THREE ESSAYS IN BANKING SECTOR OF THAILAND

A Dissertation

Presented to the Faculty of the Graduate School

of Cornell University

in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

by

Itthipong Mahathanaseth

August 2011

© 2011 Itthipong Mahathanaseth

THREE ESSAYS IN BANKING SECTOR OF THAILAND

Itthipong Mahathanaseth, Ph.D.

Cornell University 2011

This dissertation consists of three essays. The first essay examines the cost efficiency and production technology in the banking sector of Thailand using a stochastic frontier approach. The empirical results indicate that banks with lower Non-performing-loan-to-total-loan ratio, higher equity-to-total-asset ratio, higher liquid-asset-to-total-asset ratio, and more branches are likely to be more efficient. The second essay investigates the degree of competition in the banking industry using the new empirical industrial organization approach. The empirical results indicate that, despite the Thailand government's efforts to increase competition in the banking industry by relaxing restrictions on entry to the market after the financial crisis, the oligopolistic degree of the biggest four banks has intensified. The third essay links the results of the first and second essays, cost efficiency and competition in the banking sector, to the transmission mechanism of monetary policy in Thailand using Vector Autoregression approach. The empirical results indicate that an unexpected tightening monetary policy shock leads to higher financial costs in the banking industry, forcing banks to compete more fiercely and operate more efficiently, significantly helping strengthen the transmission of monetary policy. Hence, the policy implication is that Thai government should exert more effort to enhance efficiency and competition in the banking sector.

BIOGRAPHICAL SKETCH

Itthipong Mahathanaseth was born on August 17, 1979 in a middle-class family in Ratchaburi province of Thailand. Although his parents are uneducated, they have worked tirelessly to provide their children a good education. He attended elementary school in his home town before moving to Nakornpathom province for his middle-school and high-school education. Unfortunately, he dropped out of school while studying in grade 10. He continued to study in a non-formal setting before attending Ramkamhaeng University, an open university in Thailand, from which he obtained his Bachelor of Economics with Second Class Honors in 2001. Then, he pursued his second degree in Economics at Thammasart University in Thailand from which he received the Master degree in 2004. Upon graduation, he briefly worked as a credit official at the Export-Import Bank of Thailand before becoming a lecturer in the Faculty of Economics at Kasetsart University in Thailand. He taught at Kasetsart University for 2 years before being awarded a full scholarship from the Royal Thai Government to study aboard. In August 2007, he entered Cornell University, where he completed his dissertation in July 2011.

To my dad, mom and aunt

ACKNKNOWLEDGEMENTS

My 4 years of my graduate study at Cornell University have been an invaluable learning experience. Consequently, I would like to dedicate this dissertation to a number of people to whom I am particularly indebted.

First of all, I would like to express my deepest gratitude to the chair of my dissertation committee, Professor Loren Tauer. He has consistently devoted his precious time and attention to help me with my dissertation and encouraged me when things were difficult. His invaluable advice and comments are reflected throughout the dissertation. I also gratefully acknowledge the assistance of the other members of my dissertation committee: Professor David Just and Professor Iwan Azis. Both of whom have provided crucial insights and constructive critiques that have helped greatly improve my dissertation.

I would like to thank my best friends and colleagues at Cornell: Sivalai Vararuth, Thanasin Tanompongphandh, Surin Maneevitjit and, especially, Marc Rockmore. They have never hesitated to help me whenever I had difficulties and have been true friends through the journey. Even though the transition to student life in the USA was extremely difficult, I enjoyed many happy and memorable moments with them.

I would also like to convey my deep gratitude to the Royal Thai Government for the full scholarship that has supported my entire graduate study at Cornell University. Without this assistance, this dissertation and my study would not have been possible.

Lastly, I would like to thank my parents who, while uneducated, know very well the importance of education. Since I was a child, they have always encouraged and supported me to push my studies as far as possible. They have shared with me my successes and failures at Cornell University and throughout my life. Their unconditional love, understanding and support no matter the distance were not only the most precious source of my aspiration but have also made my life meaningful.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction and Overview

The banking sector of Thailand underwent a financial meltdown during the East Asian financial crisis of 1997. Since that crisis, banks in Thailand have been subject to financial restructuring directed by the IMF and subsequent liberalization introduced by the Thai government to enhance efficiency and competition within the industry.

The banking sector has recovered and is significantly reformed and continues to play important roles in the Thai economy. Banks are not only the major sources of funding for consumption and investment, but also serve as instruments in facilitating the transmission of monetary policy. Hence, it is useful to study how efficiently banks operate, how intensely they compete with each other, and ultimately how their efficiency and competition affect monetary policy transmission. This chapter summarizes the content of the dissertation, consisting of three essays, and discusses those questions that will be examined and answered in each chapter.

The next chapter, or the first essay, examines banks' efficiency and banks' characteristics that determine efficiency. I estimate a stochastic cost frontier function, which enables me to extract not only individual bank cost efficiency but also information about underlying production technology such as economies of scale, factor demand elasticities and technological change The results will allow me to answer the question of whether bank efficiency increased over this period and what where the causations of bank efficiency.

Chapter 3, or the second essay, examines the degree of competition in the banking industry by using the new empirical industrial organization approach (NEIO). The estimated conduct parameter will show to what extent banks are able to collude. Moreover, the model will show the direct linkage between market-concentration structure and markup pricing, enabling me to test the established belief that higher concentration leads to higher markups. The cross-sectional data also allows me to derive the Lerner index, which shows how the competition degree in banking sector evolved after the financial crisis. Ultimately, I will be able to answer the question of whether competition in the banking industry really improves after the crisis and the subsequent financial liberalization.

Chapter 4, or the third essay, relates bank efficiency and competition to monetary policy transmission by estimating a vector autoregession (VAR) equation. I incorporate the bank-efficiency index and the bank competition index into my VAR model. I find that when the central bank changes the 14-day repurchase rate, i.e. policy interest rate, this effect is transmitted to the real sector through an adjustment to banks' financial cost and lending interest rate, which is affected by banks' efficiency and competition. Using the impulse response functions, I show how aggregate output and commodity price dynamically response to an unexpected increase in the policy rate. In addition, the importance of banks' efficiency and competition can be gauged by comparing between the impact of monetary policy shock on output and price (speed and size) when the roles of banks' efficiency and competition are blocked off i.e. when they are treated as exogenous variables, and these are allowed to operate i.e. when they are treated as endogenous variables.

In the last chapter, I will summarize the answers to the questions proposed earlier: “How efficient are banks?” “How did the degree of competition in banking sector evolve after the crisis?” and “How does bank efficiency and competition affect monetary policy transmission?” and, last but not least, “What are the policy implications to strengthen banking performance in the Thai economic and make monetary policy transmission more effective?”

Chapter 2

Efficiency Analysis of Thai Banks

Abstract

Using a stochastic cost frontier approach, I estimate cost inefficiency, return to scale, factor demand elasticities, and productivity growth of commercial banks and government-owned specialized banks in Thailand after the 1997 East Asian Financial crisis. For commercial banks, Krung Thai Bank and the other three biggest banks are the most efficient banks while the smallest four banks are ranked at the bottom. Cost inefficiency of banks is significantly determined by banks' financial characteristics such as the ratio of non-performing loan to total loan, equity to total assets, and liquidity assets to total assets, as well as the number of branches. The results also indicate that commercial banks exhibit increasing return to scale whereas government-owned specialized banks suffer from decreasing return to scale. In commercial banks, labor and loanable funds appear to be substitutes; however, labor and physical capital as well as physical capital and loanable funds are complementary. In contrast, in government specialized banks' the production of loan and investment, all three inputs including labor, physical capital and loanable funds appear to be substitutes for each other.

2.1 Introduction

Thailand's financial sector mainly comprises three parts: the banking sector, government-owned specialized financial institutions, and non-bank financial intermediaries including finance companies, credit foncier companies[1], life insurance companies and various financial co-operatives. Commercial banks are the largest component of the Thailand financial sector. As of December 2010, there were 19 domestically owned commercial banks with 4,249 branches. There were 15 foreign banks which each was allowed to open only one branch in Thailand. Finance companies are not permitted to accept deposits; they raise funds by issuing debt instruments and their business concentrates on short-term consumer lending. Government-owned specialized financial institutions include the Government Saving Bank, the Government Housing Bank, the Bank for Agriculture and Agricultural Cooperatives, the Small and Medium Enterprise Development Bank of Thailand, the Export-Import Bank of Thailand, and the Islamic Bank of Thailand. Some of them are not allowed to accept deposits and they extend loans only to particular types of customers. For non-bank financial intermediaries, average size and aggregated share in the financial sector are very small.

Dating back to the late 1980s and early 1990s, and prior to the East Asian economic crisis, financial market deregulation was introduced by the Thai government. The financial liberalization program was composed of three components: dismantling of interest rate controls, relaxing portfolio restrictions, and expanding the

[1] Credit foncier company is a kind of financial institutions in Thailand whose businesses concentrate on mortgage loans. The term "foncier" derives from French, meaning "of the land".

scope of activities of finance companies and commercial banks. The ultimate goal of liberalization was to enhance efficiency of the financial sector. Consequently, the country attracted enormous capital inflows and achieved a rapid economic growth rate during this period ranging from 8% to 12%. This achievement was widely acclaimed by the IMF and the World Bank, and was known as part of the "Asian economic miracle".

However, fueled by the surge of short-term capital inflows, Thailand's economy developed into a bubble. Later, the country as well as other countries in East Asia experienced an economic crisis in 1997. Not only did the real sector of Thailand but also the financial sector severely suffered from the crisis. The growth rate of GDP was only 1.8% in 1997 and then further deteriorated to a negative 10.4%, in 1998. Foreign exchange reserves went down sharply from 26.6 billion dollar on February 13, 1997 to only 2.8 billion dollar on June 30, 1997. As a consequence, the Thai government decided to float the Thai baht. As a result, the currency depreciated 83.27% from 25.78 baht per dollar in June 1997 to 47.25 baths per dollar in December 1997. Simultaneously, the foreign debt in term of Thai baht doubled to 4.34 trillion. Because of loss confidence in the baht and excessive speculation in the foreign exchange market, the Bank of Thailand (BOT) implemented contraction monetary policy in order to protect the currency, thereby terribly increasing the 14-day repurchase rate to a peak of 22.22% by the end of 1997. This led to not only a dreadful increase in the financial cost to producers, many of whom became insolvent, but also led to the problem of Non Performing Loans (NPLs) of the financial institutions. The bank of Thailand reported that NPLs of the financial institutions as a whole in June

1998 was 47.7%, four times larger than it had been before the crisis. Eventually, several financial institutions went bankrupt, including 56 financial companies which were subsequently closed and liquidated. Inevitably, Thailand had to request financial support from the International Monetary Fund (IMF). The IMF offered a rescue package of 20.3 billion dollar in total, subject to programs of economic stabilization and reform to be implemented from 1997 to 1999. One condition of the rescue plan was financial sector restructuring, initially focused on the identification and closure of unviable financial institutions, intervention in weak banks, and the recapitalization of the banking system. These activities certainly affected the efficiency of Thai banks.

As a consequence of the reform directed by the IMF, there was significance change in the ownership structure of financial institutions. The government not only nationalized and liquidated a number of distressed banks, but also abolished the restriction on foreign ownership of commercial banks, which had been restricted to less than 25% of the equity capital, in order to attract foreign banks and investors to recapitalize the distressed banks. Before the crisis, founding families were the largest shareholders in 5 of the largest 8 banks; however, by 2003, foreign investors were the largest shareholders in two banks including the largest one. Two other banks have been either nationalized or liquidated, and there remains only one bank in which the founding family is the largest shareholder. A change in ownership structure might affect banks' performance as well.

After the IMF era, in January 2004, the Thai government announced the Financial Sector Master Plan. The substantial part of this plan addressed measures to increase efficiency of the financial sector by enhancing market mechanisms. These included (i) relaxing entry to the banking sector by promoting upgrade of finance and credit foncier companies to commercial banks; (ii) relaxing regulations on opening branches in densely populated areas; (iii) relaxing restrictions on foreign financial institutions' scope of business and number of branches. By 2006, 3 finance companies were upgraded to commercial-bank status by issuance of brand-new banking licenses. These entries would lead to an intensification of competition within the industry, thereby enhancing efficiency.

Now, several years after the crisis, Thailand's banks are fully recovered and reformed. They play important roles to lubricate and drive the Thai economy. In 2005, over 6 trillion baht (approximately 180 billions of USD) of total deposits or deposit equivalents is in the banking sector, accounting approximately for 76 percent of total deposits or deposits equivalent in all of Thailand's financial institutions. This amount is roughly 88 percent of GDP in 2005. Moreover, as the most crucial source of credit, the banks provide lending of approximately 5.5 trillion baht, accounting roughly for 77 percent of total credit provided by all of Thailand's financial institutions.

Because of the importance of banks to the government, households and investors, the efficiency of banks is a major concern. Several changes, especially in ownership structure and competition environment, have occurred in the Thai banking sector. Hence, it is useful and important to investigate what factors determine banks' efficiency and how their efficiency evolves over time. These objectives can be achieved by implementing a stochastic frontier analysis (SFA) to estimate banks' efficiency, and modeling determinant of efficiency by regressing efficiency on variables of interested.

The rest of this chapter is organized as follows; Section 2.2 provides a brief literature review especially focused on financial institutions, Section 2.3 concentrates on a description of methodology, empirical specification and data, Sections 2.4 and 2.5 provide results and conclusions, respectively.

2.2 Literature Review

As defined by Coelli, Rao and Battese (1998), efficiency of a firm consists of 2 major components: (1) *technical efficiency,* referring to the ability of a firm to produce maximal output from a given set of inputs (or alternatively, minimizing the inputs necessary to produce given set of outputs), and (2) *allocative efficiency,* referring to the ability of a firm to use inputs and produce outputs in optimal proportions given their respective prices and production technology. These two measures can be combined to provide a measure of total economic efficiency. At its heart, the primary goal of measuring efficiency is to separate those production units that perform well from those that perform poorly by some standards.

Measuring bank efficiency has become an established field of frontier analysis. These studies have developed a relatively standardized methodology and conceptual framework. Research on bank efficiency developed in two separated streams: *stochastic frontier analysis* (SFA) and *data envelopment analysis* (DEA). The first, sometimes referred to as the econometric frontier approach, specifies a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors, and allows for random error whose distribution is usually assumed to follow such symmetric distribution as the standard normal, whereas inefficiencies are assumed to be distributed asymmetrically as half-normal or truncated normal. On the other hand, DEA is a non-parametric approach which employs a linear programming technique where the set of frontier observations is formed as a piecewise linear combination of the actual input–output correspondence set that envelops the data of all the firms in the sample, yielding a convex production possibilities set. As such, DEA, unlike SFA, does not require an explicit specification of the functional form of the underlying production relationship. However, a key drawback to the nonparametric approach is the unrealistic assumption that there is no random error; in other words, it is assumed that there is no measurement error in constructing the frontier, and further that performance neither depends on good luck nor bad luck. In addition, Simar and Wilson (2007) argued that the conventional statistical inference, relying on the two-stage approach that employs the non-parametric distance function to estimate the technical efficiency in the first stage and then regressing the efficiency on exogenous factors using Tobit or censored regression in the second stage, are invalid due to complicated unknown serial correlation among the estimated efficiencies; they proposed double bootstrap procedures that permit valid inference and improves statistical efficiency in the second-stage regression.

Berger and Humphrey (1997) have surveyed the results of 130 studies of financial institution efficiency covering 21 countries that apply both parametric and non-parametric methods and found that their efficiency estimates are very similar, but the nonparametric methods generally yield slightly lower mean efficiency estimates and seem to have greater dispersion than the results of the parametric models.

Nonetheless, these days, there is really no consensus among researchers on the preferred method for determining the frontier against which relative efficiencies are measured, even though the parametric estimation has seemed to be more prevalent in recent years (see for example, Fuentes et al., 2001; Cuesta and Orea, 2002).

Due to the limitation of imposing a particular functional form necessary for the SFA approach, researchers have been searching for appropriate flexible functional forms. Initially, the *Cobb-Douglas form* was commonly used because of its attractive simplicity of linear in logarithms of inputs, constant input elasticities and homotheticity. Later, the *translog form*, the most popular alternative form, replaced the Cobb-Douglas. Unlike the Cobb-Douglas, the translog form imposes no restrictions upon substitution possibilities and need not be homothetic. Gallant (1981) and Berger et al. (1994) argue that the translog as a local approximation provides poor approximations for such data that are not near the mean scale and product mix as financial institutions' data typically are located. Besides, the translog forces the frontier average cost curve to have a symmetric U-shape in logs (in the case of the cost frontier). Fortunately, more flexible functional forms have been introduced. Several empirical studies in bank efficiency have specified a *Fourier-flexible functional form* which provides global approximations by adding Fourier trigonometric terms to a standard translog function. This greatly increases the flexibility of the frontier by allowing for many inflection points and by including essentially orthogonal trigonometric terms that help fit the frontier to the data wherever most needed.

With regard to modeling inefficiency, many studies on the determinants of inefficiency use a two-stage approach. First, efficiency scores are estimated by using the SFA. In the second step, because of the acknowledgement that the estimated inefficiency must lie between zero and one, the statistical interrelationship between efficiency and its potential determinants is analyzed by using either logit, tobit, or other truncated regression models. Nevertheless, this approach is inconsistent with the assumption about distribution of inefficiency. Indeed, the specification of the regression of the second stage conflicts with the assumption that inefficiency is independently and identically distributed. Alternatively, the method of Battese and Coelli (1995) estimates the impact of inefficiency determinants jointly with the efficiency frontier itself by using an iterative maximum likelihood procedure. Each observation of the sample is assigned an inefficiency estimate that partly depends on these determinants. In recent years, the one-stage method has been preferred to the two-stage method in bank efficiency literature.

In terms of applications, research on bank efficiency has largely focused on using institution efficiency estimates: (1) to inform government policy (e.g., by assessing the effects of deregulation, mergers, and market structure on industry efficiency); (2) to address research issues (e.g., by determining how efficiency varies with different frontier approaches, output definitions, and time periods); and (3) to improve managerial performance (e.g., by identifying best-practice and worst-practice branches within a single firm). Among these three justifications for estimating bank efficiency, the first one appears to be most popular. The policy implications can be found by *modeling inefficiency* in terms of explanatory variables representing deregulation, risks, problem loans, management quality, market structure, and merger, for example.

In econometric estimation, it is commonly acknowledged that the choice of variables affects the results. The problem is compounded by the fact that variable selection is often constrained by availability of data on relevant variables. The cost and output measurements in banking are especially difficult because many of the financial services are jointly produced and prices are typically assigned to a bundle of financial services. The role of banks is generally defined as collecting the savings of households and other agents to finance the investment needs of firms and consumption needs of individuals. Generally, according to Das and Ghosh (2006), three major alternative approaches are employed to categorize inputs and outputs in the studies in bank efficiency: (1) *intermediation approach*, (2) *value-added approach* and (3) *operating approach*. Under the intermediation approach, financial institutions are viewed as intermediating funds between savers and investors. Deposits, labor (employee expenses) and capital (defined as operating and administrative expenses related to fixed assets) are assumed as inputs for producing loans and investments. There is, however, a longstanding controversy whether deposits should be treated as an input or output. This led to the establishment of the value-added approach, which can be viewed as a variant of the intermediation approach. Under the value-added approach, labor (employee expenses) and capital (operating and administrative expenses related to fixed assets) are used as inputs producing outputs like deposits, loans and investments. In general, under this approach, the major categories of produced deposits (e.g., demand, term and saving deposits) and loans (e.g., mortgages and commercial loans) are viewed as outputs because they are responsible for the significant proportion of value added. Finally, under the operating approach, three different types of inputs are considered: interest expenses, employee expenses and other operating expenses excluding employee expenses. The relevant outputs are interest-related revenues and non-interest revenues emanating mostly from commission, exchange, brokerage, etc.

Selected inputs and outputs under various alternative approaches as employed in the study are summarized in Table 2.1. In previous studies, the intermediation appeared to be widely employed. This approach may be more appropriate for evaluating entire financial institutions because it is inclusive of interest expenses, which often accounts for one-half to two-thirds of total costs of general financial institutions.

Table 2.1: Inputs and Outputs Commonly Used in the Three Different Approaches.

Approaches	**Inputs**	**Outputs**
Intermediate	1. Labor 2. Physical capital 3. Deposits	1. Loans 2. Investments
Value-added	1. Labor 2. Physical capital	1. Deposits 2. Loans 3. Investments
Operating	1. Labor 2. Physical capital 3. Deposits	1. Interest revenues 2. Non-interest revenues

Although bank efficiency studies have long been established in the USA and Europe, efficiency studies based on the Thailand banking system are limited and most have concentrated on commercial banks. Among the earliest studies, Leightner and Lovell (1998) employed the production frontier and Malmquist index to analyze the impact of financial liberalization on the performance of Thai banks for 1989-1994;

they reported that the average bank in Thailand experienced relatively rapid growth in production and total factor productivity.

Subsequently, Kwan (2003) examined the banking industries' per unit operating costs in seven Asian economies including Thailand from 1992 to 1999. Based on commercial banks, the study showed that the country ranking of per unit labor costs and the country ranking of per unit physical capital costs were highly related; however, bank operating efficiency seemed to be unrelated to the degree of openness of the banking sector. The author also reported that on average banks improved their operating performance from1992 to 1997.

Thereafter, Chansarn (2005) investigate the efficiency in the Thai financial sector after the financial crisis by looking at the total factor productivity (TFP) growth. Based on a sample of 12 commercial banks, 13 finance and securities companies and 20 insurance companies, the finding reveals that the efficiency in commercial bank sector as well as finance and securities company sector diminished over the period.

Chantapong and Menkhoff (2005) studied the effect of foreign bank entry on banking efficiency in Thailand after the financial crisis in 1997 by using the conventional translog cost frontier; The results showed that the cost efficiency of domestic banks improved, resulting from an increase in competition arising from the foreign bank entry through acquisition since 1999.

Rangkakulnuwat (2007) utilized an output distance function approach to estimate the technical efficiency of seven Thai commercial banks surviving the 1997 crisis, from 1980 to 2005. Assumptions of time-invariant and time-variant technology are applied to three models: fixed effect, random effect, and ML. In each model, the variations in efficiency across banks are low. In addition, correlations of estimates across all three methods are always at least 0.5. The determinants of Thai commercial banks efficiency are investigated in this study using the second-step Tobit regression model. The author found that the financial liberalization plan between 1987 and 1997 as well as the economics and financial reform programs financially supported by IMF, improve efficiency of Thai commercial banks.

In addition, Chansarn (2008) utilized a DEA approach to examine the relative efficiency of Thai commercial banks during 2003 – 2006. The findings revealed that the efficiency of Thai commercial banks via the operation approach is very high and stable while the efficiency via the intermediation approach was moderately high and somewhat volatile. In term of size - large, medium and small banks, on average, were efficient via the operation approach with average efficiencies of 100%. However, small banks were the most efficient banks via intermediation approach.

Recently, Thoraneenitiyan and Avkiran (2009) employed an approach integrating DEA and SFA to measure the impact of restructuring and country-specific factors on bank efficiency in East Asian including Thailand from 1997 to 2001. The results indicated that although domestic mergers produced more efficient banks, overall, restructuring did not lead to a more efficient banking system. Banking system inefficiencies were mostly attributed to country-specific conditions, particularly, high interest rates, concentrated markets and economic development.

As mentioned previously in Section 2.1, Thai banks can be classified into one of three groups; commercial banks, government-owned specialized banks and foreign banks. Among these three groups, the commercial banks have been extensively studied in previous papers. Few studies incorporate the last two groups in spite of the fact that they compete with commercial banks in the loan business to a certain degree. Because they are different in terms of business structures, management styles and customer bases, one may argue that they operate under different production technology or different environment. In previous literature, there were two methods to address efficiency comparison across production units under different technology or different environment. Firstly, some authors separately estimated the best-practice frontiers for each kind of firms from which the average level of efficiency for each group was calculated and compared. This method can show only that firms in one group are more or less efficient than firms in another group, relative to their specific frontier technology. Put simply, it only implies that firms in a group with high average efficiency operate closer to their specific frontier than firms in a group with low average efficiency. Yet, it does not indicate that firms in one group are more efficient than firms in the other group to the same degree, because the two practices are situated on different technological frontiers. Secondly, in some papers, the authors took into account the effect of different technology and environment under which banks operate by including controls for bank types, country dummies, assets, liquidity, or a concentration ratio, for instance. These factors reflecting technology and environmental heterogeneity were allowed to influence either the cost frontier directly or to enter the model as inefficiency determinants. However, one must keep in mind that, first of all, some statistical tests are needed to evaluate suitability and significance of hypotheses that each firm's data comes from the same population distribution. examples of studies using these methods are given below.

Havrylchyk (2006) applied the stochastic cost frontier to investigate the efficiency of the Polish banking industry, especially between domestic and foreign banks, from 1997 to 2001. The author performed a number of statistic tests, both parametric and non-parametric, to investigate whether domestic and foreign banks are members of the same population distribution. He used tests such as ANOVA, Wilcoxon Rank-sum and Kruskal–Wallis. Test results reveal that the null hypothesis is rejected at the 1% significance level, thereby indicating that it would be inappropriate to pull all banks into one sample. Hence, the author constructed the best-practice frontiers for domestic and foreign banks separately.

On the other hand, Dietsch and Vivas (2000) compared the cost efficiency of French and Spanish banking industries. The authors argued that the technology used in countries like France and Spain should be the same, but the environmental conditions faced by financial institutions were likely to differ substantially; therefore, they estimated a common cost frontier that included the specific environmental conditions of each country, such as the number of branches, density of demand, per capita income and degree of concentration.

Similarly, Altunbas, Liu, Molyneux and Seth (2000) suggested that the cost characteristics and the risks associated with operation widely differed among Japanese banks, so these factors should be incorporated in the underlying industry cost functions. Otherwise, one might easily miscalculate a bank's level of inefficiency. Hence, they controlled for output quality and risk factors by adding loan-loss provisions, liquidity ratio and adjusted values of the output for each bank to the cost frontier model.

Majid, Saal and Battisti (2010) analyzed the impact of Islamic banking on the cost efficiency of Malaysian commercial banks. Islamic banks operate under the Islamic legal code, so interest payments are prohibited in any transaction; therefore, their technology should be different from conventional banking. They specified a common cost frontier for both Islamic banks and commercial banks but allowed for controls for operating environment such as loan quality, equity-to-total assets ratio, merger dummy, and bank-type dummies.

From the literature review, it is observed that past empirical studies on Thai banks' efficiency have used both DEA and SFA methods. For the latter, researchers concentrated on using the conventional translog functional form in spite of availability of more flexible functional form. Furthermore, most focused on measuring efficiency of the commercial banks; only few studies have compared them with the foreign banks; none of them encompassed the government-owned specialized banks despite their competition with the commercial banks in the loan market and their important roles in the financial sector. This article is intended to fill these gaps in literature on Thai-bank efficiency. The first contribution of this article is to introduce the Fourier flexible functional form which is more flexible than the conventional translog form popularly used in the existing literature. The second is to compare the banking production costs between different bank types in Thailand: the commercial banks and the government-owned specialized banks. Finally, more recent years are added to a longitudinal data set allowing more efficient estimates.

2.3 Methodology and Data

Methodology

To evaluate the performance of Thai banks, I estimate a parametric cost frontier model. The cost function is used to measure efficiency instead of a production function because the former allows us to determine how cost efficient the bank is as a financial intermediary in channeling funds to borrowers. In this approach, those whose costs are higher than those predicted for an efficient bank producing the same input/output combination and the difference cannot be explained by statistical noise are labeled as inefficient banks. The cost frontier is obtained by estimating a cost function with a composite error term, the sum of a two-sided error representing random fluctuations in cost and a one-sided positive error term representing inefficiency. The stochastic cost frontier model can be written as

$$TC = TC\left(Q_i, P_i\right) + \varepsilon_i \qquad (1)$$

where TC is observed total cost of production, Q_i is a vector of outputs, and P_i is an input-price vector. The error term is assume to be

$$\varepsilon_i = u_i + v_i$$

where u_i and v_i are independently distributed; v_i is assumed to be distributed as two-sided normal with zero mean and variance, σ_v^2, capturing the effects of the statistical noise, and u_i is assumed to be distributed as half normal[2], $u \sim N\left(\mu, \sigma_u^2\right)$ i.e., a positive disturbance capturing the effects of inefficiency when μ is defined as

$$\mu_i = \theta_0 + \sum_j Z_{ji} \theta_j \qquad (2)$$

where Z_{ji} is the j[th] inefficiency determinant of the bank i[th]. The cost frontier model, equation (1), and the inefficiency model, equation (2), are to be estimated simultaneously via a maximum likelihood procedure.

The next step, given the choice of the half-normal inefficiency stochastic frontier approach, involves choosing the underlying cost function specification. I use the flexible Fourier (FF) form to examine the specification which best fits the underlying cost structure of Thailand banking systems. The FF functional form is the global approximation which can be shown to dominate the conventional translog form[3]. It has been widely accepted that the global property is important in banking where scale, product mix and other inefficiencies are often heterogeneous. Therefore, local approximations (such as those generated by the translog function) may be a relatively poor approximation to the underlying true cost function.

The FF is a semi-nonparametric approach used to tackle the problem arising when the true functional form of the relationships is unknown. It has been shown by Tolstov (1962), that a linear combination of the sine and cosine function, namely the Fourier series, can fit exactly any well behaved multivariate function. This is due to the mathematical behavior of the sine and cosine functions which are mutually

---

[2] According to Berger and Humphrey (1997) the half-normal assumption is relatively inflexible and presumes that most firms are clustered near full efficiency.

[3] Altunbas, Gardener, Molyneux and Moore (2001)

orthogonal over the $[0, 2\pi]$ interval and function space-spanning. The FF form, therefore, provides a better approximation of the true form of the unknown cost function without misspecification.

To calculate the inefficiency measures, the FF form, including a standard translog and all first-, second- and third-order trigonometric terms, as well as a two-component error structure is estimated using a maximum likelihood procedure. This is shown as

$$\begin{aligned}\ln TC = {} & \alpha_0 + \sum_i \alpha_i \ln Q_i + \sum_l \beta_l \ln P_l + t_1 T \\ & + \frac{1}{2}\left[\sum_i \sum_j \delta_{ij} \ln Q_i \ln Q_j + \sum_l \sum_m \gamma_{lm} \ln P_l \ln P_m + t_2 T^2\right] \\ & + \sum_i \sum_m \rho_{im} \ln Q_i \ln P_m + \sum_i \left[a_i \cos(y_i) + b_i \sin(y_i)\right] \\ & + \sum_i \sum_j \left[a_{ij} \cos(y_i + y_j) + b_{ij} \sin(y_i + y_j)\right] + u + v \qquad (3)\end{aligned}$$

where y_i is the adjusted values of the log output, $\ln Q_i$, such that they span the interval $[0, 2\pi]$, T is a time trend, and u is assumed to be distributed as half normal, $u \sim N(\mu, \sigma_u^2)$, capturing the effects of inefficiency. It is worth noting that the likelihood function is expressed in term of the variance parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma_v^2$. It is a measure of the amount of variation stemming from inefficiency relative to noise. Values of γ close to 0 indicate that the symmetric error v_{it} dominates the one-sided error u_{it}.

In addition, the data must be scaled because a Fourier series approximation near a point of discontinuity can oscillate wildly. To avoid this problem, according to Kauko (2009), for each observation, the output data were rescaled as follows:

$$y_i = 1.8\pi\left[Q_i - \min\left(Q_i\right)\right] / \left[\max\left(Q_i\right) - \min\left(Q_i\right)\right] + 0.1\pi \qquad (4)$$

Following Berger et al. (1994), the study applies Fourier terms only to the outputs, leaving the input price effects to be defined entirely by the translog terms. The primary goal is to maintain the limited number of Fourier terms for describing the scale and inefficiency measures associated with differences in bank size. Moreover, the usual input price homogeneity restrictions can be imposed on logarithmic price terms, whereas they cannot be easily imposed on the trigonometric terms.

Since the duality theorem requires that the cost function be linearly homogeneous in input prices and second-order parameters are symmetric, the following restrictions apply to the parameters of the cost function:

$$\sum_l \beta_l = 1; \qquad \sum_l \gamma_{lm} = 0; \qquad \sum_i \rho_{im} = 0; \qquad \delta_{ij} = \delta_{ji}; \qquad \gamma_{lm} = \gamma_{ml}$$

Within sample scale economies are calculated and evaluated at the mean output, input price and financial capital levels[4]. A measure of economies of scale (*SE*) is given by the following cost elasticity by differentiating the cost frontier, equation (3), with respect to output. This gives us

$$SE = \sum_i \frac{\partial \ln TC}{\partial \ln Q_i} = \sum_i \alpha_i + \sum_i \sum_j \delta_{ij} \ln Q_j + \sum_i \sum_m \rho_{im} \ln P_m$$

---

[4] It is common to evaluate the elasticity at the geometric mean $\overline{a} = \left(\prod_{i=1}^{n} a_i \right)^{\frac{1}{n}}$.

$$+1.8\pi\sum_i\left(\frac{Q_i}{\max(Q_i)-\min(Q_i)}\right)\left[-a_i\sin(y_i)+b_i\cos(y_i)\right]$$

$$+3.6\pi\sum_i\sum_j\left(\frac{Q_i}{\max(Q_i)-\min(Q_i)}\right)\left[-a_{ij}\sin(y_i+y_j)+b_{ij}\cos(y_i+y_j)\right]$$

(5)

The price responsiveness of inputs can be measured by estimating the price elasticity of demand (η_{ij}). In our analysis the price elasticity of conditional demand was estimated using the following formula:

$$\sigma_{ii}=\frac{\gamma_{ii}+S_i(S_i-1)}{(S_i)^2}, \qquad \sigma_{ij}=\frac{\gamma_{ij}+S_iS_j}{S_iS_j} \tag{6}$$

and $\eta_{ii}=S_i\sigma_{ii}$, $\eta_{ij}=S_j\sigma_{ij}$ (7)

where σ_{ij} is the Allen-Uzawa partial elasticity of substitutions and S_i is cost share of input i[th]. Alternatively, another measure of ease of substitution known as Morishima elasticity of substitutions (σ_{ij}^M) can be defined as

$$\sigma_{ij}^M=\sigma_{ij}-\sigma_{jj} \tag{8}$$

Note that the Morishima elasticity, unlike the Allen-Uzawa elasticity, is not symmetric. Morishima elasticity of substitution measures the percentage change in the ratio of a pair of factors with respect to a change in the ratio of their respective prices. Note also that for any two inputs i and j it may be that $\sigma_{ij}^M>0$ but that $\sigma_{ij}<0$, so that by the Morishima measure, the inputs are substitutes, but by the Allen measure, the inputs are complements.

According to Lang and Welzel (2006), the rate of technological progress can be inferred from changes in a bank's cost function over time. A time trend variable, T, is incorporated into the cost function to capture the disembodied technological change allowing the bank to produce a given level of output, Q, at lower cost over time, holding input prices constant. This can be measured by taking partial derivatives of the estimated cost frontier with respect to the time trend variable (T) and can be shown as follows:

$$T_c = \frac{\partial \ln TC}{\partial T} = t_1 + t_2 T \qquad (9)$$

Data

As mentioned above, the intermediation approach is chosen in this study. Under this approach, banks input are classified as deposits and acquired funds, labor and capital which are employed in the production of loans and investments. The panel data for 13 existing commercial banks and 5 government-owned banks excluding the Islamic banks are collected from their quarterly financial reports.

Data for commercial banks start from the first quarter of 1998 to the fourth quarter of 2009. However, dramatic changes in the commercial bank sector occurred during the periods included in the sample set. Specifically, after the crisis, several banks were unable to survive. As a result, they were forced to shut down, merged with, or acquired by others banks. Some banks recently emerged as the government decided to give licenses to financial companies to become new banks after 2001. The story of post-crisis reorganization of the Thai commercial banks industry is summarized in the chart below.

For the government-owned banks, 5 out of 6 banks are included. The Islamic bank is excluded from this study because it was newly established, so insufficient data are available. The remaining 5 government-owned specialized banks included in this study consist of Government Saving Bank (GSB), the Government Housing Bank (GHB), the Bank for Agriculture and Agricultural Cooperatives (BAAC), the Small and Medium Enterprise Development Bank of Thailand (SME Bank), the Export-Import Bank of Thailand (EXIM Bank). The panel data for these banks are unbalanced because they, unlike the commercial banks, need not publish their quarterly financial statements; they were forced by law to provide the ministry of finance with only their end-of-the-year balance sheets and income statements; recently, around 2003, the ministry of finance requested them to report their quarterly financial statements; however, their available data are still limited, leading to missing observations for some years.

In order to estimate the cost frontier, the following variables are constructed:

1. Total cost (TC) is composed of interest expense, non-interest expense on personnel and non-interest expense on premises and equipment.
2. Loan (Q_1) consists of quantity of loan, inter-bank and money market items.
3. Investment (Q_2) is comprised of government and state enterprise securities, and other securities.

4. Unit price of labor (P_1) is obtained from non-interest expense on personnel divided by the number of employees[5].

5. Unit price of physical capital (P_2) is constructed from expense on premises and equipment divided by their book value[6].

6. Unit price of deposits and acquired funds (P_3) is calculated by dividing interest expense by the sum of amount of deposits, short term and long term borrowing, bonds and other borrowed money.

Note that all items above are adjusted to be in real values (year base 1988).

Table 2.2: Summary Statistics of the Variables

		C	Q_1	Q_2	P_1	P_2	P_3
Commercial Banks	Mean	5,620	466,000	80,500	160,723	0.058695	0.008675
	Std	5,930	366,000	82,600	222,788	0.039783	0.011113
Government Banks	Mean	3,050	2,590	536	155,191	0.068817	0.007210
	Std	2,300	1,970	996	52,245	0.057193	0.003647
Total	Mean	5,090	372,000	64,400	159,586	0.060728	0.008381
	Std	5,480	376,000	80,500	199,951	0.043977	0.010082

Note: cost and output (C, Q_1 and Q_2) units in million baht; unit of wage and salary (P_1) in baht per quarters.

Table 2.2 above shows the summary statistics for the outputs, inputs, and prices of inputs separately for commercial and government banks. A few conclusions can be drawn from a quick look at the table. On average, commercial banks' total cost, loan, and investment are twice larger than those of government banks. However,

[5] The number of employees is reported at the end of each year, so it is assumed to be constant throughout the year.

[6] The original cost less depreciation and amortization.

prices of inputs, except for wage and salary, paid by commercial banks are slightly less than those of government banks.

Regarding modeling inefficiency, several variables, most of which related to the management and operating environment, are assumed to determine inefficiency. These factors can be taken into consideration by including dummy variables representing ownership. TAKEOVER = 1 if a bank is taken over by foreign investors; otherwise, it is equal to zero. It is believed that foreign investors have superior managerial quality, tacit knowledge and informational advantages, allowing them to outperform local bankers.

In addition, STATE = 1 if a major share holder of a bank is the government; otherwise it takes value of zero. According to incentive theory, it is believed that state-owned banks suffer from lack of ownership incentives; hence, they are prone to perform inadequately. In contrast, banks owned by private stock holder might be expected to face stronger incentive to control cost and enhance more efficiency than state-owned banks.

In addition to ownership and governance structures, several other factors that may impinge on efficiency are added to the model. Firstly, the ratio of non-performing loans to total loans is used to control for differences in banks' loan quality. Under the "bad management hypothesis" of Berger and DeYoung (1997), loan quality is indicative of the quality of bank management.

Secondly, according to Fillipaki, Margaritis and Staikouras (2009), the number of branches for each bank should be taken into consideration because the main reasons banks open up new branches are for efficient utilization of excess capacities. However, banks may have strategic motivations to expand their network such as to defend their market share. In this case, opening up new branches is not expected to increase banks' efficiency. That inefficiency increases or decreases with the expansion of branching network will be reflected by a positive or negative effect of the number of banks' branches.

Thirdly, the ratio of equity to total assets which is reflective of capital adequacy of a bank should be included in the inefficiency analysis as suggested by Altunbas, Lui, Molyneux and Seth (2000),. In most cases, well-capitalized banks are perceived to be relatively safe, which in turn lowers their cost of borrowing and consequently is efficiency enhancing. Therefore, higher levels of capital adequacy are expected to impinge positively on efficiency.

Lastly, according to Fillipaki, Margaritis and Staikouras (2009), the ratio of liquid assets to total assets, which accounts for different risk preference and risk management practices, should be taken into the specification of the inefficiency model because it directly affects cost efficiency by providing an alternative to deposits as a funding source for loans; it may also reflect the risk-return trade-off that banks face.

Summarily, the determinant of Thai commercial banks' inefficiency, equation (2), can be written in the specific form as follows:

$$\mu_i = \theta_0 + \theta_1 \text{TAKEOVER}_i + \theta_2 \text{STATE}_i + \theta_3 \left(\text{NPL/LOAN}\right)_i + \theta_4 \text{BRANCH}_i$$
$$+\theta_5 \left(\text{EQUITY/ASSET}\right)_i + \theta_6 \left(\text{LIQUID/ASSET}\right)_i \qquad (10)$$

where TAKEOVER_i is a binary variable taking value of 1 in subsequent years if the

i^{th}

bank is taken over or acquired by foreign investors,

STATE_i is a binary variable to distinguish between private banks and state banks,

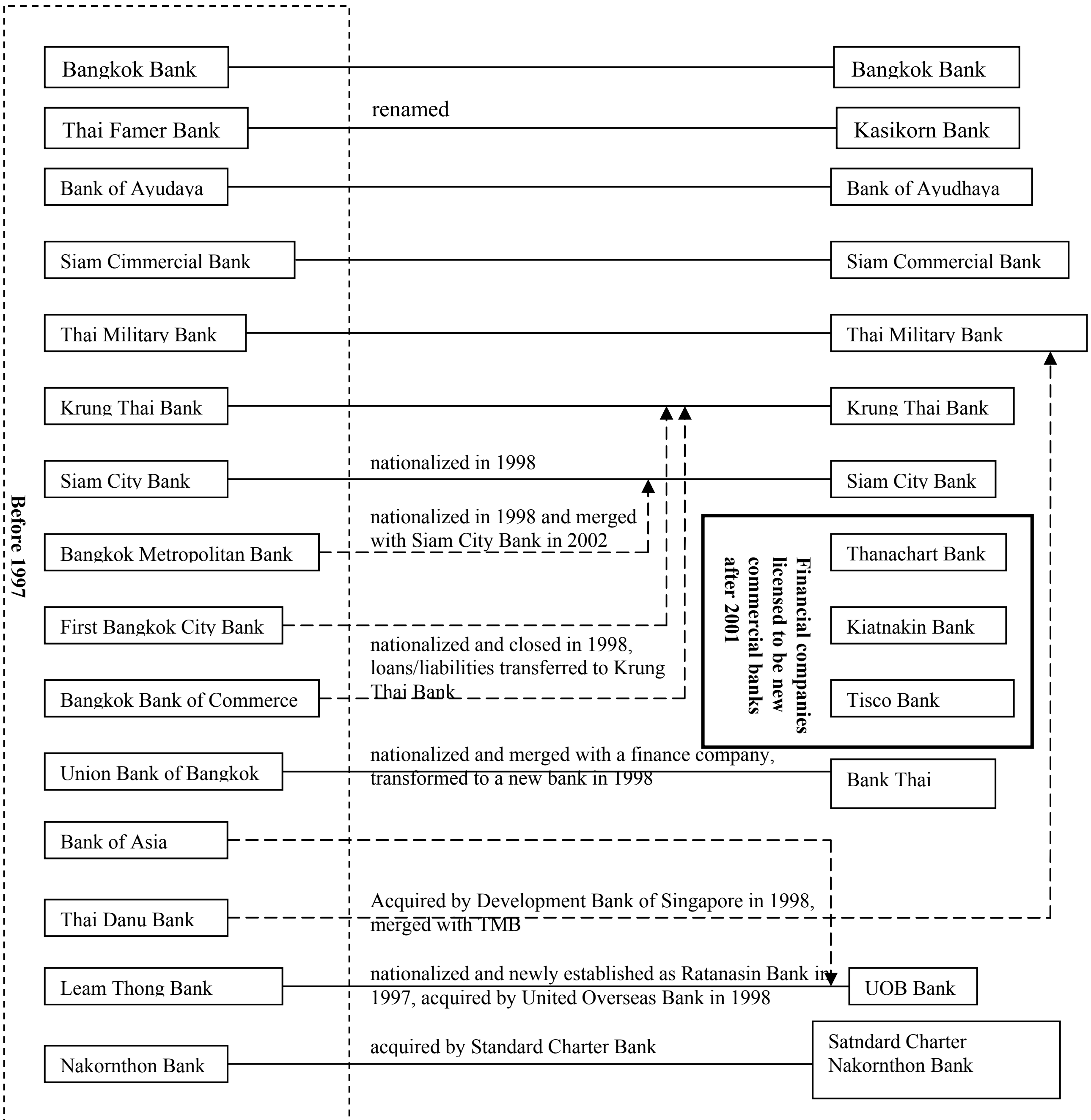
$\left(\text{NPL/LOAN}\right)_i$ is the ratio of non-performing loans to total loans,

BRANCH_i is the number of branches,

$\left(\text{EQUITY/ASSET}\right)_i$ is the ratio of share-holder equity to total assets, and

$\left(\text{LIQUID/ASSET}\right)_i$ is the ratio of liquid assets to total assets.

However, the inefficiency model for government banks must be written differently for various reasons. Basically, the dummy variables for takeover and state bank are a null set because no government bank has been taken over. They are also 100-percent owned by the Thai government. Additionally, the variable $\left(\text{NPL/LOAN}\right)_i$ is dropped due to incomplete data on amount of their Non-performing loan. Hence, the three remaining variables determining inefficiency for the government banks are the number of branches, the ratio of share-holder equity to total assets and the ratio of liquid assets to total assets.


Before 1997
Bangkok Bank
Thai Famer Bank
Bank of Ayudaya
Siam Cimmercial Bank
Thai Military Bank
Krung Thai Bank
Siam City Bank
Bangkok Metropolitan Bank
First Bangkok City Bank
Bangkok Bank of Commerce
Union Bank of Bangkok
Bank of Asia
Thai Danu Bank
Leam Thong Bank
Nakornthon Bank
renamed
nationalized in 1998
nationalized in 1998 and merged with Siam City Bank in 2002
nationalized and closed in 1998, loans/liabilities transferred to Krung Thai Bank
nationalized and merged with a finance company, transformed to a new bank in 1998
Acquired by Development Bank of Singapore in 1998, merged with TMB
nationalized and newly established as Ratanasin Bank in 1997, acquired by United Overseas Bank in 1998
acquired by Standard Charter Bank
Bangkok Bank
Kasikorn Bank
Bank of Ayudhaya
Siam Commercial Bank
Thai Military Bank
Krung Thai Bank
Siam City Bank
Financial companies licensed to be new commercial banks after 2001
Thanachart Bank
Kiatnakin Bank
Tisco Bank
Bank Thai
UOB Bank
Satndard Charter Nakornthon Bank

IV. Estimation Results

First, data poolability of commercial banks and government banks was tested. To test, I constructed a common frontier for both commercial banks and government banks and various structural tests were undertaken to determine whether commercial and government banks come from the same population frontier. Similar to Havrylchyk (2006), a number of parametric (t-test) and non-parametric (Wilcoxon Rank-Sum, Kruskal–Wallis, and Kolmogorov–Smirnov) tests were performed against the null hypothesis that all banks are drawn from the same population. Table 2.3 presents the maximum likelihood parameter estimation of the common cost frontier. The means and standard deviations of commercial banks and government banks are shown in table 2.4. Finally, table 2.5 shows the results of the tests for data poolability.

Table 2.3: The Pooled Cost Frontier

	Variable	**Coefficient**	**Standard error**	**t-statistic**	**P-value**
α_0	constant	23.80225***	5.125437	4.64	0
α_1	$\ln Q_1$	-0.6069432	0.4204108	-1.44	0.149
α_2	$\ln Q_2$	0.5864876*	0.3050339	1.92	0.055
β_1	$\ln P_1$	0.2045428	0.4847351	0.42	0.673
β_2	$\ln P_2$	-1.295936***	0.4403917	-2.94	0.003
β_3	$\ln P_3$	2.091394***	0.3612678	5.79	0
δ_{11}	$1/2(\ln Q_1)^2$	0.0264709	0.0234164	1.13	0.258
δ_{22}	$1/2(\ln Q_2)^2$	-0.0185671*	0.0095643	-1.94	0.052
δ_{12}	$\ln Q_1 \ln Q_2$	-0.0003098	0.0144104	-0.02	0.983
γ_{11}	$1/2(\ln P_1)^2$	-0.0142165	0.0242808	-0.59	0.558

	Variable	Coefficient	Standard error	t-statistic	P-value
γ_{22}	$1/2(\ln P_2)^2$	-0.0234633	0.0725699	-0.32	0.746
γ_{33}	$1/2(\ln P_3)^2$	0.1229434***	0.0193563	6.35	0
γ_{12}	$\ln P_1 \ln P_2$	0.0559804	0.0437894	1.28	0.201
γ_{13}	$\ln P_1 \ln P_3$	-0.0836738***	0.0237404	-3.52	0
γ_{23}	$\ln P_2 \ln P_3$	-0.0680066**	0.0347445	-1.96	0.05
ρ_{11}	$\ln Q_1 \ln P_1$	-0.0002101	0.0190139	-0.01	0.991
ρ_{12}	$\ln Q_1 \ln P_2$	0.0463461**	0.0197547	2.35	0.019
ρ_{13}	$\ln Q_1 \ln P_3$	-0.046136***	0.0150149	-3.07	0.002
ρ_{21}	$\ln Q_2 \ln P_1$	-0.0051029	0.0147091	-0.35	0.729
ρ_{22}	$\ln Q_2 \ln P_2$	-0.042858***	0.0166692	-2.57	0.01
ρ_{23}	$\ln Q_2 \ln P_3$	0.0479609***	0.0130986	3.66	0
t_1	T	-0.0116196***	0.0044211	-2.63	0.009
t_2	T^2	0.0002579***	0.0000762	3.38	0.001
a_1	$\cos(y_1)$	-0.861401***	0.0338588	-25.44	0
b_1	$\sin(y_1)$	-0.5622409***	0.0309905	-18.14	0
a_2	$\cos(y_2)$	-0.1676078***	0.032549	-5.15	0
b_2	$\sin(y_2)$	0.0761557**	0.0322034	2.36	0.018
a_{11}	$\cos(y_1+y_1)$	-0.2758293***	0.0227512	-12.12	0
a_{12}	$2\cos(y_1+y_2)$	-0.1442716***	0.0183909	-7.84	0
a_{22}	$\cos(y_2+y_2)$	-0.0495058*	0.0261426	-1.89	0.058
b_{11}	$\sin(y_1+y_1)$	-0.0365284	0.0244347	-1.49	0.135
b_{12}	$2\sin(y_1+y_2)$	0.0602878***	0.0161051	3.74	0
b_{22}	$\sin(y_2+y_2)$	-0.0683327**	0.0269911	-2.53	0.011
$\ln(\sigma_v^2)$		-4.98005***	0.2819226	-17.66	0
$\ln(\sigma_u^2)$		-1.961155***	0.0897751	-21.85	0
σ_v		0.0829079	0.0116868		
σ_u		0.3750945	0.0168371		
$\sigma^2=\sigma_u^2+\sigma_v^2$		0.1475696	0.0115008		
$\lambda=\sigma_u/\sigma_v$		4.524231	0.0258748		

Note: *, **, *** and represent statistical significance at 10%, 5% and 1%, respectively.
There are 657 observations.
The log likelihood is 50.685.
The distribution of inefficiency term is assumed to be half normal.

Table 2.4: Mean and Standard Deviation of Cost Efficiency

	Pooled frontier	
	Commercial banks	Government banks
mean	1.355444	1.488846
sd	0.4078303	0.534254

Table 2.5: Summary of the Tests on Cost Efficiency against the Null Hypothesis that Commercial Banks and Government-owned Banks Come from the Same Distribution

	t-test	**Wilcoxson Rank-Sum test**	**Kruskal–Wallis**	**Kolmogorov–Smirnov**
	t (prob > t)	z (prob > z)	χ^2 (prob > χ^2)	D (prob >D)
test statistics	-3.1566***	-3.549***	12.595***	0.2287***
p-value	0.0017	0.0004	0.0004	0.0000

Note: *, **, and *** represent statistical significance at 10%, 5% and 1%, respectively.

From table 2.3, most of the estimated coefficients are significant at 0.99 level of statistical confidence. Based on $\lambda = 4.52$, we can infer that most of the variation from the cost frontier is attributed to inefficiency rather than random noise. In table 2.4, the means of cost inefficiency of commercial banks and government banks are 1.35 and 1.48, respectively; their standard deviations are 0.40 and 0.53. This implies that on average commercial banks were more successfully capable of operating closely to the cost frontier than the government banks. From table 2.5, all tests which are applied on the cost-inefficiency measures allow us to reject the null hypothesis at the 1% significance level.

However, one might argue that these tests, used by Havrylchyk (2006), are invalid because they, in fact, test against the null hypothesis whether the efficiency distributions are similar. When the null hypothesis is rejected, it might be the case that their efficiency comes from different distributions or the equations explaining their inefficiency have different intercept or means. Yet, I could not conclude that their cost frontiers are indeed different from these tests on efficiency distribution. So, I propose to perform these tests again on the predicted total cost expenditure rather than the efficiency scores.

Table 2.6: Summary of the Tests on Total Cost Expenditure against the Null Hypothesis that Commercial Banks and Government-owned Banks Come from the Same Distribution

	t-test	**Wilcoxson Rank-Sum test**	**Kruskal–Wallis**	**Kolmogorov–Smirnov**
	t (prob > t)	z (prob > z)	χ^2 (prob > χ^2)	D (prob >D)
test statistics	7.3824***	7.217***	52.088***	0.3039***
p-value	0.0000	0.0000	0.001	0.0000

Note: *, **, and *** represent statistical significance at 10%, 5% and 1%, respectively.

The test results shown in table 2.6 reaffirm the statistical conclusions of table 2.5. I reject the null hypothesis that their cost expenditures are drawn from the same distribution for all tests. Therefore, it would be inappropriate to put all banks under a single common frontier.

Since the statistical tests suggest that commercial banks and government banks operate under different technology, we should estimated their cost frontier separately.

Again, by using maximum likelihood method, I construct the cost frontiers together with the inefficiency models for commercial banks and government banks separately. Parameter estimation are shown in tables 2.7 and 2.8.

Table 2.7: The Estimated Cost Frontier for Commercial Banks

	Variable	Coefficient	Standard error	t-statistic	P-value
Stochastic Cost frontier (equation 3)					
α_0	constant	-47.492***	13.1838	-3.6	0
α_1	$\ln Q_1$	4.94398***	0.99402	4.97	0
α_2	$\ln Q_2$	0.18515	0.33746	0.55	0.583
β_1	$\ln P_1$	-0.9232**	0.37213	-2.48	0.013
β_2	$\ln P_2$	0.54707	0.35509	1.54	0.123
β_3	$\ln P_3$	1.37617***	0.24601	5.59	0
δ_{11}	$1/2(\ln Q_1)^2$	-0.0638	0.04847	-1.32	0.188
δ_{22}	$1/2(\ln Q_2)^2$	0.11285***	0.01888	5.98	0
δ_{12}	$\ln Q_1 \ln Q_2$	-0.1122***	0.01863	-6.02	0
γ_{11}	$1/2(\ln P_1)^2$	-0.0279**	0.01403	-1.99	0.046
γ_{22}	$1/2(\ln P_2)^2$	-0.3606***	0.03867	-9.32	0
γ_{33}	$1/2(\ln P_3)^2$	0.09546***	0.00984	9.7	0
γ_{12}	$\ln P_1 \ln P_2$	-0.0891***	0.02325	-3.83	0
γ_{13}	$\ln P_1 \ln P_3$	-0.0672***	0.01353	-4.97	0
γ_{23}	$\ln P_2 \ln P_3$	-0.1063***	0.01951	-5.45	0
ρ_{11}	$\ln Q_1 \ln P_1$	0.02119	0.01856	1.14	0.254
ρ_{12}	$\ln Q_1 \ln P_2$	-0.0383*	0.0204	-1.88	0.06
ρ_{13}	$\ln Q_1 \ln P_3$	0.01715	0.01386	1.24	0.216
ρ_{21}	$\ln Q_2 \ln P_1$	0.01026	0.01777	0.58	0.564
ρ_{22}	$\ln Q_2 \ln P_2$	0.00034	0.01765	0.02	0.985
ρ_{23}	$\ln Q_2 \ln P_3$	-0.0106	0.01018	-1.04	0.298
t_1	T	-0.0054***	0.0019	-2.86	0.004
t_2	T^2	0.0001***	3.2E-05	3.16	0.002

	Variable	Coefficient	Standard error	t-statistic	P-value
a_1	$\cos(y_1)$	-0.0596***	0.01727	-3.45	0.001
b_1	$\sin(y_1)$	-0.144***	0.03555	-4.05	0
a_2	$\cos(y_2)$	-0.0164	0.01369	-1.2	0.231
b_2	$\sin(y_2)$	0.05799***	0.01878	3.09	0.002
a_{11}	$\cos(y_1 + y_1)$	0.02726***	0.00931	2.93	0.003
a_{12}	$2\cos(y_1 + y_2)$	-0.0248***	0.00763	-3.25	0.001
a_{22}	$\cos(y_2 + y_2)$	0.02509**	0.01068	2.35	0.019
b_{11}	$\sin(y_1 + y_1)$	-0.0236***	0.01168	-2.02	0.043
b_{12}	$2\sin(y_1 + y_2)$	0.02284***	0.00668	3.42	0.001
b_{22}	$\sin(y_2 + y_2)$	0.00819	0.01217	0.67	0.501
$\ln(\sigma_v^2)$		-5.7701	0.116595	-49.49	0
Inefficiency model (equation 10)					
θ_0	CONSTANT	-1.03717***	0.372453	-2.78	0.005
θ_1	TAKEOVER	1.080186***	0.431281	2.5	0.01
θ_2	STATE	-1.46906***	0.391788	-3.75	0.00
θ_3	NPL/LOAN	1.279289**	0.653876	1.96	0.05
θ_4	EQUITY/ASSET	-14.2237***	3.300632	-4.31	0
θ_5	LIQUID/ASSET	-3.23623***	1.088508	-2.97	0.003
θ_6	BRANCH	-0.00847***	0.000881	-9.62	0
σ_u		0.055852	0.003256		

Note: *, **, *** and represent statistical significance at 10%, 5% and 1%, respectively.
The number of observations is 523.
The log likelihood is 579.92.
The distribution of inefficiency term is assumed to be half normal.

Table 2.8: The Estimated Cost Frontier for Government Specialized Banks

	Variable	Coefficient	Standard error	t-statistic	P-value
Stochastic Cost frontier (equation 3)					
α_0	constant	-85.1997**	39.67668	-2.15	0.032
α_1	$\ln Q_1$	11.28217***	4.001251	2.82	0.005
α_2	$\ln Q_2$	-0.38396	0.45816	-0.84	0.402
β_1	$\ln P_1$	-1.43976*	0.745476	-1.93	0.053
β_2	$\ln P_2$	2.582125*	1.365805	1.89	0.059
β_3	$\ln P_3$	-0.14236	1.05888	-0.13	0.893
δ_{11}	$1/2(\ln Q_1)^2$	-0.68353***	0.205355	-3.33	0.001
δ_{22}	$1/2(\ln Q_2)^2$	0.013633	0.011959	1.14	0.254
δ_{12}	$\ln Q_1 \ln Q_2$	0.007238	0.016059	0.45	0.652
γ_{11}	$1/2(\ln P_1)^2$	-0.1488**	0.059209	-2.51	0.012
γ_{22}	$1/2(\ln P_2)^2$	-0.07091	0.06074	-1.17	0.243
γ_{33}	$1/2(\ln P_3)^2$	0.217084**	0.090458	2.4	0.016
γ_{12}	$\ln P_1 \ln P_2$	0.114185	0.094648	1.21	0.228
γ_{13}	$\ln P_1 \ln P_3$	0.221348**	0.092159	2.4	0.016
γ_{23}	$\ln P_2 \ln P_3$	0.025615	0.041903	0.61	0.541
ρ_{11}	$\ln Q_1 \ln P_1$	0.222433***	0.03235	6.88	0
ρ_{12}	$\ln Q_1 \ln P_2$	-0.19234***	0.032216	-5.97	0
ρ_{13}	$\ln Q_1 \ln P_3$	-0.03009	0.037071	-0.81	0.417
ρ_{21}	$\ln Q_2 \ln P_1$	0.004259	0.017635	0.24	0.809
ρ_{22}	$\ln Q_2 \ln P_2$	-0.00193	0.022706	-0.09	0.932
ρ_{23}	$\ln Q_2 \ln P_3$	-0.00233	0.02236	-0.1	0.917
t_1	T	0.006367	0.010421	0.61	0.541
t_2	T^2	-2.8E-05	0.000152	-0.19	0.853
a_1	$\cos(y_1)$	-0.05257	0.119746	-0.44	0.661
b_1	$\sin(y_1)$	-0.31278	0.232779	-1.34	0.179
a_2	$\cos(y_2)$	-0.27615**	0.11839	-2.33	0.02
b_2	$\sin(y_2)$	-0.4121***	0.106224	-3.88	0
a_{11}	$\cos(y_1 + y_1)$	-0.06747	0.090338	-0.75	0.455

	Variable	Coefficient	Standard error	t-statistic	P-value
a_{12}	$2\cos(y_1+y_2)$	-0.10174	0.063357	-1.61	0.108
a_{22}	$\cos(y_2+y_2)$	0.109957	0.0693	1.59	0.113
b_{11}	$\sin(y_1+y_1)$	-0.1847**	0.085613	-2.16	0.031
b_{12}	$2\sin(y_1+y_2)$	-0.18255***	0.048231	-3.78	0
b_{22}	$\sin(y_2+y_2)$	-0.04983	0.079832	-0.62	0.532
$\ln(\sigma_v^2)$		-5.97734	0.394597	-15.15	0
Inefficiency model (equation 10)					
θ_0	CONSTANT	-3.55694***	1.277006	-2.79	0.005
θ_4	EQUITY/ASSET	-30.4118	23.9808	-1.27	0.205
θ_5	LIQUID/ASSET	4.311321	4.478098	0.96	0.336
θ_6	BRANCH	0.002009	0.001453	1.38	0.167
σ_u		0.050355	0.009935		

Note: *, **, *** and represent statistical significance at 10%, 5% and 1%, respectively.
The number of observations is 134.
The log likelihood is 171.69.
The distribution of inefficiency term is assumed to be half normal.

The estimation results in tables 2.7 and 2.8 show that most parameters are statistically significant. Hence, I use these coefficients to infer about production technology such as scale economies and substitutability among inputs.

Economies of scale are the cost advantages that a firm obtains from production expansion. According to equation (6) together with the estimated coefficients of the cost frontiers in tables 2.7 and 2.8, the estimates of scale economies can be derived by evaluating at the geometric means of outputs and factor prices. I find that the scale economies of commercial banks and government banks are 0.916 and 1.729, respectively. Hence, these results show that commercial banks experience economies of scale or increasing return to scale in their production - as they double outputs, their cost increases by less than double; Government banks, on the other hand, face diseconomies of scale or decreasing return- as they double outputs, their cost increases by more than double. Note, from the summary statistics given in table 2.2, that government banks are extremely smaller than private commercial banks; Commercial banks' outputs, loans and investments, are more than a hundred times greater than those of government banks. .

Using equation (6) and (8), I can compute Allen-Uzawa and Morishima elasticities of substitutions evaluated at their geometric means of input prices. Tables 2.9 and 2.10 present Allen-Uzawa and Morishima elasticities for commercial banks and government banks, respectively.

Table 2.9: Allen-Uzawa and Morishima Elasticities of Substitution for Commercial Banks

Input i ↓ / Input j →	Labor	Physical capital	Loanable funds
Allen-Uzawa elasticities of substitution (σ_{ij})			
Labor	-3.91	-0.03	0.23
Physical capital	-0.03	-33.78	-0.16
Loanable funds	0.23	-0.16	-0.30
Morishima elasticities of substitution (σ_{ij}^{M})			
Labor	-3.91	33.75	0.54
Physical capital	3.87	-33.78	0.13
Loanable funds	4.14	0.13	-0.30

Table 2.10: Allen-Uzawa and Morishima Elasticities of Substitution for Government Banks

Input i ↓ / Input j →	Labor	Physical capital	Loanable funds
Allen-Uzawa elasticities of substitution $\left(\sigma_{ij}\right)$			
Labor	-4.419	0.029	0.944
Physical capital	0.029	-33.134	0.698
Loanable funds	0.944	0.698	-0.020
Morishima elasticities of substitution $\left(\sigma_{ij}^{M}\right)$			
Labor	-4.419	33.163	0.964
Physical capital	4.449	-33.134	0.718
Loanable funds	5.364	0.718	-0.020

For commercial banks, by the Allen-Uzawa measure, labor and loanable funds are substitutable for each other whereas labor and physical capital and physical capital and loanable funds are complementary inputs. However, by Morishima measure, all inputs are substitutable for one another. Similarly, for government banks, both Allen-Uzawa and Morishima elasticities suggest that all inputs are found to be substitutable for one another.

Allen-Uzawa elasticities of substitution can be used to compute own and cross price elasticities for input demands by using the relationship in equation (7). These are more interesting economic statistics. Tables 2.11 and 2.12 present the own and cross price elasticities for input demands of commercial banks and government banks, respectively.

Table 2.11: Own and Cross Price Elasticities of Demands for Inputs of Commercial Banks

Input i ↓ / Input j →	Own and cross price elasticities of demand for inputs (η_{ij})		
	Labor	Physical capital	Loanable funds
Labor	-0.893	-0.003	0.154
Physical capital	-0.007	-3.959	-0.108
Loanable funds	0.053	-0.019	-0.199

Table 2.12: Own and Cross Price Elasticities of Demands for Inputs of Government Banks

Input i ↓ / Input j →	Own and cross price elasticities of demand for inputs (η_{ij})		
	Labor	Physical capital	Loanable funds
Labor	-1.245	0.002	0.619
Physical capital	0.008	-2.071	0.457
Loanable funds	0.266	0.043	-0.013

From table 2.11, for commercial banks, every own price elasticity is negative, so that all factor demands display negative slope i.e. the input quantity demanded decreases as the input price increases. The own price elasticity of labor demand is less than but very close to unity. The own price elasticity of demand for physical capital is substantially greater than one; the demand for physical capital would go up by 3.95% if its price went down by only 1%. Nevertheless, demand for loanable funds appears to be inelastic because of its close-to-zero own price elasticity. Regarding their cross-price elasticities, labor and loanable funds are substitutable, whereas labor and physical capital and physical capital and loanable funds are complementary. However, all of their cross price elasticities are very close to zero, so that it is difficult for commercial banks to adjust one input quantity in response to change in another input price.

For government banks, their own and cross price elasticities shown in table 2.12 are very similar to those of commercial banks; all input demands have negative slope; own-price elasticity of demand for labor is close to unity; demand for physical capital is highly elastic but demand for loanable funds is inelastic.

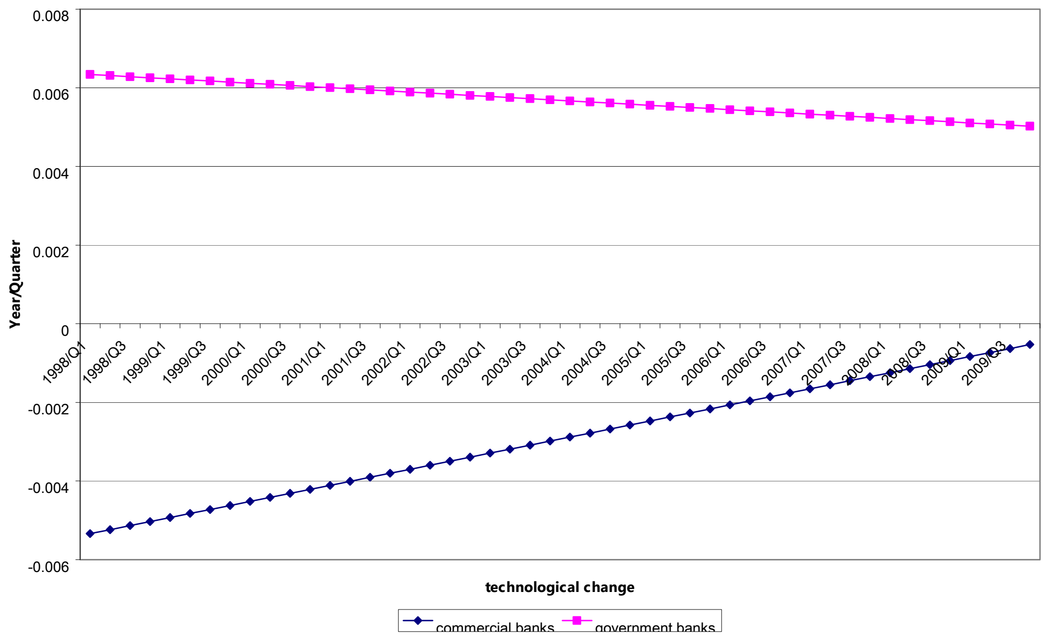
Next, I calculate estimates of technical change using equation (9). The technical progress results of commercial banks and government banks are shown in table 2.13 and figure 2.1. For commercial banks, technical change results in a decline in cost of production throughout the period of study, but cost declines at a slower rate as time passes, from 0.53% in the first quarter of 1998 to only 0.12% in the fourth quarter of 2009. On the other hand, government banks suffer from an increase in cost of production, but the rate of increase tends to decrease over time, from 0.63% in the first quarter of 1998 to 0.53% in the fourth quarter of 2009.

Table 2.13: Technical Change for Commercial Banks and Government Banks from 1998Q1-2009Q4

Year/Quarter	**Overall technical change for commercial banks**	**Overall technical change for government banks**
1998/Q1	-0.005337	0.006339
1998/Q2	-0.0052347	0.006311
1998/Q3	-0.0051324	0.006283
1998/Q4	-0.0050301	0.006255
1999/Q1	-0.0049278	0.006227
1999/Q2	-0.0048255	0.006199
1999/Q3	-0.0047232	0.006171

Year/Quarter	Overall technical change for commercial banks	Overall technical change for government banks
1998/Q1	-0.005337	0.006339
1999/Q4	-0.0046209	0.006143
2000/Q1	-0.0045186	0.006115
2000/Q2	-0.0044163	0.006087
2000/Q3	-0.004314	0.006059
2000/Q4	-0.0042117	0.006031
2001/Q1	-0.0041094	0.006003
2001/Q2	-0.0040071	0.005975
2001/Q3	-0.0039048	0.005947
2001/Q4	-0.0038025	0.005919
2002/Q1	-0.0037002	0.005891
2002/Q2	-0.0035979	0.005863
2002/Q3	-0.0034956	0.005835
2002/Q4	-0.0033933	0.005807
2003/Q1	-0.003291	0.005779
2003/Q2	-0.0031887	0.005751
2003/Q3	-0.0030864	0.005723
2003/Q4	-0.0029841	0.005695
2004/Q1	-0.0028818	0.005667
2004/Q2	-0.0027795	0.005639
2004/Q3	-0.0026772	0.005611
2004/Q4	-0.0025749	0.005583
2005/Q1	-0.0024726	0.005555
2005/Q2	-0.0023703	0.005527
2005/Q3	-0.002268	0.005499
2005/Q4	-0.0021657	0.005471
2006/Q1	-0.0020634	0.005443
2006/Q2	-0.0019611	0.005415
2006/Q3	-0.0018588	0.005387
2006/Q4	-0.0017565	0.005359
2007/Q1	-0.0016542	0.005331
2007/Q2	-0.0015519	0.005303
2007/Q3	-0.0014496	0.005275
2007/Q4	-0.0013473	0.005247
2008/Q1	-0.001245	0.005219
2008/Q2	-0.0011427	0.005191
2008/Q3	-0.0010404	0.005163
2008/Q4	-0.0009381	0.005135
2009/Q1	-0.0008358	0.005107
2009/Q2	-0.0007335	0.005079
2009/Q3	-0.0006312	0.005051
2009/Q4	-0.0005289	0.005023

Figure 2.1: Technical Changes for Commercial Banks and Government Banks from 1998Q1-2009Q4



Finally, I focus on cost inefficiency. From the cost-inefficiency model of commercial banks in table 2.7, the ratio of non-performing loan to total loan (NPL/LOAN) and the dummy variable representing the taken-over banks (TAKEOVER) have positive effects on the cost inefficiency, whereas other variables including the dummy variable representing the state-enterprise bank (STATE), the ratio of equity to total assets (EQUITY/ASSET), the ratio of liquid assets to total assets and the number of branches have inverse relationship with the cost inefficiency. Table 2.14 presents the average cost-inefficiency score for each commercial bank together with the average of the inefficiency-determinant variables.

Table 2.14: Mean and Standard Deviation of Cost Inefficiency over the Whole Period (1998-2009) for Commercial Banks

Name	**Inefficiency**	**NPL/ Loan**	**Equity/ assets**	**Liquid/ Assets**	**Branches**	**State**	**Take-over**
KTB	1.008	0.166	0.072	0.148	665.896	yes	no
SCB	1.022	0.151	0.091	0.111	628.708	no	no
BBL	1.023	0.191	0.068	0.134	654.792	no	no
KBANK	1.024	0.126	0.071	0.140	557.083	no	no
SCIB	1.041	0.193	0.063	0.092	324.958	no	no
TMB	1.051	0.171	0.058	0.066	406.167	no	no
BAY	1.064	0.164	0.067	0.093	464.438	no	no
THANA						no	no
CHART	1.112	0.033	0.100	0.129	98.645		
BT	1.127	0.187	0.033	0.122	110.021	no	yes
KK	1.131	0.116	0.175	0.058	28.235	no	no
UOB	1.189	0.096	0.094	0.208	85.021	no	yes
TISCO	1.190	0.036	0.124	0.042	25.611	no	no
SCNB	1.370	0.100	0.071	0.151	46.854	no	yes
Mean	1.091	0.133	0.084	0.115	315.110	-	-
Std	0.098	0.053	0.034	0.043	248.989	-	-

Unsurprisingly, the ratio of NPL to total loan is positively related to cost inefficiency and is broadly supportive of the bad management hypothesis of Berger and DeYoung (1997), which might suggest that efficient banks trend to perform better because they are better in evaluating credit risks. Similarly, the equity-to-total-asset ratio has a negative relationship with cost inefficiency on the ground that banks with low inefficiency will have higher profit and hence will be able to retain more earnings as capital. In addition, the coefficient on the ratio of liquid-asset-to-total-asset is negative, probably suggesting that banks that can retain a lot of liquid assets are likely to be successful in lowering their financial risks and hence tend to perform more efficiently. In addition, the number of branches is found to have a negative impact on bank inefficiency. This is consistent with the presumption that banks are likely to open up new branches for efficient utilization of excess capacities.

Surprisingly, the coefficient on the dummy variable representing state-enterprise banks is negative, suggesting that state-enterprise banks trend to outperform private-owned banks. This fact seems to contradict with the presumption that state ownership should be found to be associated with poor economic performance. In this study, banks would be categorized as state-enterprises if the Thai government holds more than 50% of their shareholder equity. According to this definition, only one bank, Krung Thai Bank, is labeled as a state-enterprise bank. For other banks like Siam City Bank and Bank Thai, they are not classified as state enterprises even though their major shareholder is the Financial Institution Development Fund (FIDF) which is the government agency that is independently managed by the board appointed by the government. For Thai Military Bank, it is not considered a state enterprise because the government is just the major shareholder but it owns only approximately 26% of the stock. After 1997 Asian financial crisis, by the prescription of the government, Krung Thai Bank merged with smaller insolvent banks. Moreover, Krung Thai Bank was better-capitalized than other banks during the period of the crisis because of the government financial support. In addition, the government provided the bank with a lot of favors including low-cost funding in order to use the bank as a tool to stimulate the slow-down economy. This might be why Krung Thai Bank was measured more efficient than private-owned banks.

Similarly, the coefficient on the dummy variable representing banks which are acquired by foreign banks has positive sign. This again contradicts our supposition that foreign investors have superior managerial ability, tacit knowledge and informational advantages, which allow them to outperform local bankers. The banks that were acquired or majorly owned by foreign investors include Bank Thai[7], UOB Rattanasin[8], and Standard Chartered Nakornthon[9]. The reason why foreigner-owned banks show less efficiency than domestically owned banks might be that although foreign banks trend to have superior management skill and culture, they might have some disadvantages such as less knowledge about the local market.

As it can be seen from table 2.14, Krung Thai Bank seems to be the most efficient bank whose average cost-inefficiency score is at the minimum of 1.008. Since cost-inefficiency score represents how much cost firms could reduce given level of outputs, if they could have produced on the cost frontier, this result implies that on average Krung Thai Bank produces outputs at only 0.8% higher cost relative to the cost frontier. Figure 2.1 illustrates the plots of cost-inefficiency scores of the four most efficient banks including Krung Thai Bank, Siam Commercial Bank, Bangkok Bank, and Kasikorn Thai Bank. It is noteworthy that these four banks also have been considered the Big-4 banks in Thailand for many years because of their enormous asset and market share[10]. Note that, from figure 2.2, the vast gaps between the most efficient bank and the other 3 banks during the early period of study. However, such gaps trend to disappear as time passes, implying that the less efficient banks succeed

---

[7] On November 5, 2008 Bank Thai was acquired by Malaysian CIMB group.

[8] UOB bank was initially Ratanasin Bank. It was acquired by Singaporean United Overseas Banks in 1998.

[9] In 1999, Singaporean Standard Chartered bank acquired 75% of the shares of Nakornthon Bank.

[10] Chansarn (2008), for example, categorizes Thai commercial banks into 3 groups: large banks consisting of Bangkok Bank, Kasikorn Bank, Siam Commercial Bank, and Krung Thai Bank: medium bank consisting of Bank of Ayudhaya, Thai Military Bank, Siam City Bank, Bank Thai, and Thanacart Bank: small banks consisting of Standard Charter Nakornthon Bank, TISCO Bank, and Kaitnakin Bank.

in catching up with the most efficient bank. On the other hand, figure 2.3 shows the plots of cost inefficiency of the 4 least efficient banks including Kaitnakin Bank, TISCO Bank, UOB Bank, and Standard Charter Nakornthon Bank, together with the Krung Thai Bank, the most efficient bank, for comparison. Again, it is noteworthy that such 4 banks are often deemed the small-size banks in Thailand, and two of them, Kaitnakin and TISCO, are new entries who emerged in the market in 2007. As it can be seen from the figure, they do not show any significant trend to move closer to the most efficient bank. They go up and down during the period of study. These results indicate that size of banks may play an important role in determination of bank efficiency.

In comparison with previous studies, our results show that KTB is the most efficient bank, followed by BBL, SCB and KBANK, and also considered the biggest four banks. These findings are very similar to previous studies; for example, Rangkakulnuwat (2007) found that KTB is the most efficient bank; Chansarn (2008) found that the average efficiency of SCB and KBANK is equal to one throughout the period (2003-2006) while KTB is the most efficient bank in the years 2004 to 2006.

Figure 2.2: Cost Inefficiency of the Four Most Efficient Banks

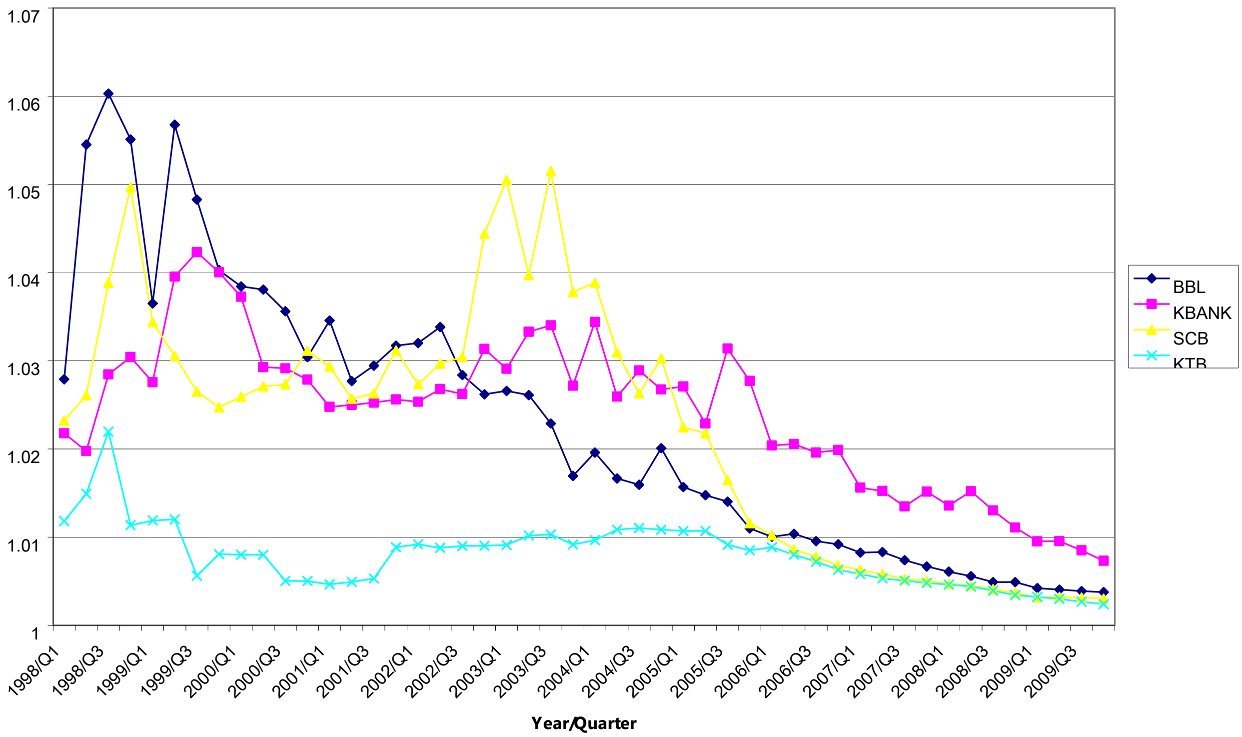
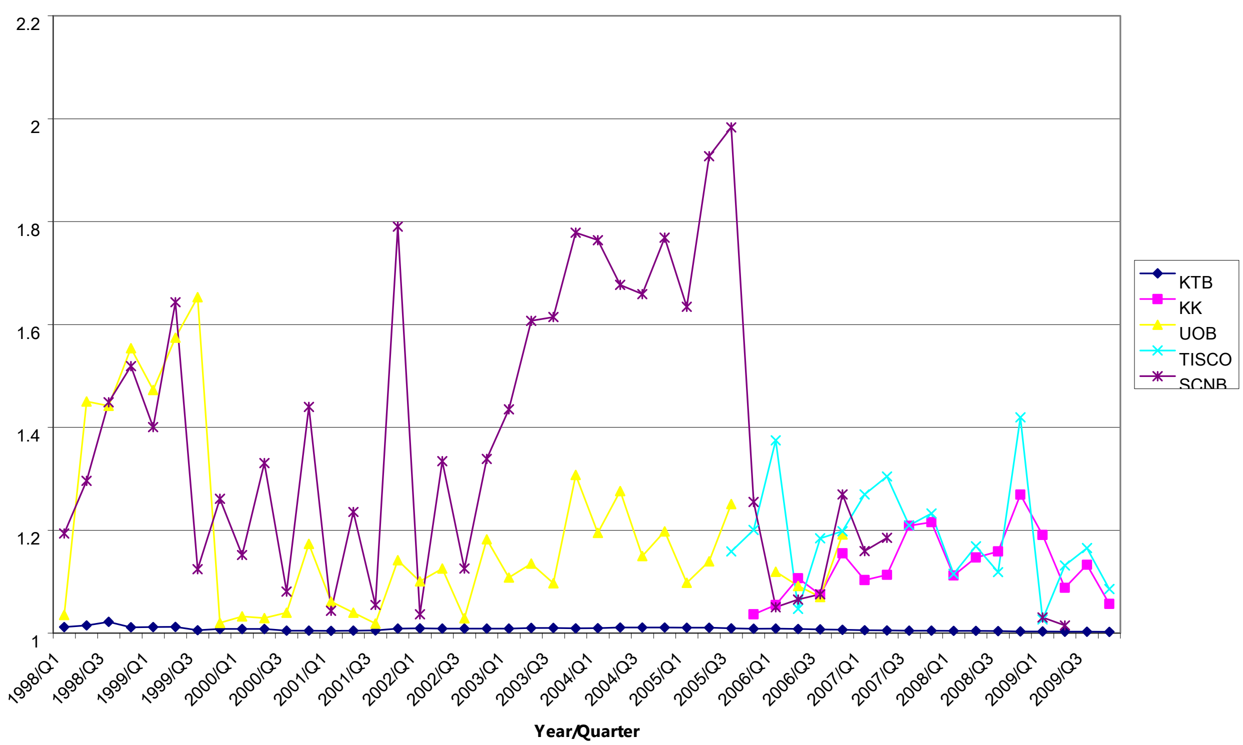


Figure 2.3: Cost Inefficiency of the Four Least Efficient Banks



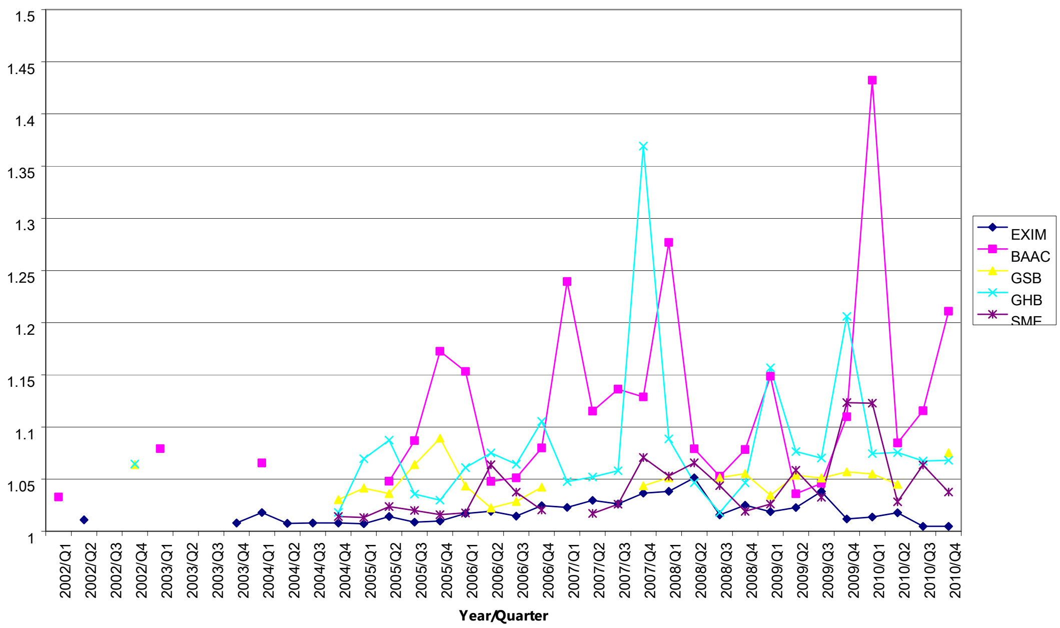
After analyzing cost efficiency of commercial banks, we turn our attention to the government-owned specialized banks. From the cost-frontier estimation results in table 2.8, we see that the equity-to-total-assets ratio varies inversely with cost inefficiency, while the other two variables, liquid-asset-to-total-asset ratio and the number of branches, have positive relationship with cost inefficiency. Table 2.15 below reports the mean and standard deviation of cost inefficiency together with the inefficiency-explanatory variables of each government-owned specialized bank.

Table 2.15: Mean and Standard Deviation of Cost Inefficiency for Government Banks

Name	**Inefficiency**	**Equity/ Assets**	**Liquid/ assets**	**Branches**
EXIM	1.018	0.158	0.108	10.875
SME	1.042	0.111	0.073	94.160
GSB	1.057	0.101	0.049	594.844
GHB	1.082	0.047	0.026	129.966
BAAC	1.122	0.089	0.069	861.546
Mean	1.064	0.101	0.065	338.278
std	0.035	0.036	0.027	331.607

As shown in the table above, on average EXIM Bank appears to be the most efficient bank. The equity-to-total-asset ratio has a negative effect on cost inefficiency which is the same result as that of commercial banks. However, it is observed that an increase in the liquid-asset-to-total-asset ratio will increase cost inefficiency; this result is different from that of commercial banks. It implies that government banks face the financial constraint of tradeoff between retaining liquid assets and holding the less-liquid and higher-risk assets but giving return such as bonds and long-term borrowing. In addition, government banks' branch expansion will result in lower cost efficiency. This result indicates that government banks, unlike commercial banks, might increase the number of their branches in order to maintain or increase their market share regardless of their potential capacity and efficiency. Figure 2.4 below shows the time trends of cost inefficiency of government banks. The time trends of cost inefficiency show stable gaps among these banks. EXIM Bank appears to be the most efficient bank throughout the period; this might pertain to their few branches and high equity-to-total-asset ratio.On the other hand, Bank of Agriculture and Cooperatives shows an upward trend over time. Its lower efficiency might be attributed to its low equity and the enormous number of branches (861 branches on average). The government encourages BAAC to establish branches in many districts throughout the country in order to facilitate poor farmers accessible to cheap loans; hence, this might be the reason for such excessive number of branches. Regarding the pattern of efficiency over time, we observe that the time trends of each government bank's efficiency, different from those of commercial banks, are unsystematic; only EXIM bank is consistently ranked as the most efficient bank throughout the period.

Figure 2.4: Cost Inefficiency of Government-owned Specialized Banks



V. Conclusion

This chapter estimates separate cost efficiency of Thai commercial banks and government-owned specialized banks using quarterly data between 1998 and 2010 employing a Fourier-specified stochastic cost function. Determinants of cost inefficiency are included in the specification. The hypothesis that both commercial banks and government banks data are drawn from the same population is rejected; therefore, the cost frontiers for commercial banks and government banks were estimated separately.

For commercial banks, the Krung Thai Bank is consistently the most cost-efficient bank, followed by Bangkok Bank, Siam Commercial Banks and Kasikorn Bank, respectively. All have been regarded as the biggest four banks dominating the banking sector of Thailand for a long. On the other hand, the small and newly established banks like Kaitnakin Bank, UOB, TISCO Bank, and SCNB were ranked at the bottom in efficiency. These results imply that the size of banks might play an important role in determining efficiency. In addition, banks with lower NPL-to-total-loan ratio, higher equity-to-total-asset ratio, higher liquid-asset-to-total-asset ratio, and more branches are likely to be more efficient. However, the results show that state-enterprise banks and banks which were acquired by foreign investors are less efficient than private-owned and local banks. In the very first years after the 1997 East Asian financial crisis, there were wide gaps between the most and least efficient banks. However, these gaps among the group of big banks have disappeared in the recent years, whereas the small banks failed to catch up the big banks.

In addition to the cost inefficiency, from the cost frontier, inferences about production technology are possible. Thai commercial banks' production technology exhibits increasing return to scale or economies of scale at their current size, indicating further growth in bank size is plausible. By Allen elasticity of substitution, labor and loanable funds appear to be substitutable for each other; however, labor and physical capital as well as physical capital and loanable funds are complementary. Nonetheless, by Morishima elasticity of substitution, all inputs appear to be substitutes for one another.

Among 5 government-owned specialized banks, the most efficient bank is the Export-Import Bank of Thailand, followed by Small-and-Medium-Enterprise Bank, Government Saving Bank, Government Housing Bank, and Bank of Agriculture and Cooperative, respectively. Regarding the factors determining their cost inefficiency, government-owned banks with higher equity-to-total-asset ratio, lower liquid-asset-to-total-asset ratio, and fewer branches are likely to operate more efficiently. Regarding their production technology, in contrast to that of commercial banks, government-owned banks seem to suffer from diseconomies of scale or decreasing return to scale. In their production of loan and investment, all three inputs including labor, physical capital and loanable funds appear to be substitutes for each other.

REFERENCES

Altunbas, Y., Liu, M., Molyneux, P., Seth, R., 2000. Efficiency and risk in Japanese banking. *Journal of Banking & Finance*, **24**(10), 1605-1628.

Battese, G. E., Coelli, T. J., 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, **20**(2), 325-32.

Berger, A.N., Leusner, J., Mingo, J., 1994.The efficiency of bank Branches. *Journal of Monetary Economic*, **40**(1), 141-162.

Berger, A.N., DeYoung, R., 1997. Problem loans and cost efficiency in commercial banks. *Journal of Banking & Finance*, **21**(6), 849-870.

Berger, A. N., Humphrey, D. B., 1997. Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research*, **98**(2), 175-212.

Chansarn, S., 2005. The efficiency in Thai financial sector after the financial crisis. *MPRA Paper 1776*, University Library of Munich, Germany, revised Dec 2006.

Chansarn, S., 2008. The Relative Efficiency of Commercial Banks in Thailand: DEA Approach. *International Research Journal of Finance and Economics*, Issue 18, 53-68.

Chantapong, S., Menkhoff, L., 2005. Cost Efficiency of Domestic and Foreign Banks in Thailand: Evidence from Panel Data. Proceedings of the German Development Economics Conference, Kiel 2005, 9, Verein für Socialpolitik, Research Committee Development Economics.

Coelli, T. J., Rao D.S.P., and Battese, G.E., 1998. *An Introduction to Efficiency and Productivity Analysis*, Kluwer Academic Publishers: USA.

Cuesta, R. A., Orea, L., 2002. Mergers and technical efficiency in Spanish savings banks: A stochastic distance function approach. *Journal of Banking & Finance*, **26**(12), 2231-2247.

Das, A., Ghosh, S., 2006. Financial deregulation and efficiency: An empirical analysis of Indian banks during the post reform period. *Review of Financial Economics*, **15**(3), 193-221.

Dietsch, M., Vivas, A., 2000. How the environment determines banking efficiency: A comparison between French and Spanish industries. *Journal of Banking & Finance*, **24**(6), 985-1004.

Filippaki, A.K., Margaritis, D., Staikouras, C., 2009. Profit efficiency under a directional technology distance function approach. *Managerial Finance*, **35**(3), 276 – 296.

Fuentes, H., Grifell-Tatjé, E., Perelman, S., 2001. A parametric distance function approach for Malmquist productivity index estimation. *Journal of Productivity Analysis*, Vol.15, 79-94.

Gallant, A.R., 1981. On the bias in flexible functional forms and an essentially unbiased form: the Fourier flexible form, *Journal of Econometrics*, Vol.15, 211–245.

Havrylchyk, O., 2006. Efficiency of the Polish banking industry: Foreign versus domestic banks. *Journal of Banking & Finance*, **30**(7), 1975-1996.

Kaoko, K., 2009. Managers and efficiency in banking. *Journal of Banking & Finance*, **33**(3), 546-556.

Kwan, S. H., 2003. Operating performance of banks among Asian economies: An international and time series comparison. *Journal of Banking & Finance*, **27**(3), 471-489.

Lang, G., Welzel, P., 1996. Efficiency and technological progress in banking: Empirical results for a panel of German cooperative banks, *Journal of Banking and Finance*, Vol. 20, 1003-1023.

Leightner, J. E., Lovell, C. A., 1998. The impact of financial liberalization on the performance of Thai banks, *Journal of Economics and Business*, **50**(2), 115-131.

Mariani, A., David S., Giuliana B., 2010. Efficiency in Islamic and conventional banking: an international comparison. *Journal of Productivity Analysis*, **34**(1), 25-43.

Rangkakulnuwat, P., 2007. Technical efficiency of Thai commercial banks between 2002 and 2005. *UTCC Journal*, **24**(1), 129 – 138.

Simar, L., Wilson, P.W., 2007. Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics* Vol. 136, 31–64.

Thoraneenitiyan, N., Avkiran, N. K., 2009. Measuring the impact of restructuring and country-specific factors on the efficiency of post-crisis East Asian banking systems: Integrating DEA with SFA. *Socio-Economic Planning Sciences*, **43**(4), 240-252.

Tolstov, G.P., 1962. Fourier Series. Prentice-Hall, Englewood Cliffs, NJ.

Chapter 3

Market-Power versus Cost-Efficiency Effects of Concentration on Competition in Thailand's Banking Sector in the Post-Crisis Period (1998-2009)

Abstract

The new empirical industrial organization (NEIO) analysis is used to shed light on how the effect of a change in the market concentration impacts the degree of competition in the banking sector of Thailand after the East Asian financial crisis of 2007. In addition, inspired by Kubo (2006), his finding of a rising trend of market power during the post crisis period is reinvestigated under dramatic changes in the competitive environment in terms of ownership structures and regulations. I find that the degree of oligopoly power, measured by the Bresnahan (1982)'s conjectural parameter, is substantially low, and that the adverse effect of market-power owing to the higher market concentration is stronger than the benefit of cost-efficiency effect pertaining to the economies of scale. As a result, a small increase in the market concentration potentially results in an enormous increase in the markup pricing. Interestingly, I reaffirm Kubo's findings that the degree of market power in the banking industry, based on the derived Lerner index, is indeed increasing. However, I contradict his claim that the concentration of the biggest banks decreased from banking-sector deregulation by showing that, in fact, the concentration ratio of the biggest four banks (CR_4) has steadily increased after the crisis, resulting in an increase in the Lerner index. This occurred mainly because the benefit of cost-efficiency resulting from the increased concentration can not offset the unfavorable effect of higher market-power associated with the higher concentration. These econometric findings might suggest the failure of the Thai government's attempts to enhance competition in the banking industry.

3.1 Introduction

The banking industry is a large component of Thailand's economy. The size of the banking sector, in term of their total assets, accounted for over 100% of GDP throughout the period of 1996-2003[11]. Among financial institutions, commercial banks have dominated the financial sector in term of size, loans, and deposits. Thus, any change in the banking sector will unavoidably and considerably affect the entire Thai economy.

Thailand's banking industry underwent unprecedented structural changes caused by the East Asian financial crisis in 1997 and the subsequent financial-sector reforms directed by the IMF, including dismantling of interest rate controls, consolidating and closing weak banks, and relaxing restrictions on foreign ownership, foreign-bank entry, and issuing new licenses to establish banks.

Prior to the crisis, the foreign ownership in financial institution was restricted to 25%. In the aftermath of the crisis, this restriction was lifted; foreign investors were allowed to hold 100% of equity capital of each bank for a period of 10 years[12], resulting in an enormous change in the banking business in term of ownership structure. Before the crisis, most of the Thai banks were controlled by a few influential families; there was no single bank in which a foreign investor was the major shareholder. By 2003, foreign investors became the largest shareholders in two banks, including the largest bank. There remained only one bank majorly owned by the

---

[11] Polsiri and Wiwattanakantang (2005)
[12] After 10 years, foreign shareholders could maintain or lower but not raise their stakes in financial institutions until the stake is less than 50%.

original founding family. As a result of bank consolidation and closure, the number of commercial banks declined from 15 in 1996 to 13 by 1997. Out of the 15 commercial banks operating in 1996, one was closed, three were merged with government-owned banks, two were taken over by the government, and three were acquired by foreign banks[13]. As a consequence of the issuance of brand-new banking licenses, three new banks, upgraded from financial companies, emerged in 2005. Certainly, these structural changes were expected to have vast implication for concentration and competition in the banking sector.

Even though the banking system has been subject to increasing competition pressures due to the financial sector reforms and has become less dominant, Thailand's financial system is still be described as “bank based”. As of 2008, commercial banks accounts for 56 percent of financial sector's assets. Moreover, the six largest banks accounted for approximately 70 percent of total loan of the banking sector as they did before the crisis[14]. Hence, the degree of competition in commercial banking in the post crisis period is still ambiguous and worthy of our interest.

To explore the impacts of changes in the business environment resulting from the reforms on competition in the banking sector, a number of empirical studies have been conducted. However, among the existing literatures most of which use the traditional structure-conduct-performance (SCP) paradigm, which is cross-sectional and descriptive, there are only a few studies which explored quantitatively how competition degree evolved after the crisis; none of these studies are able to provide explicit numerical results of the effects of changes in the market structure or

[13] Polsiri and Wiwattanakantang (2005)
[14] Kubo (2006)

concentration on the competition in the banking industry. Instead, they simply rely on concentration indices as a measurement of degree of competition, and attempt to show some number as supportive evidences such as market share of assets and loans, ownership structure, overhead cost, profit, interest spread, and other market-performance indicators, based on the assumption of a one-way causal relationship between market structure and market performance via market conduct. However, some recent studies, for example Bikker (2004), argue that this approach is increasingly unreliable, especially when applied to small and less-developed countries. There is only Kubo (2006) who applies the new empirical industrial organization (NEIO) approach to estimate the degree of competition econometrically; nonetheless, his model does not directly link the market concentration to the competitive degree. Hence, there remains room to make contributions in this field by proposing an econometric model which can directly link the market concentration to the degree of competition, and statistically assess the hypothesis of price-taking behavior in banking sector.

In this chapter, I apply the new empirical industrial organization (NEIO) analysis to explore quantitatively the degree of market power in the banking industry and its dynamic evolution in the post-crisis period. This chapter consists of six sections. Section 3.2 briefly reviews the two main streams of literature on the measurement of competition, called the structure-conduct-performance (SCP) paradigm and the new empirical industrial organization (NEIO) analysis, and then focuses the related literatures on the measurement of competition in the banking sector in other countries as well as Thailand. I derive and present the econometric model in section 3.3. Next, the estimation technique and data set are described in section 3.4. The estimation results are presented and discussed in section 3.5. Finally, in section 3.6, I summarize the analysis and offer some concluding remarks.

3.2 Literature review

There are two main streams of literature on the measure of competition; one is called the structure-conduct-performance (SCP) paradigm, considered a structural approach; another is called the new empirical industrial organization (NEIO) analysis, regarded as a non-structural approach.

The SCP paradigm aims at investigating whether a highly concentrated market leads to collusion among large firms, causing their market power to increase, thereby enhancing market performance in term of higher prices and profitability. Most empirical studies applying the SCP paradigm to the banking industry usually use the concentration ratio to measure the degree of competition. These studies, based on traditional fears of consolidation, view the degree of competition as an increasing function of the number of firms in a market and a decreasing function of the average market shares. However, some recent studies, Bikker (2004) for example, argue that empirical evidence does not support the expected positive relationship between market concentration and market power. Furthermore, he argues that the concentration ratio should not be counted on when a small number of banks is under consideration; it is very likely to exaggerate the degree of competition in small countries, thereby probably resulting in measurement problems and misleading inferences.

In response to the theoretical and empirical deficiencies of the traditional structural models, non-structural models of oligopolistic behavior or the so-called new empirical industrial organization (NEIO) approaches, namely the Panzar and Rosse (P-R) model and the Bresnahan model, have been developed. According to these methods, firms' price-cost margins as well as economic marginal cost (MC) are not taken to be observables; the degree of competition or an industry conduct is viewed as unknown parameters assessed by direct estimation of the first order condition of profit maximizing firms. Grounding in explicit optimization models and equilibrium conditions seems to be a major advantage of these approaches, which helps avoid making indirect inferences about market power based on indicators of concentration; on the other hand, these approaches require detailed information on costs and demand based largely on time series data from a single industry.

The P-R model, introduced by Panzar and Rosses (1987), formulates simple models to distinguish between oligopolistic, competitive, and monopolistic markets and develops a hypothesis test of their occurrence based on properties of a reduced form revenue equation. This test statistic, called the H statistic, corresponds to the sum of elasticities of the reduced form revenues with respect to factor prices and serves as a measure of competitive behavior of firms in an industry. Alternatively, the Bresnahan model, named after Bresnahan (1982), formulates models for profit maximizing firms in an oligopolistic market and obtains the first order conditions of profit maximization, yielding reduced-form equations to be estimated. The unknown parameter called the Bresnahan's conjectural variation is also econometrically estimated and tested. This conduct parameter indicates the extent to which the bank can manipulate the loan supply and the lending interest rate by colluding with other banks, and thereby serving as a measure of degree of market power.

The degree of competition in commercial banking, always a subject of controversy, has assumed increasing importance in developed countries like the U.S., EU, and Japan. There are substantial relevant literatures on measurement of competitive degree in those countries using NEIO approaches. For example, Shaffer (1989) has applied the Bresnahan's technique to the U.S. Banking industry, strongly rejecting the collusion but not perfect competition; Bikker and Haaf (2002) estimated the P-R model and find that European banking markets are characterized by mopolistic competition; Alley (1993) estimated the degree of collusion in the Japanese banking sector to find a high degree of collusion in 1986 and 1987.

Despite abundant empirical literature on Thailand's banking-sector reform after the 1997 East Asian financial crisis, there have been few studies which quantitatively measured the degree of competition in the banking industry. Most of the existing studies focused on issues related to changes in business environments likely to affect competition; for example, Anuchiworawong, Souma, and Wiwattanakantang (2003) and Polsiri and Wiwattanakantang (2005) described a decline in family ownership from the perspective of corporate governance; Okuda and Rungsomboon (2006) found that foreign bank entry led to an increase in overhead costs and a decline in profits of local banks.

Among the existing literature on competition in the Thai banking sector, to my knowledge, there is only Kubo (2006) who used the new empirical industrial organization approach to study the influence of the crisis and the subsequence reforms on the degree of competition in the Thai banking industry. He applied Bresnahan's (1989) conjectural variation model to estimate Lerner index, for the six largest banks in 1993-2004, which measures the markup of price over marginal cost (interest margin) indicating the market power of a bank. He presumed that the degree of competition should have risen due to the post-crisis financial reforms. Surprisingly, he found that Lerner index showed a rising trend during the 2000s, indicating that competition in the industry declined despite the financial liberalization in the post-crisis period. Without statistical analysis on the suspected factors of a change in degree of competition due to the shortness of sample period, he verbally attributed a decline in competition (the widening interest margin) to a decline in credit worthiness of borrowers associated with economic slowdown after the crisis, and the overestimation of the Lerner index because of not incorporating effects of a rise in banks' implicit cost of lending resulted from a change in concentration of banks' loan from corporate lending to consumer lending.

Yet, according to Williamson's tradeoff-model, the effects of concentration on the price-cost margin can be separated into the market-power effect and cost-efficiency effect. The former will increase the margin because of lower degree of competition, while the latter will work in the opposite direction due to scale economies. Put simply, in contrast to the certain inverse relationship between market concentration and degree of competition predicted by the traditional SCP model, the positive relationship of the concentration and the degree of competition (measured by the markup price) is possibly observed when the cost-efficiency effect dominates the market-power effect; for example, the markup price could go up in spite of a decrease in market concentration. This model might offer an alternative interpretation of the rising Lerner found by Kubo (2006) by directly linking the effect of a change in market concentration to the change in the degree of competition, which was overlooked by Kubo (2006). In so doing, I apply the NEIO model, developed by Azzam (1997) from the Bresnahan's (1982) conjectural variation model, to reinvestigate Kubo's findings. This model can show explicitly and deeply how collusively the leading banks can manipulate their output and price setting or whether they in fact act as price takers, whether the degree of competition in the banking sector actually declined, and finally which effect, market-power or cost-efficiency, has driven the observed change in the degree of competition.

3.3. The model

I will follow Azzam (1997) who used the model, firstly devised by Bresnahan (1982), to study the U.S. beef packing industry. Unlike Kubo (2006), the model developed by Azzam explicitly incorporates the Herfindahl index, as a measure of market concentration into the model to examine the direct impacts of the market concentration on the degree of competition. Yet, the model in this paper differs from Azzam's model in that I assume that the banking industry is oligopoly in output market or Cournot competition, instead of oligopsony in material input market i.e. banks are assumed to behave as price-setters in the loan market, while they face a given deposit rate on their liabilities.

Suppose that the banking sector consists of N banks converting deposits regarded as a single material input into loans also regarded as a single final output. Each bank's processing technology is characterized by fixed proportion between deposits and loans. Banks can acquire deposits in a competitive market. Nevertheless, the loan market is assumed to be oligopolistic. Consider the profit maximization problem for the ith bank (for i = 1,2, ..., N).

$$\pi_i = \big(p(Q) - w\big)q_i - C_i\left(q_i, \mathbf{v}\right) \qquad (1)$$

where p is the output price (lending interest rate),

w is the price of the raw material input (deposit interest rate),

q is the final output (quantity of loan),

$Q = \sum_{i=1}^{N} q_i$ is the industry's total output (total quantity of loan),

$C_i\left(\cdot\right)$ is the cost function, and

$\mathbf{v}$ is a vector of prices of inputs other than the material input i.e. labor and capital.

Differentiating (1) with respect to q_i yields the first order condition,

$$p = w - \frac{q_i}{Q}\frac{p}{\eta}\left(1+\theta_i\right) + c_i\left(q_i, \mathbf{v}\right) \qquad (2)$$

where $\eta = \left(dQ/dp\right)\left(p/Q\right)$ is the elasticity of loan demand to the lending interest rate.

$\theta_i = \sum_{j \neq i}^{N}\left(dq_j/dq_i\right)$ is the ith bank conjecture as to its rivals' response to a change in its quantity of loan supplied, that is, Bank ith's expectation on how other banks react to its output change. It is also a measure of collusive behavior in a market.

$c_i\left(q_i, \mathbf{v}\right)$ is the marginal cost.

Assume that the i[th] firm's cost function takes the Generalized Leontief functional form,

$$C_i\left(q_i, \mathbf{v}\right) = q_i \sum_i \sum_j \alpha_{ij} \left(v_i v_j\right)^{1/2} + \left(q_i\right)^2 \sum_i \beta_i v_i \tag{3}$$

The optimizing condition (2) becomes

$$p = w - \frac{q_i}{Q}\frac{p}{\eta}\left(1+\theta_i\right) + \sum_i \sum_j \alpha_{ij} \left(v_i v_j\right)^{1/2} + 2\left(q_i\right)\sum_i \beta_i v_i \tag{4}$$

Multiplying (4) by each firm's market share $\left(q_i/Q\right)$, summing across the N firms, and dividing by p yields

$$M = -\frac{H\left(1+\Theta\right)}{\eta} + \sum_i \sum_j \alpha_{ij} \frac{\left(v_i v_j\right)^{1/2}}{p} + 2QH \sum_i \beta_i \frac{v_i}{p} \tag{5}$$

where $M = \left(p-w\right)/p$ is the markup price,

$H = \sum_i \left(q_i/Q\right)^2$ is the Herfindahl index,

$\Theta = \left(\sum_i q_i^2 \theta_i\right) / \left(\sum_i q_i^2\right)$ is the weighted average of the N firms' conjectural variations, where $-1 \le \Theta \le 0$. This parameter indicates the competitiveness of oligopoly conduct[15], i.e. the extent to which the bank can manipulate the loan supply and the lending interest rate by colluding with other banks.

Equation (5) can be estimated and allows me to test whether banks are price-takers in the loan market, or that the price equals the marginal processing cost. Perfect

[15] It does not infer that all banks necessarily have identical equilibrium conduct (θ_i).

competition is consistent with the case of θ_i equal to negative 1 for all banks i^{th}, or Θ is equal to negative 1, implying that each bank expects an increase in its loan supply to be completely offset by a decrease in other banks' loan supply, so that the lending interest rate remains unchanged. In contrast, the loan market is a Cournot oligopoly if $\theta_i = 0$ for all i, or $\Theta = 0$. This means that each bank does not expect its rivals' supply of loan to respond to its own supply of loan.

In addition, note that equation (5), with the appearance of the Herfindahl index on the RHS, is capable of providing a direct link between the degree of concentration measured by the Herfindahl index and the market power measured by the markup. Note further that the markup is the sum of two components: the first term which is defined as a market power component, and the second a marginal cost component, which is measured by the last two terms. Differentiation equation (5) with respect to the Herfindahl index yields the effect of the market concentration on the markup,

$$\frac{\partial M}{\partial H} = -\frac{(1+\Theta)}{\eta} + 2Q\sum_i \beta_i \frac{v_i}{p} \qquad (6)$$

where the first term is the market-power effect and the second term is the cost-efficiency effect. According to Williamson's tradeoff model, these two effects will work in the opposite direction. For example, if the market concentration goes up, the market-power effect will increase the markup; whereas the cost-efficiency effect will decrease the markup.

3.4 Econometric application and data

Econometric application

As I mentioned in the previous section, banks are assumed to be price-takers when acquiring deposit but they are not necessarily price-takers when supplying loan. As a result of their profit maximization behavior, their price-quantity relationship is given by equation (5). I assume that there are two factors of production, labor and physical capital; then equation (5) can be rewritten in a specific form as follow,

$$M = -\frac{H\left(1+\Theta\right)}{\eta} + \alpha_{11}\frac{v_1}{p} + \alpha_{22}\frac{v_2}{p} + 2\alpha_{12}\frac{\left(v_1 v_2\right)^{\frac{1}{2}}}{p} + 2QH\beta_1\frac{v_1}{p} + 2QH\beta_2\frac{v_2}{p} \qquad (7)$$

where v_1 and v_2 are prices of labor and physical, respectively.

The unknown parameters in equation (7) consisting of Θ, $\eta, \alpha_{11}, \alpha_{22}, \alpha_{12}, \beta_1$ and β_2 can be econometrically estimated. Nevertheless, note that the endogenous variable, Q, appears in the RHS. Consequently, a model for Q is required. In fact, outside the perfectly competitive markets, firms do not have supply curves given by P = MC(Q). Instead, price or quantity-setting conduct follows more-general supply relation that is MR = MC[16]. Hence, I need to specify only the aggregate-demand-for-loan function. In so doing, I adopt a log-linear demand function depending on its own price, price of a substitute, and aggregate income as follow:

$$\ln\left(Q\right) = l_0 + \eta\ln\left(p\right) + l_1\ln\left(p_a\right) + l_2\ln\left(y\right) \qquad (8)$$

[16] Breshnahan (1989)

where p_a is the interest rate of loan from an alternative source, and

y is a variable representing level of income or aggregate production.

Theoretically, demand function must be linearly homogenous in all prices and income, so the demand function (8), after imposing the condition of homogeneity of degree zero, can be rewritten as the following[17],

$$\ln(Q) = l_0 + \eta \ln\left(\frac{p}{p_a}\right) + l_2 \ln\left(\frac{y}{p_a}\right) \tag{9}$$

As an empirical strategy, equation (7) and (9) are to be estimated simultaneously by using nonlinear three-stage least-squares (N3SLS)[18] because of the endogeneity of the quantity and price variables, Q and p. All exogenous variables consisting of v_1, v_2, w, H, p_a and y are used as instrumental variables.

Data

The data set is cross-sectional, which covers the four largest commercial banks in Thailand consisting of Bangkok Bank, Kasikorn Bank, Siam Commercial Bank, and Krung Thai Bank, during the period of 1998 – 2009[19]. These four banks are selected in accordance with the bank of Thailand's peer-group comparison in which large-size banks are defined as banks with market share of total assets greater than 10%[20]. Data were acquired from the quarterly financial statement of each individual bank, and the

[17] See Varian (1992) Chapter 12.
[18] 3SLS combines two stage least squares (2SLS) with seemingly unrelated regression (SUR). The first deals with endogeneity problem, while the latter is relevant to the correlation of error terms across equations. I use SAS programs to perform the N3SLS estimation in this study.
[19] Kubo (2006) adds two more banks in his study including Bank of Ayudhaya and Thai Military Banks. His data span over the period of 1992-2004.
[20] Medium-bank group includes 4 banks with market share of total assets between 3% and 10%. Small-bank group consists of 6 banks with market share less than 3%.

financial statistics published on the bank of Thailand's website[21]. The definition of variables and their sources are provided in table 3.1 below.

Table 3.1: List of Variables and Their Definitions

	Definition	Source
p	Minimum loan rate (MLR)	Bank of Thailand's financial statistics
w	3-month time deposit interest rate	Bank of Thailand's financial statistics
M	Interest-rate margin	$(p-w)/p$
v_1	Expenses on personnel/ the number of employees	Individual bank's Quarterly financial statements
v_2	Expenses on premises and equipment/ value of premises and equipment	Individual bank's Quarterly financial statements
q_i	Loan and accrued interest receivables	Individual bank's Quarterly financial statements
Q	Total credits of all commercial banks	Bank of Thailand's financial statistics
H	CR_4 (concentration ratio of the biggest four firms)	$\sum_{i \in I} q_i \Big/ Q \quad I = \{BBL, KBANK, SCB, KTB\}$
p_a	State enterprises' bond rate[22]	Bank of Thailand's financial statistics
y	Real GDP	Bank of Thailand's financial statistics

[12] Weighted average interest rates of new issues in each month. Almost all of the state enterprise bonds have initial maturities of 3-10 years.

With regard to the price of output (p), I use the minimum loan rate (MLR), the interest rate at which each bank charge its most favored customers, i.e. those with high creditability; higher-risk customers are charged MLR plus their specific risk premium; it can be comparable to the prime rate in the US. I choose the interest rate paid on 3-month time deposit to represent the price of material input (w). Regarding the cost variables, I assume that banks use labor and physical capital, in addition to

[21] http://www.bot.or.th/English/Pages/BOTDefault.aspx

deposits, in the production of loans. The factor prices, wage (v_1) and rent (v_2), are computed from the expenses on personnel, and expenses on premises and equipment divided by the number of employees, and value of premises and equipment, respectively. Since information on the Herfindahl index (H) for the loan market is not available, I use the four-firm concentration ratio for the loan market (CR_4) as a substitute[23].

In estimating the aggregate demand for loans, the total amount of loans and accrued-interest receivables issued by commercial banks registered in Thailand (Q) is obtained from commercial banks' credits reported on the bank of Thailand's website. Interest rate on state enterprises' bond is adopted as the price of a substitute for bank loans; it is believed that this rate is a good measure (up to monotone increasing transformation) of the private-corporate bonds' rate. Real GDP is chosen to be a variable representing aggregate production (y). Finally, note that all nominal variables like wage and loan are adjusted to be in the real terms by the consumer price index (CPI) [24]. Table 3.2 below shows the descriptive statistics of variables used in estimation.

[23] Azzam (1997) argued that there are close correlation between CR_4 and the Herfindahl index. Also, strong correlation between CR_3 and the Herfindahl index was found by Bikker and Haff (2002).
[24] 2007 is the base year.

Table 3.2: Summary of Descriptive Statistics of Variables

Variable	Mean	S.D.	Max.	Min.
p	7.59	2.29	15.50	5.50
w	2.80	2.18	10.00	0.65
M	0.67	0.14	0.89	0.34
v_1	145,168	34,321	257,326	88,623
v_2	0.05	0.01	0.08	0.03
Q	5,826,683	596,432	7,127,449	4,559,200
H	0.52	0.03	0.58	0.46
p_a	5.29	2.68	14.82	2.48
y	893,576	143,695	1,144,005	658,899

Note: unit of Q and y in million Baht; unit of v_1 in baht.

3.5 Empirical results

Table 3.3 below reports the estimation results. Consider the margin equation (equation 7) first. Although most of the cost variables' coefficients, $\alpha_{22}, \beta_1, \beta_2$, are not significantly different from zero, they are of the correct signs as pointed out by Diewert (1971), i.e. $\alpha_{12} > 0$ implies the substitutability between labor and physical capital; $\alpha_{11} < 0$, $\alpha_{22} < 0$ and $(\alpha_{12})^2 > \alpha_{11}\alpha_{22}$ ensure that there exists a range of factor prices in which the cost function is increasing in the factor prices. In addition, of particular interest is the conduct parameter, Θ, showing the negative sign as expected and being in the range between negative 1 and 0 and significantly different from zero at the confident level of 99 percent. Specifically, $\Theta = -0.908$ is significantly close to negative 1, suggesting that each bank expects an increase in its loan supply to be mostly offset by a decrease in other banks' loan supply. This also implies a low degree of oligopolistic behavior in the banking sector.

With regard to the estimated aggregate demand for loan (equation 9), the estimation results are reasonable. All estimated coefficients, except for the income elasticity (l_2), have the expected sign, although the income elasticity is not significantly different from zero. The price elasticity (η) is negative 0.154 and statistically significant different from zero; on the other hand, the income elasticity turns out to be negative 0.032, but it is not significantly different from zero. These estimation results suggest that the demand for loan is highly inelastic with respect to both price and income.

Table 3.3: Results of Estimation (Margin and Demand equation)

Item	Parameter	Estimate	Standard Error
Margin equation:	Θ	-0.908^{***}	0.056
(equation 7)	α_{11}	-0.00033^{*}	0.0002
	α_{22}	-3427.48	2553.2
	α_{12}	1.278^{*}	0.794
	β_1	-5.56E-09	5.74E-09
	β_2	0.0177	0.056
Demand equation:	l_0	11.425^{***}	0.2377
(equation 9)	η	-0.154^{***}	0.0497
	l_2	-0.032	0.0209
Market-power effect:		0.593	
Cost-efficiency effect:		-0.084	
Total effect:		0.509	

*,**, and *** indicate that parameters are statistically significant at confidence level of 90%, 95% and 99%, respectively.

From these estimation results, the tradeoff between market-power effect and cost-efficiency effect from increased market concentration can be assessed using equation (6). The point estimates of the market-power effect and the cost-efficiency effect, evaluated at the sample mean value of lending interest rate, factor prices, and total amount of loan, are 0.593 and negative 0.084, respectively. Therefore, the resulting net effect of an increase in the market concentration on the markup is 0.509, suggesting that the benefit of the higher concentration in terms of cost efficiency is insufficient to offset the unfavorable effects of increased market power. Consequently, an increase (decrease) in market concentration will be inevitably accompanied by an increase (decrease) in the markup. This result is evidence in favor of the long-held view of the traditional SCP hypothesis that the structure and the market performance are positively related.

Because I have a panel-data set, my estimated econometric results can be used to explore the dynamic evolution of competition in the banking sector in the post crisis period, i.e. 1998-2009 and to compare these results with the previous study by Kubo (2006). Figure 3.1 and 3.2 illustrate the plots of concentration ratio (CR_4) and the Lerner index against time, respectively.

First of all, I observe that the concentration ratio CR_4 of the Thai banking industry, as a structural measure of oligopolistic degree in the market, varying around 0.5 during the post crisis period, is as high as developed countries[25]. Preceded by small fluctuation in the early years of the post crisis period, the concentration ratio still shows a steadily rising trend. Surprisingly, the market structure appears to be even

[25] Bikker and Haff (2002) report CR3 of the banking sector in 23 developed economies, like USA, UK Australia, Korea, and European countries, of which the average number is 0.49.

more concentrated over time despite the banking-sector reform, including relaxing restrictions on entry to the market, initiated by the Thai government in 2004. This can be interpreted by the fact that emerging banks such as Thanachart, Kaitnakin, and TISCO, all of which were upgraded from financial companies to commercial banks, as well as banks merged with and acquired by foreign banks like UOB Rattanasin, CIMB, and Standard Chartered Nakornthon, are so small in both size and market share[26] that their entry seems not seriously threatening to the biggest-four incumbents.

Next, I employ the Lerner index to analyze the dynamic evolution of the market power in the banking sector in the post-crisis period. Usually, the Lerner index is defined as $\left(P-MC\right)/P$, ranging from a high of one to a low of zero with a higher number indicating greater degree of market power. For a perfectly competitive market, in which P = MC, the Lerner index is equal to zero. According to the first-order condition of profit maximization given by equation (1)-(5), the Lerner index can be specifically written as

$$L_t = \left(\frac{p-MC}{p}\right)_t = -\frac{H_t\left(1+\Theta\right)}{\eta} \qquad ; \qquad t = time \qquad (10)$$

Note that, from this formula, the Lerner index increases or decreases proportionally with the degree of market concentration[27], as measured by the Herfindahl index (H) or the CR_4 as a substitute. The computed Lerner index starting from the first quarter of 1998 to the fourth quarter of 2009 are plotted in figure 3.2.

[26] In December 2009, amount of loan issued by Thanachart, Kaitnakin, and TISCO accounts for only 4.11%, 1.24% and 1.6% of the total loan in the market, respectively. For UOB Rattanasin, CIMB, and Standard Chartered Nakornthon, the market shares are 2.05%, 1.15%, and 1.17%, respectively.

[27] This is because θ and η are constant i.e. they are estimates of average the conduct parameter and price elasticity of demand for loan over the period. I note this in section 3.6.

Just like the market concentration ratio, the Lerner index has kept steadily increasing in the post-crisis period, from slightly lower than 0.30 to as high as 0.35. This confirms Kubo (2006)'s finding that the Lerner index rose continually in the post-crisis period (from 1999 on), implying a continuous decrease in competition in the banking sector, despite changes in competitive environment in term of ownership structures and regulations. He was surprised by this fact since he presumed that the deregulation in financial sector after the crisis should lead to the lessening degree of structural concentration in the market; yet, he did not provide any concrete evidence to support his claim. Using the CR_4 as the measure of concentration, I find that the market concentration is indeed increasing rather than decreasing after the crisis as plotted in figure 3.1. This direct linkage between market concentration and market power, ignored by Kubo, is a critical key interpretation of a rise in market power. As a consequence of rising market concentration, together with estimation results showing that the cost-efficiency effect is dominated by the market-power effect, the rising trend of the derived Lerner index, or a decline in the degree of competition, is observed after the post crisis period. That the estimated degree of market power or the derived Lerner index is increasing is consistent with the fact that the actual markup price in the banking industry is increasing as illustrated by the rising trend, from 30% to nearly 90% by the fourth quarter of 2009, in figure 3.3.

Figure 3.1: Concentration Ratio of the Biggest Four Banks (CR4)

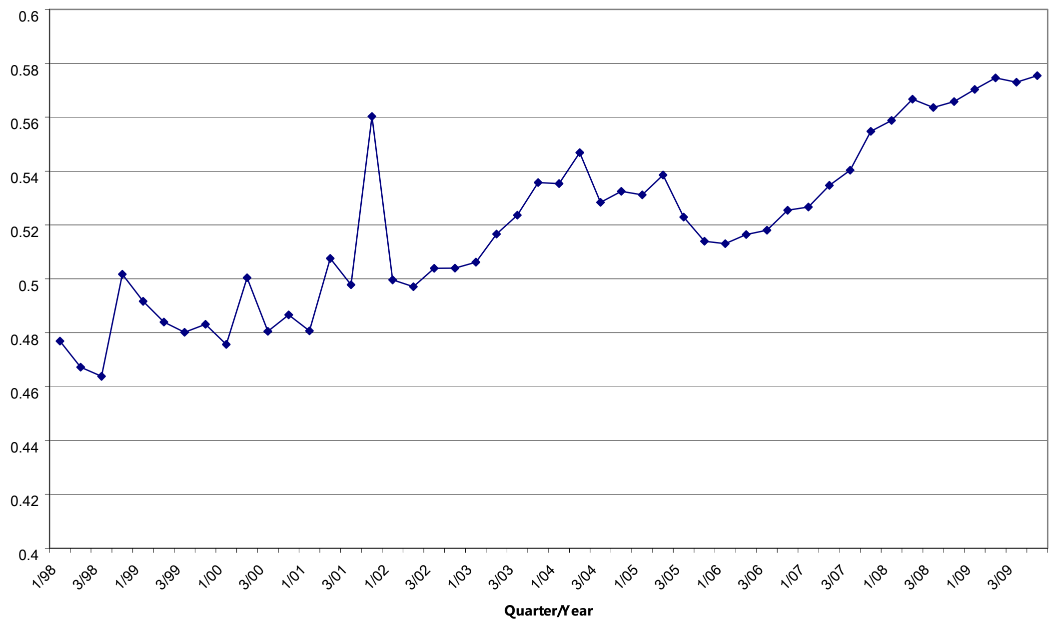


Figure 3.2: The Derived Lerner Index

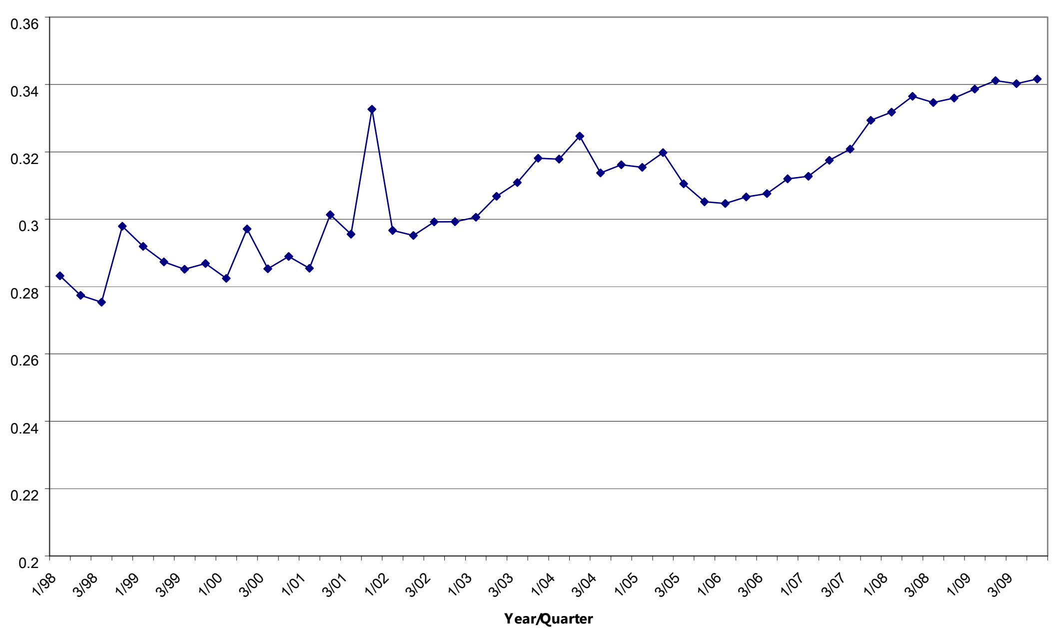
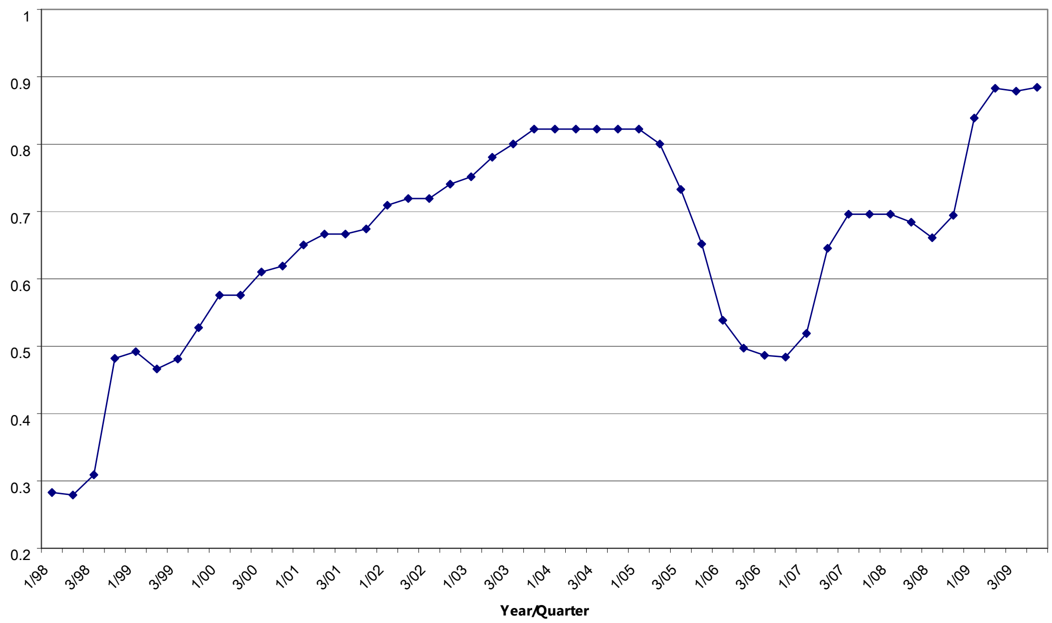


Figure 3.3: The Markup



3.6 Conclusion

In this chapter, I investigate the degree of competition in the banking sector of Thailand over the years 1998-2009, the post East Asian financial crisis period. A previous study by Kubo (2006), covering the pre and post crisis periods i.e. 1992-1997 and 1998-2004, shows the rising trend of market power, indicated by his derived Lerner index, during the post crisis period in spite of dramatic changes in competitive environment in term of ownership structures and regulations. I adapt Azzam (1997)'s competition model and the concept of Williamson's tradeoff-model to further study this phenomena by separating the effect of a change in market concentration on the margin into the market-power effect and the cost-efficiency effect.

The estimation results show that, based on the Bresnahan's conjectural variation parameter, the degree of competition in the banking industry is vigorous; a decline in a bank's loan quantity will be mostly offset by an increase in loan supply of its rivals. In addition, my findings show that the market-power effect appears to be intensely stronger than the benefit of the cost-efficiency effect of larger banks, leading to a positive relationship between the margin and the degree of market concentration, implying that a higher market concentration is unfavorable.

Based on the concentration ratio, CR_4, I show that the market concentration is indeed increasing in the post crisis period despite some new entries into the market. As a result of higher concentration ratio, the market power of the biggest four banks, indicated by the derived Lerner index, is remarkably increasing. This reaffirms Kubo (2006)'s findings. However, unlike Kubo, I provide evidence of higher concentration ratio and an estimated relationship between the higher concentration ratio and the margin.

Summarily, despite the Thailand government's efforts to increase competition in the banking industry by relaxing restrictions on entry to the market after the financial crisis, the oligopolistic degree of the biggest four banks has intensified. Even though the competition degree of Thailand's banking sector is still considerably high and may have been even higher without the government actions, borrowers and banks' customers are likely to suffer from a widening interest-rate margin associated with increased market power over time. In order to protect them and enhance market efficiency in the long term, more market interventions and reforms by the Thai government and the Bank of Thailand are needed. The government should introduce new appropriate policies or financial development plans to promote financial liberalization and to lessen the concentration of the large banks.

However, there are two main caveats of the model and results. First, the Bresnahan's conjecture is treated as a constant; in fact, it is very likely that this conduct parameter varies with the degree of concentration. Second, in the analysis of dynamic evolution of competition degree, I use the estimated coefficients, the price elasticity of demand for loan and the conduct parameter, to compute the quarterly Lerner index in equation (10); however, these parameters are treated as constants over the period; they are estimates of average price elasticity and conduct over the period of study; in other words, I assume that the structure of relationship has not changed over time. These issues are left as a task for future research.

REFERENCES

Anuchiworawong, C., T. Souma and Y. Wiwattanakantang, 2003. Family ownership of financial institutions: Evidence from Thailand. In Economic Analysis of Corporate Governance: Japan and East Asia in Changing Environment, edited by M.Hanazaki and J. Teranishi, pp.397- 420. University of Tokyo Press, Tokyo.

Alley, W.A., 1993. Collusion versus efficiency in the Japanese regional banking industry. *Economic Studies Quarterly* 44, 206-215.

Azzam, A.M., 1997. Measuring market power and cost efficiency effects of industrial concentration. *The Journal of Industrial Economics*, **45**(4), 377-386.

Bikker, J., Haff, K., 2002. Competition, concentration and their relationship: An empirical analysis of the banking industry. *Journal of Banking and Finance*, Vol. 26, 2191-2214.

Bikker, J.A., 2004. Competition and efficiency in a unified European banking market. Edward Elgar, Cheltenham.

Bresnahan, T.F., 1982. The oligopoly solution concept is identified. Economics Letters Vol. 10, 87-92.

Bresnahan, T.F., 1989. Empirical studies of industries with market power. In Schmalensee, R., Willig, R. (Eds.), Handbook of Industrial Organization. North-Holland, Amsterdam.

Diewert, W.E., 1971. An Application of the Shephard duality theorem: A generalized Leontief production function. *The Journal of Political Economy*, **79**(3), 481-507

Greene, W., 2000. *Econometric Analysis*. 4th ed. Prentice Hall.

Kubo, K, 2006. The degree of competition in the Thai banking industry before and after the East Asian crisis. *ASEAN Econmic Bulletin*, 23(3), 325-340.

Menkhoff, L., Suwanaporn, C., 2007. 10 Years after the crisis: Thailand's financial system reform. *Journal of Asian Economics*, Vol. 18, 4–20.

Okuda, H., Rungsomboon, H., 2006. The effects of foreign bank entry on the Thai banking market: Empirical analysis from 1990-2002. *Journal of Asian Economics*, Vol. 17, 714–737

Panzar, J.C., Rosse, J.N., 1987. Testing for "monopoly" equilibrium. *Journal of Industrial Economics*, Vol. 35, 443-456.

Polsiri, P., Wiwattanakantang, Y., 2005 Corporate governance of banks in Thailand. Center for Economics Institutions Working Paper Series. No. 2005-20.

Shaffer, S., 1989. Competition in the U.S. banking industry. *Economics Letters*, Vol. 29, 321-23.

Varian, H., R.,1992. *Microeconomic Analysis*. 3rd ed., New York, Norton.

Wooldridge, J., 2001. Econometric Analysis of Cross Section and Panel Data. 1st ed., the MIT Press.

Chapter 4

The Transmission Mechanism of Monetary Policy in Thailand incorporating Commercial Banks' Efficiency and Competition

Abstract

This chapter studies the monetary transmission in Thailand using a VAR model and impulse response analysis taking into account the roles of bank efficiency and competition. The empirical results indicate that an unexpected tightening monetary policy shock leads to higher financial costs in the banking industry, forcing banks to compete more fiercely and operate more efficiently, significantly helping grease and strengthen the transmission of monetary policy. Thus, I suggest that the bank of Thailand attempt to improve efficiency and competition in the banking sector in order to strengthen monetary transmission.

4.1 Introduction

The banking sector plays significant roles in Thailand's economy. It is a major source of funding for both private consumption and investment. In addition, it acts as an instrument for the Bank of Thailand (BOT) in facilitating the transmission of monetary policy.

After the IMF program in May 2000, Bank of Thailand announced the adoption of inflation-targeting regime under which the bank claimed that inflation targeting would operate successfully and help rebuild confidence in the central bank and maintain stability of price and the financial system. In conducting monetary policy under the inflation-targeting framework, the monetary policy stance is signaled through an increase or decrease in the policy interest rate (the 14-day bilateral repurchase rate), whose impact channels through the cost of lending and borrowing, then transmitting to the adjustments in consumption and investment, and ultimately affecting production and inflation. For example, when the central bank decides to decrease the policy rate, adjustments in short-term money market rates occur. Given that prices are sticky, real interest rates (i.e. inflation adjusted nominal interest rates) decline firstly in the short-run then in the long-run, in line with the term structure. Part of these adjustments can be explained through portfolio management of financial institutions in order to maintain competitiveness and generate profit and ultimately result in a decline in deposit and lending rates. Then, a decline in real interest rate will lower the opportunity cost in consumption and investment causing private domestic demand to expand. Subsequently, the economy grows at a higher pace and inflationary pressures increase.

It is noteworthy that adjustment of the lending interest rate (considered an output price of financial institutions) in response to a change in the repurchase rate (considered a part of marginal cost to financial institutions) is of great importance. In a perfectly competitive market, any profit-maximizing producer is a price taker facing a market price equal to its marginal cost; any change in an industrial-wide marginal cost will be promptly and fully transmitted to the market price due to price flexibility. On the other hand, in a monopolistic or oligopolistic market where market power can be exercised, marginal-cost pricing is unlikely to be sustained; for example, sellers who are price setters may charge different prices to different consumers and refuse to appropriately lower their price despite the fact that a large decline in their marginal cost is observed; this may create market friction and hinder the adjustment process. As a result, lending rates may not promptly and fully adjust to the changes in money market rates. Hence, it is reasonable to infer that an increase in the degree of competition in the banking industry might facilitate implementation of the central bank's monetary policy through greasing the banks' interest-rate adjustment. Moreover, competition is generally regarded as a favorable force in most industries including banking because it is supposed to foster and boost efficiency, which is regarded as another potential force reducing the adjustment cost and increasing the degree of interest rate pass-through. Evidently, in order to attain this goal, the Thai government has unprecedentedly implemented liberalization in financial sector since the end of the IMF era in 2000s, including dismantling of interest rate controls, relaxing restrictions on foreign-bank entry, and issuing new licenses to establish banks.

Obviously, monetary policy is not exempt from the effect of competition in financial markets. As a result, a number of recent research articles attempt to establish empirically the relationship of financial-market structure and the degree of lending-rate stickiness, and their roles in the transmission mechanism of monetary policy. For instance, Cottarelli and Kourelis (1994) study how market concentration, efficiency, and barriers to entry in banking sector affects the degree of stickiness of bank lending rate with respect to changes in money market rates in 31 countries. Also, Disyatat and Vongsinsirikul (2003) employ the dynamic multiplier method and the error correction model to analyze the size and speed of the interest-rate pass-through in Thailand. Later, Charoenseang and Manakit (2007) reinvestigate the relationship of various financial-market interest rates and the Bank of Thailand 14-day repurchase rate, during 2000-2006 i.e. in the inflation targeting era. Note that, in these studies, the role of financial-market structure is not directly incorporated in the transmission mechanism of monetary policy, that is, they do not examine how the financial market structure together with the speed and size of the pass-through affects the adjustment of aggregate output and the price level which are the final targets of monetary policy.

For analyzing the transmission mechanism and evaluating of monetary policy, prior to the 1970s, the traditional structural multi-equation models like the Cowles commission model was firmly established in the field of macroeconometrics; however, the Cowles commission practice was critically attacked on both empirical and theoretical grounds by Lucas (1976). Nowadays, Vector Autoregression (VAR), proposed by Sim (1980), has become a household name. While the typical large multi-equation econometric models depend on theoretical assumptions, the non-theoretical VAR models are actually data-determined. They are the dynamic system of equations of the interrelationships between economic variables with few theoretical assumptions about the underlying economic structure, which are suitable for the limited priori knowledge for modeling the transmission mechanism in many developing countries including Thailand. For example, Disyatat and Vongsinsirikul (2003) study the transmission mechanism under various channels through which monetary shocks are potentially propagated, such as the bank lending channel, the exchange rate channel, the asset price channel, and the direct interest rate channel. Also, Charoenseang and Manakit (2007) show that the transmission of monetary policy through the interest rate channel seems to be weak; nonetheless, the credit channel through the commercial banks' lending is interestingly significant. Even though they recognize that the banking sector plays a vital role in monetary policy transmission, they, as previously mentioned, do not directly incorporate the competition degree and efficiency of banking sector into their VAR models; instead, they employ the dynamic multiplier and error correction approaches to measure the speed and size of interest rate adjustment separately.

Unarguably, understanding the complete picture of the roles of competition and efficiency in the banking sector on the transmission mechanism of monetary policy is greatly important to monetary authorities. This chapter is intended to investigate the interdependencies of efficiency and competitiveness in banking sector and the transmission of monetary policy in Thailand. Equipped with the VAR model and competition as well as efficiency indices[28], I will be able to explore and quantitatively gauge the overall impact of monetary policy taking into fully account the roles of competition and efficiency in the banking industry.

This rest of this chapter is structured as follows. Section 4.2 briefly discusses related literature. Section 4.3 describes methodology, model specification and data. Section 4.4 and 4.5 provide the empirical results, robustness and specification issues, respectively. Finally, conclusion is given in section 4.6.

4.2 Literature Review

Whether the market is competitive and efficient is an interesting question in the banking industry. Many approaches to answer this question have been developed, for example, the New Empirical Industrial Organization Analysis (NEIO) for the first and the Stochastic Frontier Analysis for the latter. Berger and Humphrey (1997) and Bresnahan (1989) provide a good review in measuring banks' efficiency and competition, respectively. The traditional belief is that competition fosters economic efficiency and is good for the banking industry. Casu and Girardone (2009) test the casual relationship of competition and efficiency. Using the cross-country data on cost efficiency obtained from stochastic cost frontiers and the estimated Lerner index [29]of banking sector, they employ the Granger-causality test and find a positive causation

[28] I use the Lerner index and cost efficiency, estimated in chapter 2 and chapter 3, as indices of competition and efficiency, respectively.
[29] The Lerner index is defined as the difference between output price and marginal cost over price and can be used as an indication of market-power degree.

between market competition and efficiency, even though the causality running from efficiency to competition is weak.

Recognizing the role of competition in the banking sector on the effect of monetary policy, several researchers have attempted to investigate the impact of bank competition on monetary policy transmission. For instance, Stiglitz and Greenwald (2003) show that in a competitive banking sector the effect of raising interest rate on bank lending is weaker than in a less competitive banking sector. Similarly, Freixas and Rochet (1997) suggest that a high degree of bank competition decrease the effects of the interbank rate on the lending rate. On the other hand, Alencar and Nagane (2004), using the dynamic general equilibrium model, demonstrate that increased bank competition causes the economy to be more sensitive to interest rates. This finding contradicts those of the first two studies. As a result, Gunji, Miura and Yuan (2009) use cross-country data to reinvestigate the impact of bank competition on the effect of monetary policy. They measure the degree of bank competition by their estimated Panza and Rosse’s (1987) H-statistic and an index of monetary policy shocks by the cumulative impulse response function of the interest rate equation in a VAR model for each country. Their results suggest that competition in banking industry leads to smaller monetary policy effects on bank lending.

However, the opposite implication is suggested by Cottarelli and Kourelis (1994) who study how the financial structure affects the degree of stickiness of bank lending rates, that is, the speed at which bank lending rates adjust to their long-run equilibrium after a shock affecting money market rates in 31 industrial and developing countries, by regressing the lending rate on the distributed lag of money market rates.

They obtain the so-called “estimated dynamic multipliers” as indicators of the degree of lending-rate stickiness. They find that the degree of stickiness in the short run is, on average, relatively high, while the lending rate appears to adjust fully in response to the money market rate. In addition, they regress the dynamic multipliers on variables related to the structure of financial system, for instance the degree of concentration, the existence of barriers to entry and the efficiency of the money market; their results suggest that the transmission of monetary policy can be enhanced by removing barriers to entry and enhancing competition.

Similarly, Disyatat and Vongsinsirikul (2003) employ the dynamic multiplier method and the error correction model to analyze the size and speed of the interest-rate pass-through in Thailand. They find that the pass-through from the 14-day repurchase rate to the 3-month deposit rate and the lending rate is quiet low; by comparing their results with those of Cottarelli and Kourelis (1994), they conclude that the speed and size of interest-rate pass-through in Thailand is slower and smaller than most developed countries. By splitting the sample into the pre-and-post financial liberalization periods (pre-and-post the 1997 financial crisis) and comparing the results between the two periods, they find that the speed and size of the interest-rate adjustment increases after financial liberalization. Unlike Cottarelli and Kourelis (1994), they verbally attribute the lower stickiness to the more competitive market structure of banking system without econometric estimation. However, this attribution seems to contradict with the findings of Kubo (2006) that suggest the less competitive market structure of banking industry after the 1997 financial crisis. Later, Charoenseang and Manakit (2007) reinvestigate the relationship of various financial-market interest rates and the Bank of Thailand 14-day repurchase rate, during 2000-2006 i.e. in the inflation targeting era, using cointegration and error-correction procedures; they reaffirms the results of Disyatat and Vongsinsirikul (2003) that the pass-through effect is quite low.

Regarding macroeconomic studies on the transmission of monetary policy, prior to the 1970s, much of the early empirical work was concerned with estimating structural parameters in the multi-equation Cowles Commission-style models regarded as the structural models. However, such complicated models of economies, containing in some cases thousand of variables, did not perform very well in forecasting and were severely criticized by Lucas (1976) and Sims (1980). Lucas (1976) points out that the coefficients of such structural models describing the impact of monetary policy on macroeconomics variables of interest are inappropriately treated structurally invariant; they actually depend on monetary policy regimes; shifting regime requires different parameterization. Hence, a model estimated under a specific regime cannot be used to simulate the impact of a different monetary policy regime. The other criticism was directed toward the requirement of priori theoretical restrictions on endo-exogenous variables. The Cowles Commission practice was viewed as inappropriate in a seminal paper by Sims (1980), in which the new methodology of Vector Autoregression (VAR) modeling was first formulated. The Sims modeling methodology requires no theoretical restrictions or endo-exogenous divisions of variables. This is why the Sims methodology is often called the non-structural approach. The VAR models, in which each variable is considered an endogenous variable and regressed on lag value of itself as well as other variables, require no priori knowledge to specify theoretical restrictions and endo-exogenous variables.

Several recent VAR literatures applied in the US focus on identifying monetary policy shocks with the functioning of the bank reserves market. Studies include Bernanke and Blinder (1992), Bernanke and Mihov (1998), and Christiano, Eichenbaum and Evans (1996). The main purpose of these papers is to use the VAR model to evaluate the implied dynamic response of the economy to monetary policy action affecting bank reserve market under different hypotheses of central bank behavior.

In Thailand, a number of studies apply VAR to analyze monetary policy shocks after the Bank of Thailand adopted the inflation-targeting monetary policy regime under which monetary authorities are supposed to react endogenously to macroeconomic variables.

Disyatat and Vongsinsirikul (2003) use the VAR model to investigate how monetary policy shocks channel to the real activity. They extract the following stylized fact of the Thai economy; firstly, investment is more sensitive to monetary policy shocks than private consumption, export, and import; secondly, the aggregate price level responds very little and the aggregate output follows a U-shaped response; finally, the impacts of monetary policy channeling through bank loan appear to be stronger than interest rate, asset prices, and real exchange rate; hence, they recognize that banking sector acts as an important conduit for monetary policy in Thailand.

Charoenseang and Manakit (2007) also use the VAR model to investigate the impacts of monetary policy shocks through bank credit and interest rate channels.

They found that the transmission of monetary policy through the interest rate channel has become weak after the inflation targeting has been adopted. On the other hand, the credit channel through bank lending appears to be very strong. Their results are consistent with Disyatat and Vongsinsirikul (2003).

Note that those authors, Disyatat and Vongsinsirikul (2003) and Charoenseang and Manakit (2007), do not directly introduce variables representing banks' efficiency and competition into their VAR models, even though, in their studies, VAR models are used to evaluate the transmission and impact of monetary policy; instead, they analyze the impact of banks' efficiency and competition on the degree of the pass-through separately. Compared to their approaches, I look at the direct and indirect impacts of competition and efficiency in banking sector on aggregate output and price by introducing variables representing banks' competition and efficiency into the VAR model. VAR modeling allows me to place minimal restrictions on how banks' competition and efficiency affect the whole economy given limited knowledge of their roles in the transmission mechanism and seems to be a distinct advantage.

To examine the roles of banks' competition and efficiency in the transmission mechanism, I begin with estimating a baseline VAR model including private demand, price level, the monetary policy rate, banks' lending, banks' efficiency, and banks' competition. Next, I compare the output and prices responsiveness to the monetary shocks when competition and efficiency variables are exogenized or blocked off with the baseline response when banks' competition and efficiency are allowed to operate. Differences in the path - speed and size - of output and price give an indication of the importance of competition and efficiency in facilitating the transmission of monetary policy. Bayoumi and Morsink (2001) and Disyatat and Vongsinsirikul (2003) also applied this method to analyze the importance of a particular channel, like interest rate, real exchange rate, and asset price, as a conduit for monetary policy to the real economy.

4.3 Methodology

The VAR Specification

In this section, I begin with specifying my VAR model which includes economic activity, prices, monetary policy rate, bank credit, bank efficiency, and bank competition. The first four variables commonly appear in most existing VAR models. The last two variables are introduced, so that I can analyze their roles in facilitating monetary policy transmission. The measure of economic activity is real private demand – real GDP minus government spending – because public sector demand is primarily driven by exogenous fiscal policy. I use the consumer price index as an indicator of price level and inflation. The measure of monetary policy stance is the 14-day repurchase rate. The measure of bank credit is given by the total credit issued by all commercial banks registered in Thailand. The measure of bank efficiency is the average cost efficiency obtained from the stochastic cost frontier estimated in chapter 2. The definition of variables and their sources are summarized in table 4.1 below and the data set is provided in the appendix. The measure of bank competition is defined as the Lerner index estimated in chapter 3. Hence, my six-variable VAR model can be written as follows:

$$\mathbf{y}_t = \mathbf{B}_0\mathbf{y}_t + \mathbf{B}_1\mathbf{y}_{t-1} + ... + \mathbf{B}_p\mathbf{y}_{t-p} + \boldsymbol{\varepsilon}_t \tag{1}$$

where $\mathbf{y}_t = \begin{bmatrix} PD_t \\ CPI_t \\ RP_t \\ CREDIT_t \\ EFFICIENCY_t \\ LERNER_t \end{bmatrix}$, and $\boldsymbol{\varepsilon}_t = \begin{bmatrix} \varepsilon_{PD,t} \\ \varepsilon_{CPI,t} \\ \varepsilon_{RP,t} \\ \varepsilon_{CREDIT,t} \\ \varepsilon_{EFFICIENCY,t} \\ \varepsilon_{LERNER,t} \end{bmatrix}$

$\mathbf{y}_t$ is a vector of 6 variables in the system at time t containing real private demand (PD), consumer price index (CPI), 14-day repurchase rate (RP), banks' credit (CREDIT), banks' efficiency (EFFICIENCY) and banks' competition (LERNER). $\boldsymbol{\varepsilon}_t$ is a vector of structural shocks with a variance-covariance matrix of $E\left(\boldsymbol{\varepsilon}_t\boldsymbol{\varepsilon}_t'\right) = \mathbf{I}$. $\mathbf{B}_i$ for $i = 1,..., p$ are 6×6 matrix of coefficients. The VAR system in (1) can be rewritten in the reduced form as follow:

$$\mathbf{y}_t = \mathbf{A}_1\mathbf{y}_{t-1} + \mathbf{A}_2\mathbf{y}_{t-2} + ... + \mathbf{A}_p\mathbf{y}_{t-p} + \mathbf{u}_t \tag{2}$$

where $\mathbf{u}_t$ is the vector of reduced-form residual with variance-covariance matrix $E\left(\mathbf{u}_t\mathbf{u}_t'\right) = \mathbf{\Omega}$. Defining $\mathbf{A}_0 = \left(\mathbf{I} - \mathbf{B}_0\right)^{-1}$ implies that $\mathbf{A}_i = \mathbf{A}_0\mathbf{B}_i$ for $i = 1,..., p$. Hence, the structural shocks and the reduced-form residuals are related by

$$\mathbf{u}_t = \mathbf{A}_0\boldsymbol{\varepsilon}_t \tag{3}$$

and $$\mathbf{\Omega} = \mathbf{A}_0\mathbf{A}_0' \tag{4}$$

Table 4.1: List of Variables and Their Definitions

Variable	Definition	Source
PD	Real private demand (real GDP minus government spending)	Office of the national economic and social development board
CPI	Consumer price index (Quarter 2 of 2007 is base)	Thailand bureau of trade and economic indices
RP	14-day repurchase rate	Bank of Thailand’s financial statistics
CREDIT	Total credit issued by commercial banks	Bank of Thailand’s financial statistics
EFFICIENCY	Average cost efficiency of commercial banks	Estimated in chapter 2
LERNER	Lerner index	Estimated in chapter 3

Lag-structure Specification

The estimation of the reduced form in (2) is done using quarterly data from 1998Q1 to 2009Q4. In order to specify the optimal lag length, I consider various criteria including likelihood-ratio test (LR), Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ). The results provided by Eview7 are shown in table 4.2 below.

Table 4.2: Optimal-lag Criteria

VAR Lag Order Selection Criteria

Endogenous variables: PD CPI RP CREDIT EFFICIENCY LERNER

Exogenous variables: C

Date: 01/25/11 Time: 17:01

Sample: 1998Q1 2009Q4

Included observations: 43

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1102.790	NA	1.01e+15	51.57163	51.81738	51.66225
1	-904.5549	331.9286	5.41e+11	44.02581	45.74605*	44.66018
2	-874.2295	42.31441	7.78e+11	44.28975	47.48448	45.46787
3	-837.4425	41.06464	9.87e+11	44.25314	48.92237	45.97500
4	-760.2539	64.62297*	2.66e+11	42.33739	48.48111	44.60301
5	-693.4457	37.28830	2.25e+11*	40.90445*	48.52267	43.71381*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Note that the LR test and SC suggest four and one lag, respectively, whereas all other criteria suggest five lags. If too many lags are included, I run into degrees of freedom problem. Thus, in order to satisfy the parsimonious principle, one lag suggested by SC seems most appealing; however, I feel uncomfortable with one lag because it is too short to capture the underlying dynamic structure of the system. In addition, all these criteria are subject to criticisms, so they should be regarded as guides rather than hard-fast rules. I decide to include two lags in the VAR system for two reasons; first, many previous studiess such as Disyatat and Vongsinsirikul (2003), Bayoumi and Morsink (2001), and Ramaswamy and Sloek (1998) used two lags in their VAR analysis of Thailand, Japan, and EU, respectively; second, the estimated VAR is non-stationary if only one lag is included; it becomes stationary when two lags are included. The AR roots table and graph are shown in tables 4.3 and figure 4.1, respectively.

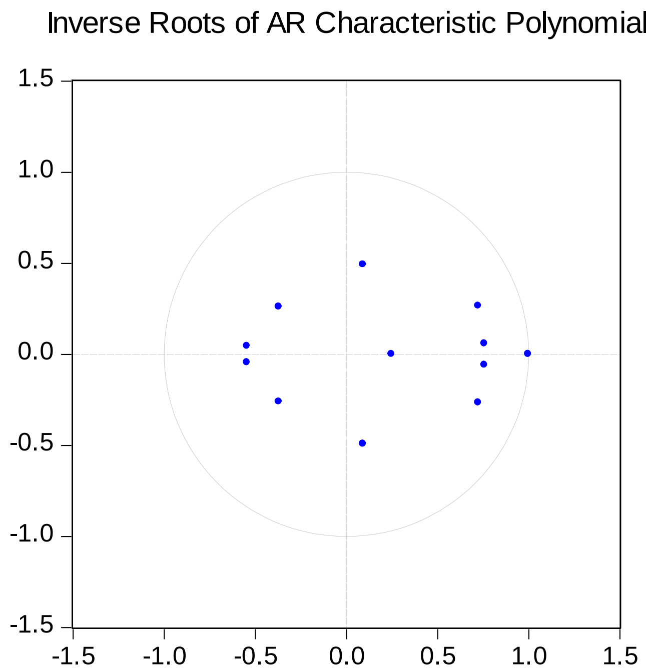
Table 4.3: The AR Root Table

Roots of Characteristic Polynomial
Endogenous variables: PD CPI RP CREDIT EFFICIENCY LERNER
Exogenous variables: C
Lag specification: 1 2
Date: 01/25/11 Time: 18:18

Root	Modulus
0.997119	0.997119
0.724625 - 0.265006i	0.771563
0.724625 + 0.265006i	0.771563
0.757660 - 0.059276i	0.759975
0.757660 + 0.059276i	0.759975
-0.544921 - 0.044304i	0.546719
-0.544921 + 0.044304i	0.546719
0.091782 - 0.491968i	0.500456
0.091782 + 0.491968i	0.500456
-0.370188 - 0.261520i	0.453246
-0.370188 + 0.261520i	0.453246
0.248416	0.248416

No root lies outside the unit circle.
VAR satisfies the stability condition.

Figure 4.1: The AR Root Graph



Note that all 12 roots shown in table 4.3 have modulus less than one and lie inside the unit circle as shown in figure 4.1, so the estimated VAR is stable (stationary) when two lags are included. The stationary of VAR system is necessary to validate the impulse response and accumulated response analysis.

Stationary and Cointegration Tests

Generally, regression models for non-stationary variables give spurious results. As a result, the conventional Ordinary Least Square (OLS) estimates are not consistent. Most macroeconomic and time-series variables usually exhibiting strong trend are not stationary and are thus not amenable to the VAR analysis. Hence, it is imperative for time-series analysis to test whether variables in a model are stationary. I perform the augmented Dickey-Fuller test on each variable against the null hypothesis that the variable has a unit root (non-stationary). The results for private demand (PD), consumer price index (CPI), 14-day repurchase rate (RP), banks' loan (CREDIT), banks' efficiency (EFFICIENCY), and banks' competition (LERNER), are shown in tables 4.4 – 4.9, respectively.

Table 4.4: The Augmented Dickey-Fuller Test on Private Demand (PD)

Null Hypothesis: PD has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.045612	0.0137
Test critical values:	1% level	-4.165756	
	5% level	-3.508508	
	10% level	-3.184230	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PD)
Method: Least Squares
Date: 01/26/11 Time: 15:54
Sample (adjusted): 1998Q2 2009Q4
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PD(-1)	-0.535290	0.132314	-4.045612	0.0002
C	266770.7	65579.75	4.067882	0.0002
@TREND(1998Q1)	4124.840	1084.158	3.804647	0.0004

R-squared	0.271268	Mean dependent var	6217.043
Adjusted R-squared	0.238144	S.D. dependent var	42286.37
S.E. of regression	36909.39	Akaike info criterion	23.93202
Sum squared resid	5.99E+10	Schwarz criterion	24.05012
Log likelihood	-559.4025	Hannan-Quinn criter.	23.97646
F-statistic	8.189421	Durbin-Watson stat	2.126634
Prob(F-statistic)	0.000947		

Table 4.5: The Augmented Dickey-Fuller Test on Consumer Price Index (CPI)

Null Hypothesis: CPI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.026796	0.5712
Test critical values:	1% level	-4.175640	
	5% level	-3.513075	
	10% level	-3.186854	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CPI)
Method: Least Squares
Date: 01/26/11 Time: 16:02
Sample (adjusted): 1998Q4 2009Q4
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CPI(-1)	-0.136934	0.067562	-2.026796	0.0494
D(CPI(-1))	0.321500	0.137313	2.341364	0.0243
D(CPI(-2))	-0.326346	0.139915	-2.332451	0.0248
C	10.63809	5.166418	2.059084	0.0460
@TREND(1998Q1)	0.096033	0.041262	2.327410	0.0251

R-squared	0.307820	Mean dependent var	0.506667
Adjusted R-squared	0.238602	S.D. dependent var	1.109955
S.E. of regression	0.968526	Akaike info criterion	2.878356
Sum squared resid	37.52167	Schwarz criterion	3.079096
Log likelihood	-59.76300	Hannan-Quinn criter.	2.953189
F-statistic	4.447117	Durbin-Watson stat	2.004718
Prob(F-statistic)	0.004561		

Table 4.6: The Augmented Dickey-Fuller Test on 14-day Repurchase Rate (RP)

Null Hypothesis: RP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.264046	0.0000
Test critical values:	1% level	-4.165756	
	5% level	-3.508508	
	10% level	-3.184230	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RP)
Method: Least Squares
Date: 01/26/11 Time: 16:03
Sample (adjusted): 1998Q2 2009Q4
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RP(-1)	-0.308556	0.033307	-9.264046	0.0000
C	0.124625	0.307526	0.405251	0.6873
@TREND(1998Q1)	0.019553	0.009477	2.063101	0.0450

R-squared	0.717611	Mean dependent var	-0.440781
Adjusted R-squared	0.704775	S.D. dependent var	1.546375
S.E. of regression	0.840217	Akaike info criterion	2.551388
Sum squared resid	31.06243	Schwarz criterion	2.669482
Log likelihood	-56.95762	Hannan-Quinn criter.	2.595828
F-statistic	55.90669	Durbin-Watson stat	1.448715
Prob(F-statistic)	0.000000		

Table 4.7: The Augmented Dickey-Fuller Test on Banks' Credit (CREDIT)

Null Hypothesis: CREDIT has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.389950	0.0652
Test critical values:	1% level	-4.170583	
	5% level	-3.510740	
	10% level	-3.185512	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(CREDIT)
Method: Least Squares
Date: 01/26/11 Time: 16:04
Sample (adjusted): 1998Q3 2009Q4
Included observations: 46 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CREDIT(-1)	-0.299352	0.088306	-3.389950	0.0015
D(CREDIT(-1))	-0.311800	0.127977	-2.436381	0.0192
C	2416657.	866146.7	2.790125	0.0079
@TREND(1998Q1)	63054.46	15598.33	4.042386	0.0002

R-squared	0.362067	Mean dependent var	78448.87
Adjusted R-squared	0.316500	S.D. dependent var	974670.9
S.E. of regression	805800.0	Akaike info criterion	30.12000
Sum squared resid	2.73E+13	Schwarz criterion	30.27901
Log likelihood	-688.7600	Hannan-Quinn criter.	30.17957
F-statistic	7.945867	Durbin-Watson stat	2.199217
Prob(F-statistic)	0.000261		

Table 4.8: The Augmented Dickey-Fuller Test on Banks' Efficiency (EFFICIENCY)

Null Hypothesis: EFFICIENCY has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.949673	0.1573
Test critical values:	1% level	-4.170583	
	5% level	-3.510740	
	10% level	-3.185512	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(EFFICIENCY)
Method: Least Squares
Date: 01/26/11 Time: 16:05
Sample (adjusted): 1998Q3 2009Q4
Included observations: 46 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EFFICIENCY(-1)	-0.494690	0.167710	-2.949673	0.0052
D(EFFICIENCY (-1))	-0.204721	0.142941	-1.432207	0.1595
C	0.449317	0.151970	2.956612	0.0051
@TREND(1998Q1)	0.000408	0.000265	1.541783	0.1306

R-squared	0.350639	Mean dependent var	0.001390
Adjusted R-squared	0.304256	S.D. dependent var	0.024180
S.E. of regression	0.020169	Akaike info criterion	-4.886415
Sum squared resid	0.017085	Schwarz criterion	-4.727402
Log likelihood	116.3875	Hannan-Quinn criter.	-4.826848
F-statistic	7.559653	Durbin-Watson stat	1.962375
Prob(F-statistic)	0.000374		

Table 4.9: The Augmented Dickey-Fuller Test on Banks' Competition (LERNER)

Null Hypothesis: LERNER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.493985	0.0041
Test critical values:	1% level	-4.165756	
	5% level	-3.508508	
	10% level	-3.184230	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LERNER)
Method: Least Squares
Date: 01/26/11 Time: 16:06
Sample (adjusted): 1998Q2 2009Q4
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LERNER(-1)	-0.632518	0.140748	-4.493985	0.0001
C	0.177794	0.039475	4.503912	0.0000
@TREND(1998Q1)	0.000760	0.000187	4.052044	0.0002

R-squared	0.315170	Mean dependent var	0.001244
Adjusted R-squared	0.284041	S.D. dependent var	0.009905
S.E. of regression	0.008381	Akaike info criterion	-6.664082
Sum squared resid	0.003090	Schwarz criterion	-6.545987
Log likelihood	159.6059	Hannan-Quinn criter.	-6.619642
F-statistic	10.12474	Durbin-Watson stat	2.145556
Prob(F-statistic)	0.000241		

The ADF tests reveal that the set of variables is a mixture of stationary and non-stationary processes. Specifically, 14-day repurchase rate (RP) and banks' competition (LERNER) appears to be stationary at 1% statistical significance, while the remaining variables have unit roots or are non-stationary. Hence, OLS estimation might result in a spurious regression unless those variables are found to be cointegrated.

Engel and Granger (1987) pointed out that a linear combination of two or more non-stationary time series may be stationary; such linear combination, if any, may be interpreted as a long run equilibrium relationship among variables. In other words, a principal feature of cointegrated variables is that their time paths might deviate from equilibrium in the short run; however, the system of cointegrated variables will ultimately return to the long run equilibrium.

The Johansen test is performed to detect cointegration. I specify the test based on the assumption that the level data have linear deterministic trend but the cointegrating equation has only intercept (without trend). And, I use one lag in differences or two lags in level which are the optimal number of lags suggested by Schwarz information criterion above. The test result is shown in table 4.10 below.

Table 4.10: Johansen Cointegration Test

Sample (adjusted): 1998Q3 2009Q4

Included observations: 46 after adjustments

Trend assumption: Linear deterministic trend

Series: PD CPI RP CREDIT EFFICIENCY LERNER

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.801753	158.0895	95.75366	0.0000
At most 1 *	0.597597	83.65032	69.81889	0.0027
At most 2	0.354711	41.77648	47.85613	0.1651

At most 3	0.213569	21.62589	29.79707	0.3198
At most 4	0.205182	10.57438	15.49471	0.2391
At most 5	0.000236	0.010835	3.841466	0.9169

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.801753	74.43918	40.07757	0.0000
At most 1 *	0.597597	41.87384	33.87687	0.0045
At most 2	0.354711	20.15059	27.58434	0.3308
At most 3	0.213569	11.05151	21.13162	0.6422
At most 4	0.205182	10.56354	14.26460	0.1775
At most 5	0.000236	0.010835	3.841466	0.9169

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The Johansen cointegration test reports that there are two cointegrating relationships for both trace statistics and maximum eigenvalue statistics. Generally, if cointegration is detected, the short-run relationship of variables should be estimated through the Error Correction Model or ECM, in which those variables in levels are transformed into first differences. Inevitably, there is a trade-off between loss of efficiency when the VAR is estimated in levels and the loss of information about the long run relationships when VAR is estimated in first differences.

However, most of the empirical literature on VAR concentrates on estimating VAR in levels for two reasons; first, the primary concern of most economic theories is to provide information about the long run equilibrium; second, according to Disyatat and Vongsinsirikul (2003), while estimation in levels might incur some efficiency losses, it incurs no cost in term of consistency of estimators, as pointed out by Sims et al. (1990) who have shown that even if some variables in VAR model have unit roots, the estimates of VAR are consistent. As a result, I estimate VAR in levels.

4.4 Empirical Results

My VAR model is based on the typically named "bank lending channel". Monetary policies operate through the fall or rise in bank reserves. For example, a contractionary monetary policy makes supply of loanable funds fall short, implying fewer bank credits can be used to finance consumption and investment. The lending channel presumes that bank loans and bonds are imperfect substitutes; consumers and firms live in frictional financial markets where issuing securities is very costly. The influence of monetary policy thus depends on the degree to which the central bank can affect the supply of bank loans and the reliance of borrowers on bank loans. Apparently, these two factors are influenced by the structure of the financial market such as efficiency and competition.

So far, I have specified my unrestricted VAR model in levels with 2 lags, which includes private demand (PD), consumer price index (CPI), 14-day repurchase rate (RP), banks' loan (CREDIT), banks' efficiency (EFFICIENCY), and banks' competition (LERNER). The quarterly data cover the period of 1998Q1 to 2009Q4. In this section, I begin with VAR estimates presented in table 4.11 below and then turn to the impulse response function analysis illustrating the implied dynamic paths of the variables following a one-time shock in the measure of monetary policy. Ultimately, I gauge the effect of banks' efficiency and competition by comparing two sets of impulse response: one with banks' efficiency and competition treated as endogenous and another in which they are treated as exogenous. The two procedures generate identical VAR results, except that the latter block off any responses within VAR which pass through the variables of interest. Thus, comparing the output response of the two models gives a measure of the importance of banks' efficiency and competition in facilitating the monetary policy to the real economy.

Table 4.11: The VAR Estimates

	PD	CPI	RP	LOAN	EFF	COM
PD(-1)	0.360491	5.65E-06	3.03E-06	-1.330327	-7.83E-08	3.26E-08
(S.E.)	(0.17107)	(4.6E-06)	(2.3E-06)	(3.17753)	(7.5E-08)	(3.8E-08)
[t-statistics]	[2.10729]	[1.22881]	[1.34766]	[-0.41867]	[-1.04223]	[0.85530]
PD(-2)	0.311329	5.64E-06	4.25E-07	-2.815154	1.09E-09	1.15E-08
(S.E.)	(0.17214)	(4.6E-06)	(2.3E-06)	(3.19740)	(7.6E-08)	(3.8E-08)
[t-statistics]	[1.80860]	[1.21907]	[0.18755]	[-0.88045]	[0.01443]	[0.30058]
CPI(-1)	11243.48	1.016294	0.256755	135805.9	0.001381	-0.000744
(S.E.)	(5989.42)	(0.16087)	(0.07884)	(111251.)	(0.00263)	(0.00133)
[t-statistics]	[1.87722]	[6.31762]	[3.25658]	[1.22072]	[0.52514]	[-0.55771]
CPI(-2)	-6897.049	-0.287789	-0.162512	18038.28	0.001827	0.000976
(S.E.)	(5647.35)	(0.15168)	(0.07434)	(104897.)	(0.00248)	(0.00126)
[t-statistics]	[-1.22129]	[-1.89736]	[-2.18609]	[0.17196]	[0.73671]	[0.77531]
RP(-1)	7782.457	-0.032294	0.735271	544252.3	0.003480	-0.003748
(S.E.)	(10641.8)	(0.28582)	(0.14008)	(197667.)	(0.00467)	(0.00237)
[t-statistics]	[0.73131]	[-0.11299]	[5.24878]	[2.75338]	[0.74472]	[-1.58037]
RP(-2)	-8888.205	0.046554	-0.141849	-420769.0	-0.006626	0.003227

(S.E.)	(8378.37)	(0.22503)	(0.11029)	(155625.)	(0.00368)	(0.00187)
[t-statistics]	[-1.06085]	[0.20688]	[-1.28615]	[-2.70374]	[-1.80085]	[1.72850]
CREDIT(-1)	-0.009168	-9.19E-08	-2.56E-07	0.131896	-3.83E-09	-1.98E-09
(S.E.)	(0.00892)	(2.4E-07)	(1.2E-07)	(0.16574)	(3.9E-09)	(2.0E-09)
[t-statistics]	[-1.02750]	[-0.38353]	[-2.17888]	[0.79581]	[-0.97659]	[-0.99346]
CREDIT(-2)	0.003667	4.58E-07	3.88E-08	0.421775	2.06E-09	1.51E-09
(S.E.)	(0.00891)	(2.4E-07)	(1.2E-07)	(0.16548)	(3.9E-09)	(2.0E-09)
[t-statistics]	[0.41166]	[1.91432]	[0.33085]	[2.54876]	[0.52550]	[0.76119]
EFFICIENCY(-1)	-244630.7	22.18051	-1.212783	-8239794.	-0.028406	0.183305
(S.E.)	(436508.)	(11.7239)	(5.74599)	(8107950)	(0.19169)	(0.09727)
[t-statistics]	[-0.56043]	[1.89190]	[-0.21107]	[-1.01626]	[-0.14819]	[1.88441]
EFFICIENCY(-2)	-335840.1	-9.957624	-2.159449	-15959231	0.129657	-0.006031
(S.E.)	(340705.)	(9.15080)	(4.48488)	(6328443)	(0.14962)	(0.07593)
[t-statistics]	[-0.98572]	[-1.08817]	[-0.48150]	[-2.52183]	[0.86661]	[-0.07943]
LERNER(-1)	-219738.0	30.11397	-20.11210	20877100	-0.009111	0.347904
(S.E.)	(834525.)	(22.4140)	(10.9853)	(1.6E+07)	(0.36647)	(0.18597)
[t-statistics]	[-0.26331]	[1.34353]	[-1.83082]	[1.34683]	[-0.02486]	[1.87074]
LERNER(-2)	660097.4	-9.967260	-7.017477	8724348.	-0.538530	0.309706
(S.E.)	(781301.)	(20.9845)	(10.2847)	(1.5E+07)	(0.34310)	(0.17411)
[t-statistics]	[0.84487]	[-0.47498]	[-0.68232]	[0.60117]	[-1.56962]	[1.77879]
C	310913.1	-4.759218	4.175372	7735895.	0.797298	-0.100853
(S.E.)	(417108.)	(11.2029)	(5.49062)	(7747603)	(0.18317)	(0.09295)
[t-statistics]	[0.74540]	[-0.42482]	[0.76046]	[0.99849]	[4.35286]	[-1.08501]
R-squared	0.909388	0.988535	0.931089	0.938718	0.637427	0.832594
Adj. R-squared	0.876438	0.984365	0.906031	0.916434	0.505582	0.771719
Sum sq. resids	4.98E+10	35.89462	8.622092	1.72E+13	0.009595	0.002471
S.E. equation	38830.86	1.042936	0.511151	721266.4	0.017052	0.008653
F-statistic	27.59907	237.1007	37.15660	42.12484	4.834673	13.67709
Log likelihood	-543.7127	-59.56593	-26.76196	-678.1152	129.6564	160.8590
Akaike AIC	24.20490	3.155041	1.728781	30.04849	-5.072019	-6.428654
Schwarz SC	24.72169	3.671831	2.245571	30.56528	-4.555229	-5.911864
Mean dependent	681996.2	91.74348	2.590673	12983985	0.927189	0.309884
S.D. dependent	110467.4	8.340894	1.667463	2495063.	0.024251	0.018111

Determinant resid covariance (dof adj.)	1.83E+12
Determinant resid covariance	2.49E+11
Log likelihood	-995.1525
Akaike information criterion	46.65881
Schwarz criterion	49.75955

Because VAR models are regarded as approximation of the reduced form of the structural models, VAR estimates have little or no economic behavioral interpretation; instead the VAR models' proposes focus on forecasting and assessing the impacts of shocks.

To assess the monetary policy transmission mechanism, there are two common methods of identifying a VAR: the recursive identification and the structural identification. The recursive or Cholesky method is in favor with most recent VAR literature on monetary policy mechanism for two reasons. First, Christiano et al. (1999) completed a survey of monetary VAR literature and found that the different identification schemes produced substantial agreement about the qualitative effects of monetary policy. Second, the structural identification requires a good-understanding of monetary policy interdependencies in the economy, resulting in a more complicated but unnecessarily less controversial model. Hence, my analysis focuses on Cholesky decomposition.

Impulse Response Analysis

In order to identify the dynamic response of any endogenous variables to the monetary-policy shock using Cholesky decomposition, I identify the ordering of variables, according to the speed with which each variable responses to shocks, as follows: private demand (PD), consumer price index (CPI), 14-day repurchase rate (RP), banks' loan (CREDIT), banks' efficiency (EFFICIENCY), and banks' competition (LERNER). The ordering is implied by the assumption on the dynamic structure of the economy. According to my assumption, private demand is the least responsive variable, followed by the consumer price index because it is generally believed that changes in output and price level require extensive periods of time. The 14-day repurchase rate is ranked third because the Bank of Thailand sets the policy interest rate according to indication about contemporaneous development in output and prices. Next to the policy rate is an amount of banks' total credit, which is assumed to reflect contemporaneous shocks to private demand, prices, and monetary policy. Then, the last two variables are banks' efficiency and competition, implying that these variables react without delay to all shocks in the system, but disturbances to them have no contemporaneous effect on the other variables. Hence, the reduced-form errors and the structural disturbance are given by:

$$\begin{bmatrix} u_t^{PD} \\ u_t^{CPI} \\ u_t^{RP} \\ u_t^{CREDIT} \\ u_t^{EFFICIENCY} \\ u_t^{LERNER} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^{PD} \\ \varepsilon_t^{CPI} \\ \varepsilon_t^{RP} \\ \varepsilon_t^{CREDIT} \\ \varepsilon_t^{EFFICIENCY} \\ \varepsilon_t^{LERNER} \end{bmatrix}$$

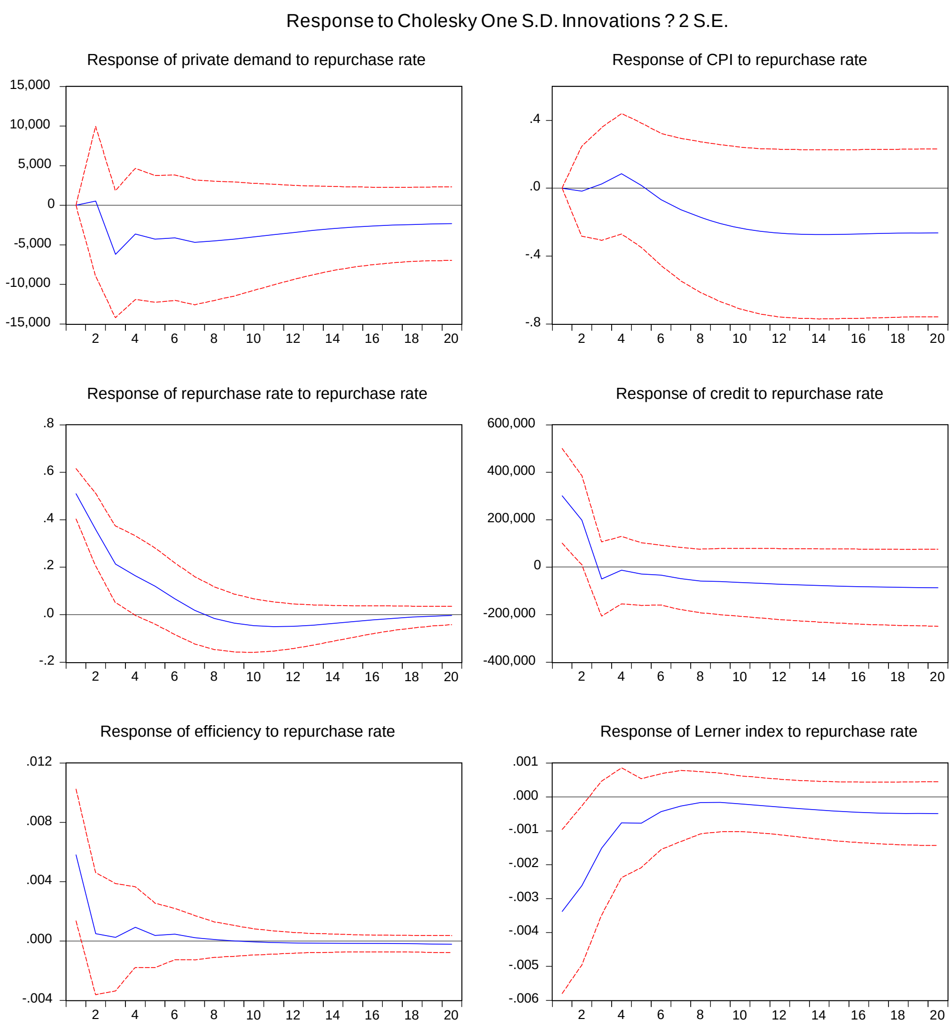
To assess the monetary transmission mechanism taking into account the effect of banks' efficiency and competition, I use the impulse responses of a one standard deviation of monetary policy shock (an exogenous, unexpected, temporary rise in the repurchase rate) on private demand, prices, the repurchase rate, banks' credit, efficiency, and competition. Then, I estimate another set of impulse responses identical to the benchmark model except that the effects of bank's efficiency and competition are blocked off as they are assumed to be exogenous.

Figure 4.2 below presents impulse response functions of the impact of the repurchase rate. An unexpected tightening of monetary policy – corresponding to a 0.45% basis-point rise in the 14-day repurchase rate –causes private demand and inflation to decline. Private demand bottoms out after three quarters and trends return to pre-shock level. The effect on inflation is more persistent as inflation continues to be lower than its pre-shock value without significant sign of recovery. Note that, however, for the third to the fifth period, the price level is higher than its pre-shock level. This contradictory result is commonly found in the empirical VAR literature on the monetary policy transmission mechanism in USA and is dubbed the "price puzzle[30]". The 14-day repurchase rate initially increases by 0.45%, continually declining and taking around 7 quarters to dissipate. This adjustment reflects the reaction of monetary authority to the one time shock in the economy. Banks' loans are also affected by an increase in the monetary-policy rate. Even though banks' loans initially increase, they begin to decline at the third quarter. The effect of tightening monetary-policy shock on banks' loan seems persistent as they decline and do not turn back to the pre-shock level after 20 quarters. Banks appear to operate more efficiently under the tightening monetary policy regime. Average cost efficiency increases in response to the monetary policy shock. However, the efficiency index continuously declines and dies out in 9 quarters. Similarly, the competition degree in the banking industry is intensified by the monetary policy shock. However, the Lerner index trends

[30] Sims (1992) pointed out that the price puzzle could result from the failure to include a rich enough specification of the information available to the policy makers. If the policy makers can observe variables containing useful information about future inflation, but those variables are ignored in the model, then positive innovation in the policy rate may be result in the higher price because they partly reflect systematic policy responses to information indicating that inflation is on the way.

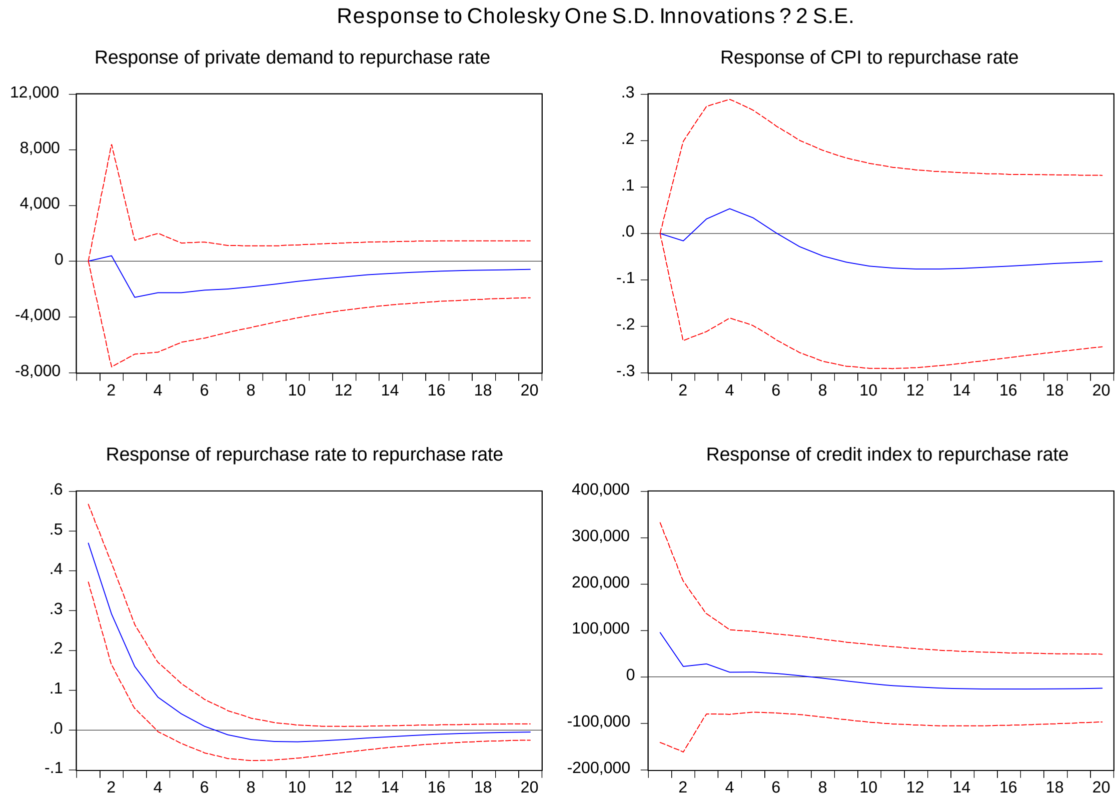
to increase and return to its normal level. Summarily, an one-time unexpected shock in the policy rate gives rise to a temporary fall in private demand; however, the effect on price level and banks' lending appear to be permanent; the results on banks' efficiency and competition seem to be temporary as expected because both efficiency and competition are regarded as structural variables and should be driven by only the real forces in the long run.

Figure 4.2: Impulse Responses to a Shock in Repurchase Rate in the Baseline Model



To examine the role of banks' efficiency and competition in the transmission mechanism, I exogenize the efficiency and competition indices. The VAR thus composes of private demand, consumer price index, 14-day repurchase rate, and bank loans. Figure 4.3 shows the impulse responses of those variables to an innovation in the 14-day repurchase rate. First of all, the response of private demand to the monetary policy shock has quite similar shape but is now smaller than in the baseline model and the effects dissipate faster. Second, the shape of the impulse response of consumer price index is similar to the baseline model, but the effects are smaller. Third, the 14-day repurchase rate dissipates more quickly i.e. it takes only six quarters to bottom out, which are less than 7 quarters of the baseline model. Lastly, bank-loan responses are now notably less than in the baseline model. Thus, by comparing the two sets of impulse response, I can conclude that ignoring the role of banks' efficiency and competition lessens the influence of monetary policy on output, price and bank credit. In other words, the impacts of monetary policy through the lending channel can be amplified by the adjustment in banks' efficiency and competition in the short run. Specifically, an unexpected tightening shock of monetary policy means higher financial costs to the banking industry, leading them to operate more efficiently and compete more fiercely to survive. This helps lubricate the transmission mechanism and enlarge the impacts of monetary policy.

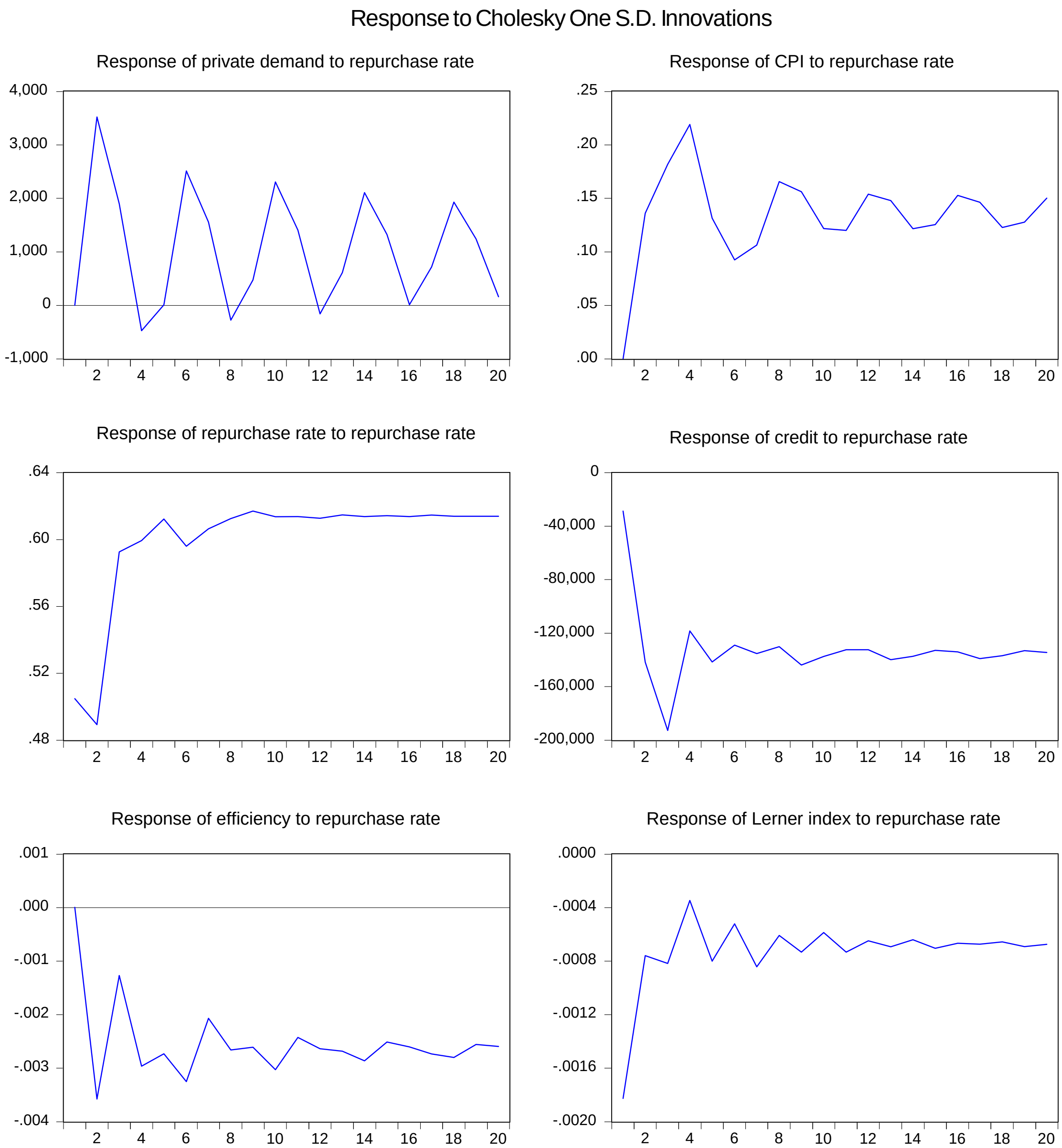
Figure 4.3: Impulse Responses to a Shock in Repurchase Rate When Efficiency and Competition Are Exogenized.



4.5 Robustness

First of all, as the stationary tests indicate in section 4.3, some of the variables are found to have unit roots. Thus, it might be arguable that this model should be estimated as a Vector Error Correction model (VEC). In the VEC model, all variables are transformed into first differences. The impulse responses of VEC to the monetary shock are given in figure 4.4.

Figure 4.4: Impulse Responses of VEC Model to a Shock in Repurchase Rate



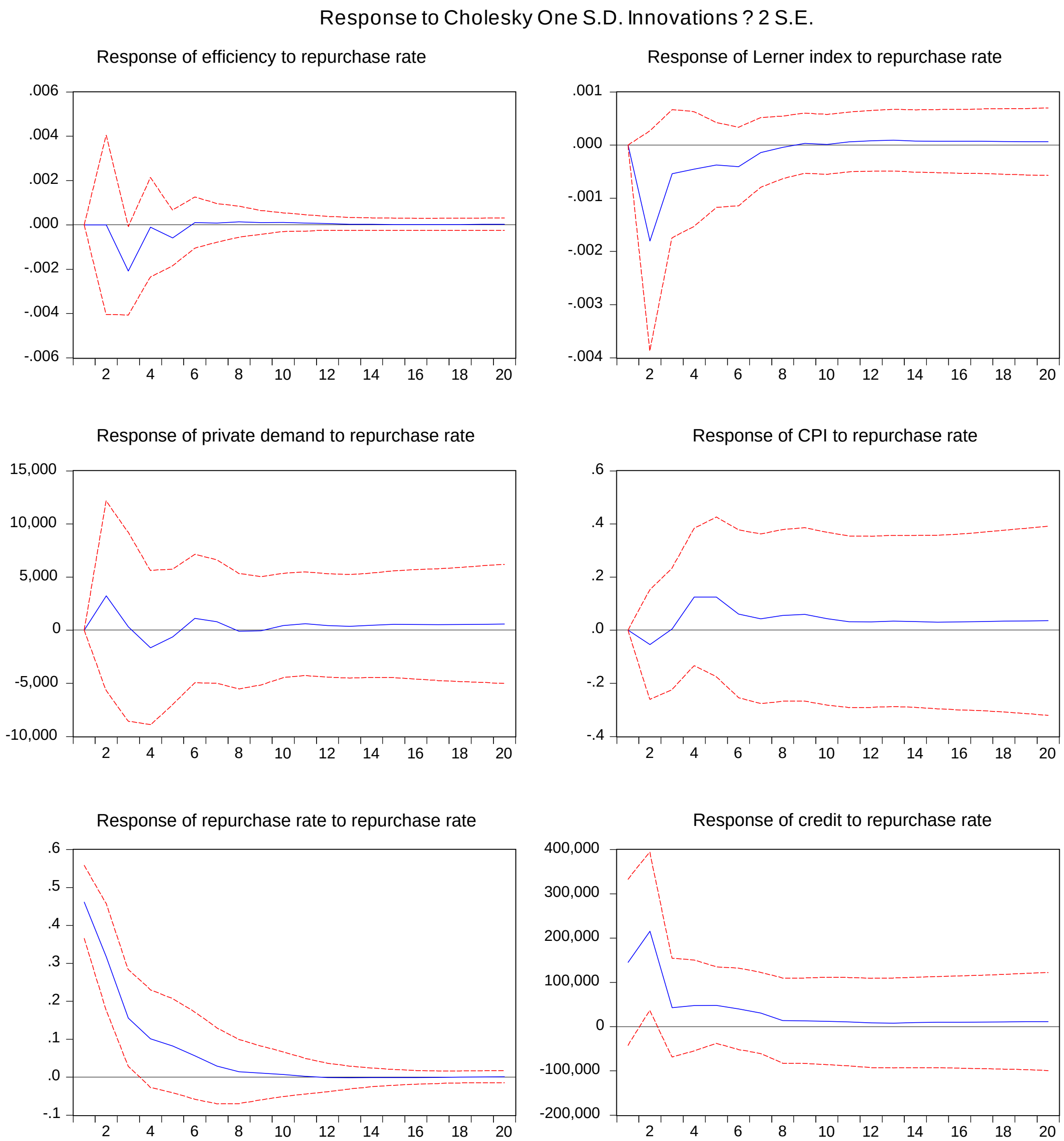
From figure 4.4, it is noticeable that the adjustments of all variables fluctuate less as time passes, suggesting that these variables will ultimately converge to their stable growth rate. Comparing VEC results with VAR results, I find agreement because the monetary policy can affect the output and price only in the short run.

However, it has no impact on real variables including efficiency and competition in banking sector in the long run.

In the Cholesky decomposition method, specification of variable ordering is important. I alternate the order of variables to see what happens to VAR impulse responses. Variables like bank efficiency and competition might be argued could not adjust in the short run. I alter their position from the last two to the first two i.e. lying before private demand; so that the order becomes efficiency, competition, private demand, consumer price index, 14-day repurchase rate, and bank credit. The new impulse response of each variable to the monetary shock is given in Figure 4.5 below.

The reordered Cholesky decomposition gives similar results as the baseline model. The unexpected tightening of monetary policy shock affects efficiency and competition very little in the very first quarters and the impacts ultimately disappear in the long run. Private demand fluctuates only slightly and trends to return to zero after 8 quarters. However, the responses of price look peculiar; the price level remains positive even after 20 quarters. The "price puzzle" mentioned in section 4.4 is a possible explanation. A similar result is also found for the 14-day repurchase rate even though it takes about 12 quarters to dissipate, which are slightly longer than the baseline model. The shape of response of bank credit is quite different. The tightening monetary policy shock has positive impact on bank credit in contrast to negative in the baseline model. However, summarily, reordered Cholesky decomposition does not significantly change the impulse responses.

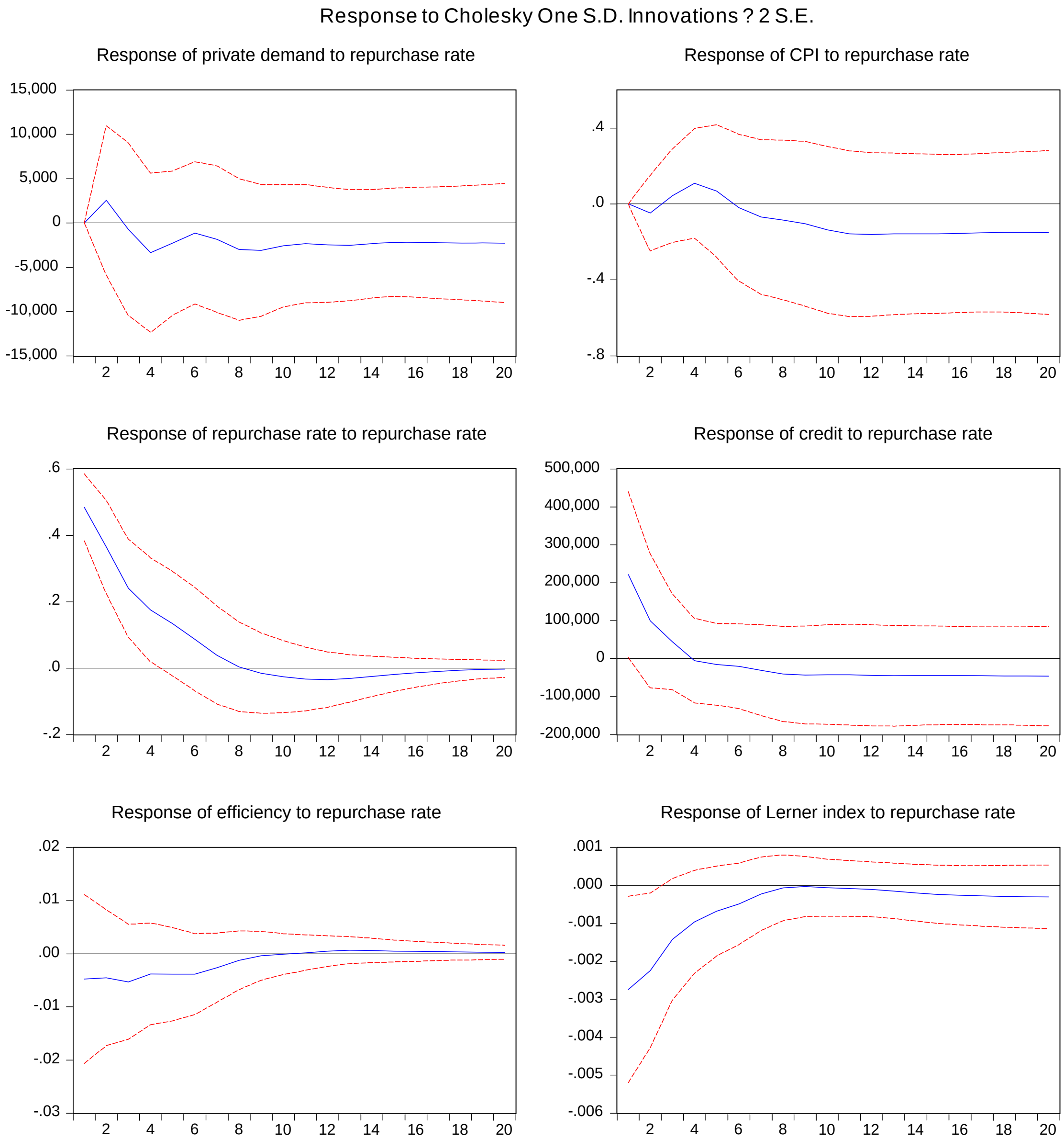
Figure 4.5: Impulse Responses to Monetary Shock When Cholesky Decomposition Reordered



Finally, in the baseline model, I used average cost efficiency as a measure of change in efficiency within the banking industry. However, the cost efficiency of each bank is defined in relative terms to the most efficient bank or banks. However, there should be as much interest in the dispersion of efficiency in the industry in addition to average efficiency. If the most efficient bank's performance drops, whereas all other banks' performance remain the same, allowing cost efficiency scores of all banks and the average cost efficiency of the banking industry to increase, the banking industry may not be considered more efficient. Hence, I tried an alternative efficiency index for the banking industry. An appealing choice is the standard deviation of cost efficiency (STD) which provides information about the dispersion in cost efficiency across the banks. A lower standard deviation of cost efficiency indicates that inefficient banks decrease their deviation from the most efficient bank, implying an improvement in the industry-wide cost efficiency. The new impulse responses when STD is used in place of the average efficiency are shown in figure 4.6 below.

From figure 4.6, the response of STD is different from the baseline as illustrated in figure 4.2. The STD reacts negatively to the tightening monetary policy shock; this means that on average the gaps between the most efficient bank and those who are less efficient become closer. However, the responses of other variables look similar with those of the baseline; private demand, price and bank loan decline; the competition degree improves firstly but trend to turn back to the normal level in the long run. Hence, switching the cost-efficiency index from the average to standard deviation does not change the direction of responses of each variable.

Figure 4.6: Impulse Responses when the Standard Deviation is Used in Place of Average efficiency



4.6 Conclusion

Presently, the Bank of Thailand adopts the inflation-targeting scheme of monetary policy which firmly focuses on curbing inflation and stabilizing the economy. The objective of this chapter is to uncover the impact of this monetary policy transmission mechanism in Thailand on key macroeconomic variables taking into account the roles of banks' efficiency and competition in this transmission process. In doing so, I employ Vector Auto Regressive model (VAR) and the impulse-response analysis to show how the economy reacts to an unexpected tightening monetary policy.

The effect of monetary policy on the economy is estimated by the baseline VAR model consisting of 6 variables, which are private demand, consumer price index, 14-day repurchase rate, bank loan, bank efficiency, and bank competition. From the impulse responses to a tightening monetary policy shock, I can extract the following results:

1. Private demand follows a U-shaped response. It reacts negatively, bottoming out after 3-4 quarters, then showing a recovery trends.
2. The consumer price index responses only a little in the very first quarters, but begin to decrease permanently after five quarters.
3. Both bank efficiency and competition are temporarily enhanced. Nonetheless, they are not affected by the monetary policy shock in the long run.

The responses of output and price level to monetary policy shock are consistent with previous studies in both Thailand and other developed countries like the EU, USA, and Japan. These finding confirm the neutrality of money in the long run. My finding about the impact of tightening monetary policy on bank efficiency and competition shows that these are temporarily improved, but both efficiency and competition are structural variables driven by the real forces of the economy such as input supply, innovation and productivity growth as predicted by modern economic theories.

Second, I unearth the roles of bank efficiency and competition in the transmission mechanism by estimating the VAR model again except that bank efficiency and competition are modeled as exogenous variables. The impulse responses reveal that the impacts of tightening monetary on output and price level are less powerful in the short run and dissipate faster because banks are not allowed to improve their cost efficiency and competition in response to the tightening-monetary policy shock as otherwise they should be in the baseline case, implying that an improvement in bank efficiency and competition helps strengthen the impacts of monetary policy.

Hence, my findings suggest that, in order to strengthen the monetary transmission mechanism in the near future, bank of Thailand should somehow enhance efficiency and competition in banking sector for example by liberalizing and developing the financial market.

The VAR model used in this study, although including bank efficiency and competition as proxies of bank operation, may not completely represent bank management. For example, some measures of excess fund available in the banking industry such as the loan-to-deposit ratio or government bonds-to-loan ratio might be included in the VAR model because the power of monetary policy in the bank-lending channel crucially depends on banks' available funding and banks' decision on allocating funding between government securities regarded as safe investments and loans regarded as risky assets. This might help improve insights into the monetary policy transmission mechanism but is left for the future research.

4.7 Appendix

Data Set

Y/Q	GDP - Government Expenditure (million baht)	CPI	14-day repurchase	Bank credit (million baht)	Average cost efficiency	Lerner index
1998Q1	660,815	80.4	21.97	14,078,740	0.94	0.28
1998Q2	605,679	82.2	17.72	13,658,195	0.89	0.28
1998Q3	578,721	82.9	10.66	13,281,355	0.87	0.28
1998Q4	641,507	82.5	4.82	8,527,465	0.84	0.30
1999Q1	658,425	82.5	3.34	12,400,674	0.91	0.29
1999Q2	619,031	81.9	1.84	12,198,351	0.89	0.29
1999Q3	639,223	82.1	1.61	11,859,443	0.91	0.29
1999Q4	684,272	82.6	1.53	11,584,150	0.94	0.29
2000Q1	699,715	83.2	1.53	11,256,501	0.94	0.28
2000Q2	662,813	83.2	1.57	11,113,525	0.93	0.30
2000Q3	651,940	83.8	1.50	10,675,403	0.95	0.29
2000Q4	716,801	83.9	1.50	9,963,834	0.91	0.29
2001Q1	710,954	84.4	1.50	9,902,127	0.95	0.29
2001Q2	672,766	85.3	1.75	9,826,660	0.95	0.30
2001Q3	664,392	85.2	2.50	9,508,860	0.96	0.30
2001Q4	741,463	84.8	2.49	9,327,261	0.91	0.33
2002Q1	739,363	84.9	1.85	10,345,264	0.94	0.30
2002Q2	711,705	85.5	1.82	10,936,736	0.93	0.30
2002Q3	708,992	85.5	1.73	10,881,012	0.95	0.30
2002Q4	790,923	86.0	1.63	11,077,510	0.92	0.30
2003Q1	801,338	86.5	1.74	11,267,163	0.93	0.30

Y/Q	GDP - Government Expenditure (million baht)	CPI	14-day repurchase	Bank credit (million baht)	Average cost efficiency	Lerner index
2003Q2	759,739	86.9	1.73	11,427,580	0.92	0.31
2003Q4	856,629	87.4	1.25	11,699,058	0.90	0.32
2004Q1	854,199	88.2	1.25	11,909,648	0.91	0.32
2004Q2	809,950	89.2	1.25	12,230,787	0.91	0.32
2004Q3	808,961	90.0	1.35	12,419,874	0.92	0.31
2004Q4	905,196	90.1	1.75	12,824,573	0.92	0.32
2005Q1	879,571	90.7	2.08	12,850,687	0.92	0.32
2005Q2	845,083	92.6	2.32	13,039,503	0.91	0.32
2005Q3	842,278	95.0	2.86	13,269,483	0.90	0.31
2005Q4	946,165	95.5	3.72	13,818,620	0.95	0.31
2006Q1	935,422	95.9	4.28	14,114,065	0.94	0.30
2006Q2	889,086	98.1	4.80	14,470,420	0.94	0.31
2006Q3	885,790	98.5	5.00	14,522,112	0.94	0.31
2006Q4	993,738	98.6	3.33	14,802,285	0.92	0.31
2007Q1	974,510	98.2	4.72	14,775,043	0.94	0.31
2007Q2	925,251	100.0	3.81	15,017,354	0.93	0.32
2007Q3	927,872	100.1	3.30	15,058,213	0.94	0.32
2007Q4	1,042,034	101.5	3.25	15,461,276	0.93	0.33
2008Q1	1,041,874	103.2	3.25	15,968,106	0.96	0.33
2008Q2	980,033	107.5	3.25	16,636,650	0.95	0.34
2008Q3	956,491	107.4	3.58	17,194,613	0.95	0.33
2008Q4	983,684	103.7	3.47	17,519,387	0.92	0.34
2009Q1	955,877	102.9	1.65	17,353,108	0.96	0.34
2009Q2	920,294	104.5	1.26	17,206,586	0.95	0.34
2009Q3	917,004	105.0	1.25	16,991,662	0.93	0.34
2009Q4	1,039,803	105.7	1.25	17,266,843	0.95	0.34

REFERENCES

Alencar, L.S., Nakane, M.I., 2004. Bank competition, agency costs, and the performance of the monetary policy. Working Paper Series 81.

Bayoumi, T., Morsink, J., 2001. A peek inside the black box: The monetary transmission mechanism in Japan. *IMF Staff Papers*, Journals, 48(1).

Berger, A. N., Humphrey, D. B., 1997. Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research*, **98**(2),175-212.

Bernanke, B., Blinder, A.S., 1992. The Federal Funds Rate and the Channels of Monetary Transmission. *American Economic Review*, **82**(4), 901-21.

Bernanke, B., Mihov, I., 1998. Measuring Monetary Policy. *The Quarterly Journal of Economics*, **113**(3), 869-902.

Bresnahan, T.F., 1989. Empirical studies of industries with market power. In Schmalensee, R., Willig, R. (Eds.), Handbook of Industrial Organization. North-Holland, Amsterdam.

Charoenseang, J., Manakit, P., 2007. Thai monetary policy transmission in an inflation targeting era. *Journal of Asian Economics*, **18**(1), 144-157.

Christiano, L. J., Eichenbaum, M., Evans, C., 1996. The effects of monetary policy shocks: Evidence from the flow of funds. *The Review of Economics and Statistics*, **78**(1), 16-34.

Christiano, L., J., Eichenbaum, M., Evans, C. L., 1999. Monetary policy shocks: What have we learned and to what end? Handbook of Macroeconomics, in: J. B.

Taylor and M. Woodford (ed.), Handbook of Macroeconomics, edition 1, volume 1, chapter 2, pages 65-148 Elsevier.

Cottarelli, C., Kourelis A., 1994. Financial structure, bank lending rates, and the transmission mechanism of monetary Policy. *IMF Staff Papers*, 41(4), 587-623.

Disyatat, P.,Vongsinsirikul, P., 2003. Monetary policy and the transmission mechanism in Thailand. *Journal of Asian Economics*, **14**(3), 389-418.

Engle, Robert F., Granger, Clive W. J., 1987. Co-integration and error correction: Representation, estimation and testing. *Econometrica*, **55**(2), 251-276.

Freixas, X., Rochet, J.C., 1997. Microeconomics of banking. MIT Press, Cambridge.

Girardone, C., Casu, B., 2009. Testing the relationship between competition and efficiency in banking: A panel data analysis. *Economics Letters*, **105**(1), 134-137.

Gunji, H., Miura, K.,Yuan, Y., 2009 Bank competition and monetary policy. *Japan and the World Economy*, **21(**1), 105-115.

Kubo, K, 2006. The degree of competition in the Thai banking industry before and after the East Asian crisis. *ASEAN Econmic Bulletin*, **23**(3), 325-340.

Lucas, R., "Econometric policy evaluation: A critique" Carnegie Rochester conference on public policy 1 (Amsterdam: North-Holland, 1976), 19-46.

Panzar, J.C., Rosse, J.N., 1987. Testing for ''monopoly'' equilibrium. *Journal of Industrial Economics*, 35, 443–456.

Ramaswamy, R. and Sloeck, T.,1998. The real effects of monetary policy in the EU: what are the differences? *IMF Working Paper*, 97/160.

Sims, C. A., 1980. Macroeconomics and reality. *Econometrica*, **48**(1), 1-48.

Sims, C.A., Stock, J., Watson, M.W., 1990. Inference in linear time series models with some unit roots. *Econometrica*, 58, 113-144.

Stiglitz, J.E., Greenwald, B., 2003. Towards a new paradigm in monetary economics. Cambridge University Press, Cambridge.

Chapter 5

Conclusion and Summary

This dissertation studies microeconomic and macroeconomic issues in banking sector. I first study individual-bank efficiency, then the competition in banking industry, and finally the roles of efficiency and competition of banking sector in monetary policy transmission. A set of questions are posed in the first chapter and this chapter will summarize the answers.

In chapter 2, the major questions were "Which banks are efficient and why are some banks less efficient?" To answer those questions, I estimate a stochastic cost frontier and measure individual cost inefficiency. Both commercial banks and government-owned specialized banks are included in this study, although in this chapter I focus on commercial banks' results because their performance are relevant to the analysis in the following two chapters. The evidence indicates that Krung Thai Bank is the most efficient bank, followed by Siam Commercial Bank, Bangkok Bank, and Kasikorn Bank, respectively. These are the biggest four banks who have dominated the banking sector of Thailand for decades. On the other hand, the smallest four banks that are new entries to the industry are ranked at the bottom in efficiency. In addition, the evidence indicates that banks with lower Non-performing-loans-to-total-loan ratios, higher equity-to-total-asset ratios, higher liquid-asset-to-total-asset ratios, and more branches are likely to be more efficient.

In chapter 3, I use the new empirical industrial organization approach to answer the following questions: "What is the extent of collusive behavior in the banking sector?" and "Did competition in banking sector increase as a result of financial deregulation after the financial meltdown in 1997?" The estimated conduct parameter indicates that the degree of banks collusion is substantially low, that is, a decline in a bank's loan quantity will be mostly offset by an increase in loan supply of rivals. However, surprisingly, the empirical results suggest that the degree of competition in the banking sector as measured by the Lerner index, continually deteriorated after the financial crisis in 1997 and the subsequent deregulation of the industry. In fact, the concentration ratio of the biggest four banks (CR_4) has steadily increased after the crisis, resulting in an increase in the Lerner index, or a decline in the competition environment, mainly because the benefit of cost-efficiency resulting from the increased concentration does not offset the unfavorable effect of higher market-power associated with the higher concentration. These econometric findings might suggest the relative failure of the Thai government's attempts to enhance competition in the banking industry.

In chapter 4, the question is "How do bank efficiency and competition affect monetary policy transmission? To answer this question, I employ the Vector Autoregression (VAR) model to study the transmission of monetary policy, taking into account the role of bank efficiency and competition. To accomplish this,, I incorporate the bank efficiency index and bank competition index computed in chapter 2 and chapter 3, respectively, into my VAR model. The impulse response functions indicate the neutrality of money, that is, the real variables such as output, efficiency and competition are not affected by the monetary policy in the long run; however, monetary policy is still a reliable tool to alleviate inflation in the long run. To answer the major question of chapter 4, I gauge the importance of banks' efficiency and competition by comparing two set of impulse response functions, which are identical except that the bank efficiency and competition variables are treated either as endogenous or exogenous variables. The impulse responses reveal that the impact of tightening monetary policy on output and price level are less powerful in the short run and dissipate faster when bank efficiency and competition are blocked off or treated as exogenous variables. Hence, these empirical results might imply that bank efficiency and competition have important roles in helping strengthen the transmission of monetary policy.

Summarily, bank efficiency and competition are not only unanimously regarded as preferable forces to foster long run economics growth, but also it is shown in chapter 4 that they play important roles in helping strengthen the impact of monetary policy. Hence, the policy implication is that Thai government should exert more effort to enhance efficiency and competition in the banking sector. To improve efficiency, the results of chapter 2 suggest that the government introduce policies to stabilize the banking system, such as encouraging banks to reduce their non-performing loans and increase their equity. The results of chapter 3 suggest the government should intensify financial liberalization and deregulation to encourage more new entries into the industry, which should help decrease market concentration and enhance competition in the banking sector.