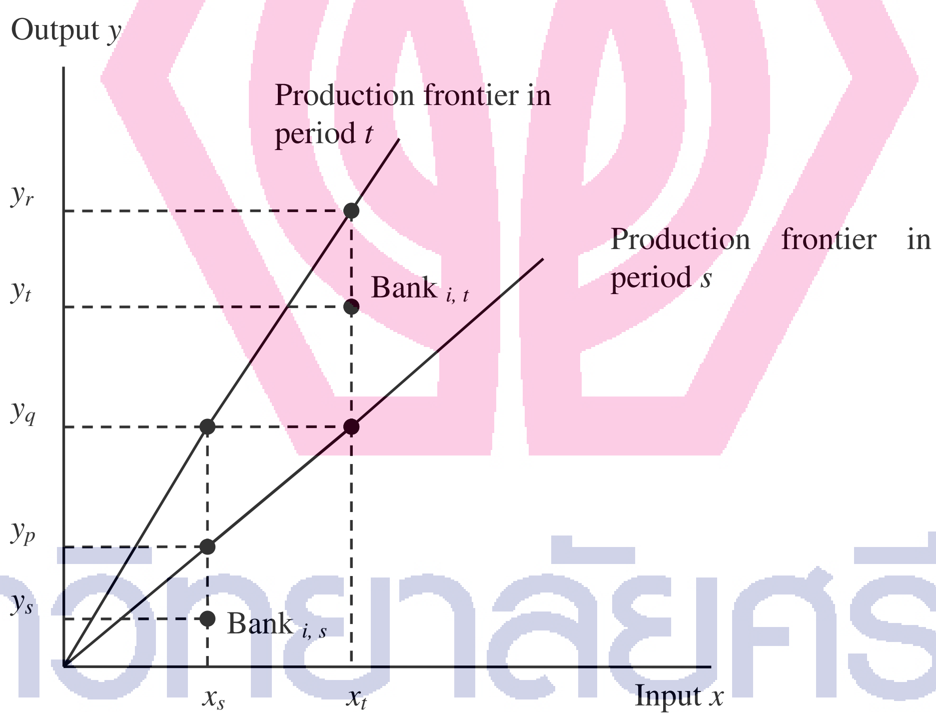

Figure 3.2 Output-Oriented Malmquist Productivity Index Using Constant Returns to Scale Technology

The change in technical efficiency and technological change shown in Figure 3.2 are represented by the distance functions in Equations 3.7 and 3.8.

$$Technical\ Efficiency\ Change = \frac{y_t / y_r}{y_s / y_p} \tag{3.7}$$

$$Technological\ Change = \left[\frac{y_t / y_q}{y_t / y_r} \times \frac{y_s / y_p}{y_s / y_q} \right]^{1/2} \tag{3.8}$$

Although Färe et al. (1994) propose an enhanced decomposition, which further decomposes the efficiency change component into pure technical efficiency change and scale efficiency change, this has been subjected to a number of criticisms on the assumptions of the variable returns to scale (VRS) and constant returns to scale (CRS) (as discussed in Ray & Desli, 1997). Grifell-Tatje and Lovell (1995) illustrate that a Malmquist index may not correctly measure total productivity changes when VRS is assumed for the technology. They appear to be a consensus that the Malmquist index is correctly measured by the ratio of the CRS distance function even when the technology exhibits VRS (Casu, Girardone, & Molyneux, 2004). In this study, therefore, the CRS is used as the reference technology in calculating the Malmquist index.

3.6.2 The Non-Radial Malmquist Index

The radial Malmquist index presented in the previous section is based on the radial DEA models (i.e., the CCR model), and hence remaining non-zero slacks are not counted in the scores. If slacks are not freely disposable, the radial Malmquist index cannot fully characterise the productivity change (Chen, 2003). Chen notifies that it is important to consider the possible non-zero slacks in measuring the productivity change.

Tone (2004) proposes a non-radial Malmquist productivity index to measure the productivity change based on SBM and-Super-SBM (Tone, 2001, 2002). The non-radial Malmquist model addresses the issues that a radial model cannot fully capture bank efficiency because of the slacks that are ignored. Hence, in this study, the non-radial Malmquist index as per Tone (2004) is also used to measure productivity change during the restructuring period.

3.7 Efficiency Estimated and Stock Returns

The relationship between profit efficiency and stock returns can be estimated by using the Sharpe-Lintner's excess-returns version of the Capital Asset Pricing Model (CAPM) as presented in Kirkwood and Nahm (2006).

$$ER_{it} = \alpha_i + \beta_i EM_{it} + \sigma_i PE_{it} + \varepsilon_{it} \qquad (3.9)$$

where ER_{it} is the excess return on stock *i* in time *t* (excess return is the return on stock *i*, less the risk free rate), EM_{it} is the excess market return, and PE_{it} is the percentage change in profit efficiency. ε_{it} is a random error term. Subscript '*i*' has been added to *EM* to note that different market returns are applied to the banks with different financial years. If the original version of the CAPM model is valid for the current data, the intercept term, α_i , and the coefficient of PE_{it}, σ_i , will have to be zero. If either of the two coefficients turned out to be different from zero, it might imply that the market portfolio is not mean-variance efficient.

3.8 Chapter Summary

This chapter presents the data and methodology used to test the research propositions discussed in the previous chapter. Thai commercial banks during 2001 and 2007 are selected to measure impact of the post-crisis restructuring. The sample includes 12 banks operating throughout the seven-year period of study. First, the Data Envelopment Analysis will be used to measure bank profit, as well as technical, and allocative efficiencies. Then the Stochastic Frontier Analysis will be applied for robustness checks on the main results. Also, consistency tests will be conducted to investigate whether efficiency scores estimated by different approaches are consistent. Finally, relationship between excess stock return and bank efficiency will be analysed using Sharpe-Lintner's CAPM.

Chapter 4

Results

4.1 Introduction

The findings of the research are discussed in this chapter in seven main parts. Section 4.2 provides a statistical description of the sample data. Outlier detection and dimensionality tests are presented in sections 4.3 and 4.4 respectively. Section 4.5 discusses the results of the non-parametric frontier analysis, and details the findings of the Total Factor Productivity analysis. The results of the relationship between profit efficiency and stock return are presented in section 4.6.

4.2 Descriptive Statistics

Before efficiency results are obtained, each variable is screened for missing data, normality, and univariate outliers. The frequencies of the variables are obtained and no missing values are detected. Table 4.1 provides aggregate descriptive statistics for the variables used in the non-parametric and parametric frontier models.

The average total cost for banks in the sample is 259 million US$, while the average amount of deposits and loans are 2,968 and 1,798 million US$, respectively. Most of the variables have a standard deviation greater than their mean, and exhibit high ranges (between minimum and maximum values) in all variables. This means there are high variations among the selected commercial banks. Moreover, the distributions of these variables are positively skewed due to the presence of several large banks influencing the means of these variables. The high values of skewness and kurtosis lead to the rejection of the normality hypothesis.

Table 4.1 Descriptive Statistics (US$ millions)

	Mean	*Median*	*Maximum*	*Minimum*	*Std. Dev.*	*Skewness*	*Kurtosis*
Inputs:							
Interest expenses	2,968.935	1,433.100	97,460.800	9.900	9,243.428	3.936	26.637
Non-interest expense	51.884	17.300	864.500	0.300	94.233	3.972	24.228
Outputs:							
Interest incomes	1,798.533	905.450	87,400.100	0.700	7,387.788	4.525	36.893
Non-interest incomes	2,098.339	547.850	34,203.000	1.400	3,998.407	3.387	17.667

The presence of univariate outliers is first visually examined using stem-leaf diagrams and box plots. The box plots indicate a small number of extreme values that need to be scrutinised. Then, parametric and non-parametric tests for outliers are performed. The results from the Grubbs' test cannot reject the null that there is no outlier in the data.[3] The Walsh's test (1959), which is a non-parametric test without the assumption of normal distribution, is also used to examine whether there are outliers in the data. Only a few observed data points in per unit labour cost and cost of physical capital are recognised as potential outliers. Further analysis indicates that the outliers identified are large merged banks, which are in the treatment sample (restructured banks). However, having satisfactorily explained these data points, they are not discarded.

Table 4.2 reports the correlations among the variables in the analysis. The correlation matrix reveals that the input and output variables are highly correlated (greater than

[3] As the normally distributed data are required for the Grubbs' test, the observed data are transformed by taking natural logarithm, which are log-normally distributed, before the test is conducted (Iglewicz & Hoaglin, 1993).

0.5) implying structural relationships in production function. Two inputs and two outputs are significantly inter-correlated in moderate degree (0.546 and 0.616), whereas two input variables are highly associated with two output variables (0.930, 0.897, 0.961 and 0.940), but are inter-correlated to a small degree indicate that multi-collinearity is not an issue.

Table 4.2 Spearman Correlation Matrix of Variables Used in the Research

	Interest expenses	Non-interest expense	Interest incomes	Non-interest incomes
Interest expenses	1.00	0.546**	**0.930****	**0.897****
Non-interest expense	0.546**	1.00	**0.961****	**0.940****
Interest incomes	**0.930****	**0.961****	1.00	**0.616****
Non-interest incomes	**0.897****	**0.940****	**0.616****	1.00

** Correlation is significant at the 1% level (two-tailed); * Correlation is significant at the 5% level (two-tailed)

4.3 Detecting Potential Outliers in DEA

Referring to section 3.5.5 in chapter 3, a key disadvantage of using a frontier technique, such as DEA, is its sensitivity to outlying observations. Therefore, the non-oriented slacks-based measure of efficiency, assuming the variable returns to scale is used to obtain super-efficiency scores (Tone, 2002) for identifying potentially outlying DMUs. Even though there is no standard cut-off suggested for determining which efficient banks are outliers, banks with super-efficiencies of two or higher are regarded as potential outliers, as a conservative rule of thumb (Avkiran, 2007; Hartman et al., 2001). The super-efficiency estimates reveal that none of the banks in the sample fall into this category, and hence it is assumed that there are no outliers and further analyses proceed with the full sample.

4.4 Dimensionality Tests

Apart from the outlier issue, the DEA results are also sensitive to the selection and number of variables in the efficiency models, referred to as dimensionality effects. Therefore, the dimensionality test, as proposed by Hughes and Yaisawarng (2004), is conducted. The results indicate that, on the average, 48.84% of banks are efficient where all values are randomly generated, whereas 11.51% of banks are efficient using actual values across all variables. The *t*-statistic of 24.69 against the one-tailed critical value of 2.32 for 1% significance level shows that there is no evidence to accept the null hypothesis. Thus, the alternative hypothesis, which states that the mean proportion of efficient banks to emerge from DEA with actual data is less than the average proportion of efficient units from the simulated samples, is supported. In other words, the efficiency model is appropriate, and the scores capture the relative inefficiencies of banks in the actual data set and are not driven by dimensionality.

4.5 Measuring Bank Efficiency Using Non-Parametric Approaches

This section presents the results from the non-parametric frontier analysis presented in section 3.5 of Chapter 3. The discussion starts with an analysis of profit efficiencies. Then, technical efficiency of banks is discussed in section 4.5.2, followed by section 4.5.3, which illustrates productivity change in selected Thai commercial banks.

4.5.1. Profit Efficiency of Thai Commercial Banks

The summary results of relative profit efficiencies based on the variable returns to scale assumption can be found in Table 4.3. Individual efficiency scores are estimated using all the observations across seven years. The results suggest that during the study period of 2001-2007, the profit efficiencies of Thai banks not only have not improved; but also, on the average, have slightly deteriorated.

Table 4.3 Profit Efficiency Score for Thai banks from 2001 – 2007

	2001	2002	2003	2004	2005	2006	2007	Period Average
Bank of Ayudhya (BAY)	1.0000	0.7911	0.6290	0.6516	0.6334	0.6876	0.9781	0.7673
Bangkok Bank (BBL)	1.0000	0.8841	0.8936	0.8879	1.0000	1.0000	1.0000	0.9522
Bank Thai (BT)	0.6090	0.6946	0.3273	0.6518	0.6900	0.5697	0.5457	0.5840
Kasikorn Bank (KBANK)	0.8229	0.9122	0.9708	0.9549	1.0000	0.9741	0.8636	0.9284
Kiatnakin Bank (KK)	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9071	0.9867
Krung Thai Bank (KTB)	0.6794	0.9739	0.9487	0.8653	1.0000	1.0000	0.8255	0.8990
Siam Commercial Bank (SCB)	0.7293	0.4865	0.9014	1.0000	1.0000	0.9183	0.8655	0.8430
Siam City Bank (SCIB)	1.0000	0.8189	0.7847	0.9365	0.9470	0.9644	0.7660	0.8882
TISCO Bank (TISCO)	1.0000	0.9752	0.9601	1.0000	1.0000	0.9835	0.7005	0.9456
TMB Bank (TMB)	0.9518	0.7345	0.3895	0.6812	1.0000	0.5753	0.6450	0.7110
Sample Average	**0.8673**	**0.9270**	**0.8629**	**0.7805**	**0.8271**	**0.8792**	**0.8097**	**0.8505**

The overall profit efficiency estimate of 0.8505 suggests that, on the average, banks earn 85% of the profits that the best-practice bank could make under the same conditions. Kiatnakin Bank appears to be the most efficient bank across seven-year period of study. This may be due to the fact that Kiatnakin Bank just transformed to a commercial bank to collect deposit from retail customers during the post-crisis period, and therefore less capital expenditure had been invested in physical assets. On the other hand, Bank Thai just makes, on the average, 58% that of the best-practice produced. This may be due to Bank Thai having been established from the finance companies that were in trouble in 1997 and recapitalised and controlled by the Thai government. Therefore, politically motivated policy may be an explanation of inefficiency. The sample average profit efficiency score of 86.73% in the year 2001 increases to 92.70% in 2002, and then, declines to 86.29% and 78.05% in 2003 and 2004, respectively. However, the mean profit efficiency improves again in 2005. The figures in Table 4.3 reveal that the mean efficiency score in 2006 stands at that the higher level that of in 2001 although the profit efficiency in 2007 is well below the starting point of analysis. This observation reject Proposition 1, which states the level of profit efficiency of Thai bank in 2007 was higher than the efficiencies measured in 2001.

4.5.2. DEA Technical, Pure Technical and Scale Efficiency Scores

The sample average technical efficiency score of 60.48% in the start of recovery period increases to 73.32% in 2002, and then, slumps to 68.66%, 62.90% and 53.62% during 2003 to 2005, respectively. However, the mean technical efficiency steps up again in 2006 to 65.38% before declines to 59.98 in 2007 which is lower than the start of recovery period. The figures in Table 4.3 reveal that the mean efficiency score in 2007, when the banks have forced to market mechanism, is not greater than that in 2001 when the effects of restructuring have flowed through the system.

Table 4.4 Mean DEA Technical, Pure Technical and Scale Efficiency Scores Categorised by Bank and Year

	BAY	*BBL*	*BT*	*KBANK*	*KK*	*KTB*	*SCB*	*SCIB*	*TISCO*	*TMB*	*Sample Average*
2001											
TE	1.00000	0.73800	0.31174	1.00000	0.52810	0.55367	0.78697	0.09935	0.07503	0.92530	0.60482
PTE	0.34760	0.86898	0.27839	0.95825	0.44388	0.16047	0.35765	0.42342	0.09570	0.08585	0.40202
SE	0.54796	0.28196	0.11919	0.49707	0.57233	0.18258	0.53482	0.42311	0.35979	0.82404	0.43429
2002											
TE	0.25307	0.75641	0.53067	0.69892	0.91787	1.00000	0.93451	0.83573	1.00000	0.40543	0.73326
PTE	0.75928	0.48776	0.65110	1.00000	0.99838	1.00000	0.76638	0.44356	0.18491	0.78603	0.70774
SE	0.70638	0.84573	0.42887	0.76198	1.00000	0.74879	0.48636	0.40030	0.06195	0.75173	0.61921
2003											
TE	0.72096	1.00000	1.00000	0.39136	0.35849	0.43136	0.32603	1.00000	0.30418	0.59996	0.68660
PTE	0.69752	0.91788	0.93710	0.42997	0.05151	0.59036	0.11570	0.56026	1.00000	0.01833	0.53186
SE	0.75566	0.23307	0.58098	0.61845	1.00000	0.03997	0.62212	0.53999	0.05237	0.39389	0.48365
2004											
TE	0.54426	0.66655	0.75898	0.70779	0.82348	0.25003	1.00000	0.91409	0.92535	1.00000	0.62905
PTE	0.02558	0.05846	0.97614	0.13310	0.81756	0.88655	0.46256	0.56330	0.83593	0.20049	0.49597
SE	0.78278	0.90375	1.00000	0.36741	0.34499	0.12998	0.57080	0.22232	0.69077	0.94394	0.59567

Table 4.4 (Cont.)

	BAY	*BBL*	*BT*	*KBANK*	*KK*	*KTB*	*SCB*	*SCIB*	*TISCO*	*TMB*	*Sample Average*
2005											
TE	0.14477	0.40514	0.98113	1.00000	0.68523	0.65842	0.10328	0.24896	0.49328	0.64194	0.53622
PTE	0.42690	0.95367	0.26577	0.65671	0.84818	0.77259	0.67395	0.16963	0.66415	0.47512	0.59067
SE	0.97989	0.14270	0.77473	0.48533	0.87191	0.90022	0.77206	0.86013	0.98307	0.94264	0.77127
2006											
TE	1.00000	0.14859	0.59785	0.79619	1.00000	0.66672	1.00000	0.25024	0.79100	0.28807	0.65387
PTE	0.37523	0.89007	0.28255	0.83905	0.09869	0.45009	0.31802	0.05284	1.00000	0.24207	0.45486
SE	0.49619	0.83321	0.90798	0.99027	0.13391	0.68435	0.60619	0.45981	0.77269	0.25353	0.61381
2007											
TE	0.29154	1.00000	0.50045	0.65216	1.00000	0.27705	0.70740	0.51574	0.33863	0.71503	0.59980
PTE	0.38659	0.53031	0.28808	0.86458	0.25368	0.94742	1.00000	0.79627	0.45310	0.76659	0.62866
SE	0.84525	0.90328	1.00000	0.75845	0.26199	0.84475	0.40046	0.04319	1.00000	0.85797	0.69153
Period Average											
TE	0.47923	0.67353	0.58350	0.74949	0.75902	0.50961	0.69403	0.55202	0.52250	0.65368	0.61766
PTE	0.43124	0.67245	0.52559	0.69738	0.50170	0.68678	0.52775	0.42990	0.60483	0.36778	0.54454
SE	0.73059	0.59196	0.68739	0.63985	0.59787	0.50438	0.57040	0.42127	0.56009	0.70968	0.60135

The determinants of scale efficiency over the period 2001 to 2007 shown in Table 4.3 also indicate that the majority of banks exhibit diminishing returns to scale. That is, where all bank inputs increase by a constant proportion, bank outputs increase by less than that proportional change. During the restructuring period, the Thai government encouraged banks to merge in order to create large healthy banks. However, the scale inefficiency in Thai banking implies that the policy to create such large healthy banks may not have been effective.

4.5.3. Productivity Changes over Time: Technical Efficiency or Technological Change?

Measuring technical efficiency in the previous sections provides an assessment of how well banks convert the inputs into outputs by the production process. However, using the technical efficiency measure alone can be a misleading measure of productivity for a banking industry during a period of significant change (e.g., restructuring). This is because total factor productivity of the banking system may change between period one and period two by the changes in bank technical efficiency as well as bank technology. Thus, the radial and non-radial Malmquist index that decomposes total factor productivity change into technical efficiency change, which reflects the 'catch-up' effect, and technological change, which reflects the shift in the efficient frontier, is presented in this section.

4.5.6.1 The Radial Malmquist Index to Measure Total Factor Productivity Change

Mean values of the indices for Thai banking sector are provided in Table 4.5. With respect to the impact of the post-crisis restructuring on the total factor productivity change, the Malmquist index and its components take an initial mean score of 1 for

2001 as a reference. Comparisons in Panel A indicate that during the crisis recovery period, the total productivity of the Thai banking industry had deteriorated by 7.49% in 2002, mainly due to a sharp decline in technological change (27.65%). After the banks had been forced to market mechanism, the total factor productivity in 2003 to 2007 improved considerably. This was mostly attributable to the rise in technical efficiency.

Table 4.5 Radial Malmquist Decomposition of the Change in Total Factor Productivity in Asian Banks as Restructuring Unfolds

Year	*Change in Technical Efficiency*	*Technological Change*	*Change in Total Factor Productivity*
Panel A (Sample Average)			
2001 – 2002	1.2992	0.7235	0.9251
	(0.4796)	(0.1591)	(0.3729)
2001 -2003	1.2932	0.6999	1.0274
	(0.6194)	(0.1474)	(0.4589)
2001 – 2004	1.4788	0.7427	1.0869
	(0.5769)	(0.1951)	(0.5137)
2001 - 2005	**1.8112**	**0.5863**	**1.0569**
	(0.7059)	(0.1742)	(0.5568)
2001 - 2006	**1.9519**	**0.5684**	**1.0973**
	(1.0277)	(0.1311)	(0.6607)
2001 - 2007	**1.9615**	**0.5354**	**1.0983**
	(1.0177)	(0.1151)	(0.6518)

This table shows the average change in technical efficiency, technological change and the change in total factor productivity in reference to 2001 using the radial Malmquist index. Standard deviations are in parentheses.

Table 4.5 (Cont.)

Year	*Change in Technical Efficiency*	*Technological Change*	*Change in Total Factor Productivity*
Panel B (Bank Type)			
Large Banks			
2001 – 2002	1.2477	0.7094	0.8616
	(0.4648)	(0.1678)	(0.3397)
2001 -2003	1.5656	0.6983	1.0940
	(0.6653)	(0.1540)	(0.5117)
2001 – 2004	1.5564	0.7297	1.1324
	(0.5845)	(0.1747)	(0.5276)
2001 – 2005	**1.9558**	**0.5851**	**1.1534**
	(0.7514)	(0.1583)	(0.6537)
2001 - 2006	**1.8515**	**0.6684**	**1.0573**
	(1.5172)	(0.0311)	(0.6907)
2001 - 2007	**1.7519**	**0.5674**	**1.1373**
	(1.0277)	(0.1341)	(0.6807)
Small Banks			
2001 – 2002	1.0638	0.5866	0.7606
	(0.4797)	(0.1592)	(0.3729)
2001 -2003	0.9611	0.4698	0.6622
	(0.6194)	(0.1474)	(0.4589)
2001 – 2004	0.9278	0.4844	0.6865
	(0.5769)	(0.1951)	(0.5138)
2001 - 2005	**1.0486**	**0.3577**	**0.6072**
	(0.7059)	(0.1743)	(0.5569)
2001 - 2006	**1.2110**	**0.5684**	**0.8973**
	(0.0276)	(0.7541)	(0.6707)
2001 - 2007	**1.2520**	**0.5784**	**0.9541**
	(1.0574)	(0.1614)	(0.1654)

This table shows the average change in technical efficiency, technological change and the change in total factor productivity in reference to 2001 using the radial Malmquist index. Standard deviations are in parentheses.

The rise in technical efficiency derived from the Malmquist index here is contrasted with the technical efficiency measured based on the BCC model presented in Table 4.4, which did not account for technological change during the crisis period. Thus, it can be seen that relying on technical efficiency measures alone may misconstrue the technical efficiency estimates. However, the positive impact of the increases in technical efficiency was partially offset by a downward shift of the efficient frontier. In summary, there is little evidence to support the expectation that restructuring enhanced the productivity of the Thai banking system during the crisis recovery period.

Panel B of Table 4.5 shows comparisons of average indices for each type of banks during the years 2001 to 2007. It is clear that large banks, which include BBL, KBANK, KTB, and SCB, exhibit total productivity gains during the recovery period. On the other hand, even though small banks appear to improve their technical efficiency, this is outweighed by the regress in the best practice frontier; therefore, productivity experienced declines.

4.5.6.2 The Non-Radial Malmquist Index to Measure Total Factor Productivity Change

The radial Malmquist index used in the previous section is based on the radial DEA models, and thus, remaining non-zero slacks are not counted in the scores. This section presents a non-radial Malmquist productivity index to analyse the change in total factor productivity based on SBM and-Super-SBM (Tone, 2001, 2002).

As observed in Table 4.6, although the figures presented are different from those in the radial Malmquist index, similar conclusions apply. That is, there is a little evidence to support productivity gains for the banking system during the recovery period. Even though the general trend of technical efficiency change is upward, the downward trend of the efficient frontier mostly cancels out total productivity gains. Consistent with the radial Malmquist index results, large banks appear to improve their total factor productivity.

Table 4.6 Decomposition of the Change in Total Factor Productivity Using Non-Radial Malmquist Index

Year	*Change in Technical Efficiency*	*Technological Change*	*Change in Total Factor Productivity*
Panel A (Sample Average)			
2001 – 2002	1.3461	0.7644	0.8982
	(0.6499)	(0.7983)	(0.4245)
2001 -2003	1.5013	0.7502	1.0733
	(0.8180)	(0.3314)	(0.5694)
2001 – 2004	1.5353	0.7642	1.1406
	(0.9181)	(0.2010)	(0.6387)
2001 - 2005	**1.5513**	**0.7646**	**1.1173**
	(1.1234)	(0.1315)	(0.6427)
2001 - 2006	**1.5421**	**0.6652**	**1.0983**
	(1.1056)	(0.6382)	(0.6607)
2001 - 2007	**1.5344**	**0.6784**	**1.1803**
	(1.0123)	(0.0511)	(0.1607)

This table shows the average change in technical efficiency, technological change and the change in total factor productivity in reference to 2001 using the non-radial Malmquist index. Standard deviations are in parentheses.

Table 4.6 (Cont.)

Year	*Change in Technical Efficiency*	*Technological Change*	*Change in Total Factor Productivity*
Panel B (Bank Type)			
Large Banks			
2001 – 2002	1.2472	0.7024	0.8347
	(0.5246)	(0.2124)	(0.3639)
2001 -2003	1.6044	0.7338	1.1723
	(0.8484)	(0.1139)	(0.6345)
2001 – 2004	1.5781	0.7577	1.1929
	(0.7592)	(0.1476)	(0.6363)
2001 - 2005	**2.1682**	**0.5701**	**1.2333**
	(1.3400)	(0.0965)	(0.8460)
2001 - 2006	**1.9519**	**0.5684**	**1.0973**
	(1.0277)	(0.1311)	(0.6607)
2001 - 2007	**1.9519**	**0.5684**	**1.0973**
	(1.0277)	(0.1311)	(0.6607)
Small Banks			
2001 – 2002	1.1125	0.6285	0.7393
	(0.6500)	(0.7983)	(0.4246)
2001 -2003	0.9668	0.5093	0.6824
	(0.8180)	(0.3315)	(0.5694)
2001 – 2004	0.9777	0.4959	0.7197
	(0.9181)	(0.2011)	(0.6388)
2001 - 2005	**0.9052**	**0.3461**	**0.6167**
	(0.6275)	(0.8611)	(0.4108)
2001 - 2006	**1.0519**	**0.5684**	**0.6973**
	(0.5247)	(0.4381)	(0.6507)
2001 - 2007	**1.1519**	**0.5684**	**0.7273**
	(1.5298)	(0.9324)	(0.4905)

This table shows the average change in technical efficiency, technological change and the change in total factor productivity in reference to 2001 using the non-radial Malmquist index. Standard deviations are in parentheses.

4.6 Efficiency and Stock Returns

In this section, we investigate the influence of profit efficiencies on the share prices of the banks. This exercise appears to be a first in the Thai banking efficiency literature. We first employed the method suggested by Andersen and Petersen (1993) to modify all the profit efficiency scores of 1.00 obtained in the original run of DEA. The modified scores were all in excess of one. Their inherent ranking should in theory enhance the statistical fit for this second-stage parametric exercise.

We regressed annual stock returns (adjusted for capitalisation changes) on percentage changes in the annual profit efficiency. SCIB01 and SCIB02 were excluded as SCIB was suspended from the Stock Exchange of Thailand until 2002. The correlation coefficient was 0.10 (Adjusted R-square=0.10), statistically significant at the 5% level. This can be implied that percentage changes in smoothed profit efficiencies are associated with 10 percentage changes in smoothed stock returns although the explanation power is weak. A similar implication also surfaces in the regression based on using unsmoothed changes in share prices and profit efficiencies. One of explanations may be that the information on bank efficiency might be outweighed by other market information during the recovery period. In summary, the result from this exercise support the Proposition 2, which states that the profit efficiency measured has a relationship with the bank stock returns.

4.7 Chapter Summary

This chapter presents the empirical results of the study. Overall, the results of this study reveal that efficiencies of selected Thai commercial banks, on the average, do not improve during the recovery period. One possible reason is that the tighter restrictions in risk assessment and lack of confidence to invest in a new project may hamper new loan expansion. We show that percentage changes in profit reflect 10 percentage changes in share price although the explanation power is not strong. One of explanations may be that the information on bank efficiency might be outweighed by other market information during the recovery period.

Chapter 5

Conclusions, Discussion and Recommendations

5.1 Introduction

This study seeks to explore profit efficiency of Thai commercial banks, particularly during the crisis recovery period. The research also raises an issue whether changes in a bank's efficiency is reflected in stock prices. In this final chapter, a summary of the research and principal findings are presented first, followed by a discussion of the theoretical and practical contributions of the research. Limitations and directions for future research are presented last.

5.2 Overview of the Study and Key Findings

The aim of this research is to answer the central research questions

1. *What is the level of profit efficiency of Thai bank during the recovery period of 2001 to 2007?*

2. *Have the total factor productivity of Thai banking system improved during the economic recovery period?*

3. *What is the relationship between the efficiency measured and its response by the stock returns?*

5.2.1 Summary of the Research

This research employs efficient frontier approaches to assess bank efficiency during the crisis recovery period from 2001 to 2007. Overall, the research posits that there is an improvement in efficiency of banks during the period of study.

The research starts from estimated relative bank efficiencies across 12 Thai commercial banks during the years 2001 to 2007. These efficiencies include profit, technical, and scale efficiencies. Efficiency scores are measured under the intermediation approach, which views a bank as a mediator of funds between depositors and investors. Focusing on improvement of bank efficiency, Proposition 1 posits that the level of profit efficiency of Thai bank in 2007 was higher than the efficiencies measured in 2001. In addition, the research investigates relationship between the efficiency estimated and stock returns. Proposition 2 states that the profit efficiency measured has a relationship with the bank stock returns. Then, the study assesses total factor productivity of the Thai banking system during the crisis recovery period. Finally, relationship between changes in a bank's efficiency stock prices is examined.

5.2.2 Key Findings

The results from the non-parametric frontier analysis do not support Proposition 1, indicating that there is no sign of efficiency improvement in the Thai banking system during the crisis recovery period. In fact, the sample average of profit and technical efficiency scores for 2007, when most of the bank were forced to market power, are slightly lower than those in 2001, at the start of the crisis recovery period.

A further analysis of the cost efficiency components reveals that the major source of profit inefficiency during the post-crisis recovery period is related to scale efficiency. In fact, the scale efficiency results indicate that most of the banks exhibit decreasing returns to scale. Contrary to expectations, this implies that the majority do not operate at optimum scale. A possible reason for this may be the tighter restrictions in risk assessment that hamper the new loan granting process. In addition, a lack of strong macro-economic support may slow new investment plans.

The analysis of total factor productivity changes reveals that the productivity of the Thai banking industry slightly improved during the recovery period. Although technical efficiency changes exhibited a substantial upward trend, this was partly offset by the contracting frontier. The large banks appear to exhibit productivity gains during the period of study. This is mostly attributable to improved technical efficiency.

Finally, this research reveals that on the average the profit efficiency of Thai bank is in the moderate high level at 85%. However, the relationship between changes in profit efficiency and stock returns appears that the profit efficiency measured can explain about 10% of stock returns movement. One of explanations may be that the information on bank efficiency might be outweighed by other market information during the recovery period.

5.3 Research Implications

The research contributes to the theory of bank efficiency as well as exploring the impact of post-crisis restructuring on banking systems of developing countries. Firstly, the research extends the theory of bank efficiency in developing countries.

There has been limited research on assessing bank efficiency in developing countries. The results from this research reveal that after the 1997 banking crisis, profit and technical efficiencies of the Thai banks is slightly deteriorated, even though restructuring to enhance efficiency of the banking systems was implemented.

Secondly, this research adds to the literature on measuring bank total factor productivity changes after banking crises. There are limited publications to date that consider the relationship between post-crisis bank restructuring and bank productivity. Therefore, the results from this research add to the knowledge of bank productivity changes during the post-crisis period in developing countries. The total factor productivity analysis suggests that, although restructuring can improve bank productivity via technical efficiency, macro-economic conditions may play a role in technological contraction during the post-crisis period; hence, restructuring does not lead to the expected levels of productivity gains.

Finally, relationship between bank efficiency and changes in stock price is revealed. Since a stock market in developing countries such as Thailand is not classified as a strong-form market, therefore the market may response in any information in different degree. This exercise makes useful information for investors that at least 10% of stock movement may be due to changes in efficiency.

The findings of this study not only contribute to the growing body of literature in bank efficiency in developing countries, they also have significant practical implications for the effectiveness of post-crisis restructuring. In literature, the relative outcome of different policies implemented during a crisis is rarely discovered. Evidence from this study on the extent to which policies are successful provides policy makers with useful information in order to effectively deal with further potential crises.

5.4 Limitations of the Research

Several limitations are inherent in the results of this research. The first key limitation is that generalisation of the findings is limited to the selected Thai commercial banks. Although the selected banks are recognised as significant models for Thai banking industry, care should be taken when interpreting the results.

The second limitation of this research is the time period studied. In order to have an in-depth analysis of the changes in efficiency and productivity, a study may need a longer period of data before and after the crisis to analyse the efficiency change. However, the period of this research is limited to seven years during the crisis recovery period in 2001 due to a complexity of various macro-economic and political polices. Most of the sample banks have, somehow, experienced changes not only in financial condition, but also in political issue.

Finally, the results from this research are subjected to an issue called survivorship bias. To focus on the changes in efficiency of banks during the post-crisis, the sample in this research comprises only continuously operating institutions. As the entry and exit bank during the period are excluded, some observations in the Thai banking system are not accounted for.

5.5 Directions for Future Research

Notwithstanding the limitations presented above, the results of this research suggest some future research directions. First, to enhance the knowledge of bank efficiency in developing countries and to improve the generalisation of results, another study should be conducted in developing countries in other regions. The findings of this research provide preliminary evidence on the level of bank restructuring. However, this research considers only a developing country in the East Asian region. Consequently, further research in other regions, such as Latin America, which experience dynamic economic conditions, may broaden the scope of cross-country comparisons of bank efficiency, which are currently dominated by the European studies.

Finally, an interesting research question also emerges to investigate causality between macro-economic factors and the level of bank efficiency. Although this research suggests that economic factors have a relationship with bank efficiency, causality has not been tested. However, a causality study may need a long period of data to identify an appropriate lag-length. Therefore, when the availability of data permits, an investigation of causality between macro-economic conditions and bank efficiency should be taken, since it may provide useful information for regulators interested in preventing future crises.

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