Production Efficiency of Thai Commercial Banks

and the Impact of 1997 Economic Crisis

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Abstract

This study utilizes a constrained multiplier, input-oriented, data envelopment analysis (DEA) model to evaluate the productive efficiency and performance of 12 commercial banks in Thailand. The model has been applied to the most recent data of 1990–2003 period which covers both pre-and post-Asian Economic Crisis of 1997. We find out that among the most efficient banks are the large Thai-owned banks while the least efficient banks are the small foreign-owned banks. The results also suggest that the 1997 Economic Crisis does significantly reduce the efficiencies of commercial banks in Thailand. Moreover, we find a strong relationship between bank efficiency and its inputs and outputs.
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I. Introduction

On July 2, 1997, the Bank of Thailand changed the currency system from a fixed to a floating exchange rate which led to a continuing depreciation of Thai baht. The deterioration of Thai baht resulted in higher loan repayment costs for Thai companies, funds withdrawal by foreign investors and a negative number of economic growths. The banking system in Thailand also went through major shocks after 1997. With all of the problems that are occurring to the Thai banking system, it would seem impossible that this is the same country that experienced an average GDP growth of 11.5 percent from 1987 to 1996. During this high-growth period, Thailand was considered a newly developing economy, and many times was presented as a model for other developing countries.

The 1997 Financial Crisis that hit Thailand revealed substantial vulnerabilities in the financial sector. It turned out that most financial institutions had a large amount of non-performing loans, which were the result of poor risk management and excessive lending to some parts of the real sector. In fact, a large number of financial institutions were insolvent and subsequently had to be merged or liquidated. Poor risk management was caused by weak corporate governance and limited investment in risk management technology. Excessive lending was caused to a large extent by extensive cross-ownership of banks and private companies, weak enforcement of banking regulations and government-directed lending.

The 1997 Economic Crisis leads to a dramatic drop in previously high profits and an increase in debtors who could not repay their loans. In addition, the number of
financial institutions, both banks and financial companies, dropped from 91 to 35 in 1997 and the list of banks dropped from 15 in 1997 to 12 in 2004. Currently, banks in Thailand fall into three categories according to ownership structure. The first category consists of the five banks whose major shareholders are Thai individuals and institutional investors. The second group is the four hybrid or foreign-owned banks, which predominantly owned by foreign shareholders, especially after the 1997 Economic Crisis. The third group comprises three government-owned banks whose operations mirror government policies. In May 2001, total assets of all commercial banks are approximately US$ 125 billion (Bank of Thailand, 2002).

The Thai banking industry, relatively small in its size and incorporating only 12 commercial banks, still provides a branch banking system with a large number of branches nationwide creating an economic driving tools. In March 2002, there were 3,664 branches (Bank of Thailand, 2002) and these were the main contact points for Thai customers, especially those in urban areas. Competition in the Thai market increased remarkably after the entrance of the foreign banks. Although the five Thai and three government-owned banks are now more familiar to customers, with many of their branches across the nation, foreign banks are increasingly offering ready-made products and using advanced technology. Their better managerial skills mean changes can be introduced promptly to the market, while their competitors face higher branch investment and operating costs.

1 A. Thai-owned banks are the banks whose major shareholders are Thai and no major foreign shareholder of more than 51%. This group consists of Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.
B. Foreign-owned banks are the banks whose major shareholders are foreign entities (more than 51%). This group consists of Bank of Asia, Standard Chartered Nakornthon Bank, UOB Radhanasin Bank, and DBS Thai Danu Bank.
C. Government-owned banks are the banks that belong to the Thai Government. This group consists of Krung Thai Bank, Siam City Bank, and Bank Thai.
Thai commercial banks have, in recent years, witnessed sweeping changes due to the regulatory environment, the introduction of e-commerce and on-line banking. All of these forces have made the Thai banking industry highly competitive. In competitive industries, production units can be separated by some standards into those with good performance and those with poor performance. Typical comparisons of bank performance use either simple aggregate bank ratios relating cost to revenues or assets, or the more sophisticated frontier technique which measures a bank’s efficiency by its distance to the efficient frontier. Therefore, managerial performance can be improved by identifying best and worst practices associated with high and low efficiencies, respectively. Substantial research by financial economists has gone into an evaluation of the efficiencies of financial institutions using both parametric and nonparametric frontier efficiency analyses.

In this study, we utilize nonparametric approach called, “Data Envelopment Analysis (DEA) model”, to quantifiably benchmark the productive efficiency of Thai commercial banks. Using the parsimonious DEA model developed by Siems and Barr (1998), we measure relative productive efficiency of these institutions over the 14-year period from 1990 to 2003, which includes both pre and post 1997 Economic Crisis periods. The objectives of the study are: (1) to measure the relative productive efficiency of 12 Thai commercial banks over the study period, (2) to find the impact of the 1997 Financial Crisis on the commercial banks’ efficiency, and (3) to find a relationship between the DEA model’s input/output with Thai commercial banks’ efficiency.

The organization of this paper is as follows. Section II presents the contributions of previous studies. Section III explains the methodology used in this study. Section IV provides the details of data and testing hypotheses. Section V presents the empirical results and the last section provides concluding remarks.
II. Literature Review

The literature distinguishes two types of bank efficiency. The first is operational efficiency as introduced by Farrell (1957) to measure efficiency, and the second is X-efficiency as introduced by Leibenstein (1966) to explain differences in efficiency between banks. The concept of operational efficiency is purely technical and can be defined as the product of technical efficiency, which tells us how far the bank is from the isoquant, and allocative efficiency, which captures inefficiencies due to the fact that the bank picked a sub-optimal input combination given input prices. Under X-efficiency, the basic problem is viewed as one that is intrinsic to the nature of human organization. X-inefficiency may arise from reasons outside the knowledge or capability of management including corporate governance problems and the difficulties of principal-agent relationships within organizations.

Berger and Humphrey (1997) report that there are 130 studies that apply frontier analysis (116 were published from 1992 to 1997) to determine financial institution efficiency. They also state that there are now enough frontier analysis studies to draw some tentative comparisons of average efficiency levels both across measurement techniques and across countries, as well as outline the primary results of many applications of efficiency analysis to policy and research issues. They find that overall depository financial institutions experience annual average technical efficiency ratios of around 77 percent. Frontier inefficiency, sometimes called X-inefficiency, of financial institutions has generally been found to consume a considerable portion of costs, to be a much greater source of performance problems than either scale or product mix

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2 A 77 percent efficiency measure typically means that if the average firm were producing on the frontier instead of at its current location, then only 77 percent of the resources currently being used would be necessary to produce the same output.
inefficiencies, and to have a strong empirical association with higher probabilities of failures.

Previous studies [e.g. Button (1992), Gilbert (1998), and Leightner (1997)] have examined efficiency and associated effects on financial institution performance from several different perspectives. These include the effects of mergers and acquisitions, institution failure and deregulation issues, among others. Frontier efficiency models are employed, by these researchers, over other performance indicators primarily because these models result in an objectively determined quantified measure of relative performance that removes the effects of many exogenous factors. This permits the researchers to focus on quantified measures of costs, inputs, outputs, revenues, profits, etc. to impute efficiency relative to the best practice institutions in the population.

There are at least four frontier analysis methodologies used to compute financial institution efficiency, and there is no consensus among researchers on which method is the best. These approaches differ mainly in how they handle random error and their assumptions regarding the shape of the efficient frontier. The three main parametric methodologies include Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution-Free Approach (DFA). In general, parametric approaches specify a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors, and allow for random error. The most widely used parametric approach is called Stochastic Frontier Analysis (SFA) and the most widely used nonparametric approach is Data Envelopment Analysis (DEA). DEA, originally developed by Charnes, Cooper and Rhodes (1978), computes the relative productive efficiency of individual decision-making units by using multiple inputs and outputs.

Application of both parametric and nonparametric techniques on the same banking data can lead to very different results as Ferrier and Lovell (1990) have shown.
The choice of techniques depends on the situation. There are some possible reasons to prefer SFA to DEA as pointed out by Schmidt (1986) that DEA estimates give only an upper bound to efficiency measures so it is difficult to use DEA to compare efficiency among firms. Another reason is that DEA does not assume statistical noise, which means that all the error terms in the estimation are attributed to inefficiency. This means that DEA will account for the influence of factors such as luck, bad data and extreme observations as inefficiency. Therefore, as Schmidt (1986) has pointed out, one would expect that DEA produces greater measured levels of inefficiency than SFA.

There are some bank efficiency studies, using Asian banking data. Bhattacharyya et. al. (1997) apply DEA techniques to Indian banks which is the first study using data of a developing country. Leightner and Lovell (1997) use linear programming techniques to show that Thai banks experienced high growth rates in production during 1990-1994. They argue that these high growth rates indicate an unusual level of success of the banking system. Gilbert and Wilson (1998) use linear programming techniques to investigate the effects of privatization and deregulation on the productivity of Korean banks over 1980-1994. It is revealed that Korean banks responded to privatization and deregulation by altering their mix of inputs and outputs, yielding large changes in productivity.

Hao et. al. (1999) use the stochastic frontier approach to explain differences in inefficiency scores for 19 Korean banks during 1985-1995. They find that banks with faster growth rates, banks with a countrywide branch network and banks that made extensive use of deposits in funding their asset were most efficient. Kwan (2001) uses the stochastic econometric cost frontier approach to investigate the cost efficiency of commercial banks in Hong Kong. On average, the X-efficiency of Hong Kong banks is found to be approximately 16 to 30 percent of observed total costs, which is comparable
to the findings in the U.S. banking industry. The average large bank in Hong Kong is found to be less efficient than the average small bank, specifically X-efficiency is found to decline with bank size, deposit-to-asset ratio, loan-to-asset ratios, provision for loan loss, and loan growth, and to increase with off-balance sheet activities.

Narongtanupon (2000) examines the efficiency of commercial banks in Thailand during the 1989 to 1998 using SFA. The findings are consistent with the dominance of the Global Advantage Hypothesis which supports superior efficiency by foreign banks relative to host-country banks. Moreover, the average efficiency levels of both Thai-owned and foreign-owned banks in Thailand deteriorated after the eruption of its 1997 Economic Crisis. However, foreign-owned banks tend to handle with economic downturn better. The variation in the bank’s efficiency significantly correlates with both macro-economic variables and bank’s specific characteristics.

Estrada and Osorio (2003) discuss cost and profit efficiency for a sample of financial institutions in Colombia during the period of 1989-2003, using SFA. During the mentioned period, the cost efficient frontier deteriorates, but profit efficient frontier is relatively stable. They found significant difference when comparing the efficiency scores between types of financial intermediaries. Additionally, their analysis shows that the scores for profit and cost efficiency have different distribution. They found big differences between profit and cost efficiency among different types of banks. Fries and Taci (2004) examine the cost efficiency of 289 banks in 15 Eastern European countries by using SFA. The findings showed that banking systems in which foreign-owned banks have a larger share of total assets record lower costs and that the association between a country’s progress in banking reform and cost efficiency is non-linear. Early stages of reform are associated with cost reduction while costs tend to rise at the more advanced stages. Private banks are more efficient than state-owned banks but there are differences
among private banks. Privatized banks with majority of foreign ownership are the most efficient and those with domestic ownership are the least.

Yildirim and Philippatos (2003) examine the cost and profit efficiency of banking sectors in 12 transition economies of Central and Eastern Europe (CEE) over the period of 1993-2000, using SFA and DFA methods. The managerial inefficiencies in CEE banking markets were found to be significant. The alternative profit efficiency levels are found to be significantly lower relative to cost efficiency. According to SFA, approximately one-third of banks’ profits are lost to inefficiency, and almost one-half according to DFA. The results of the second-stage regression analyses suggest that higher efficiency levels are associated with large and well-capitalized banks. The degree of competition has a positive influence on cost efficiency and a negative one on profit efficiency, whereas market concentration is negatively linked to efficiency.

Kamberoglou et al. (2004) use DFA to investigate cost efficiency in a panel of Greek banks over 1993-1999. The results obtained indicate that important cost X-inefficiencies are in place. Some evidence provides that bank characteristics such as bank size, type of ownership and risk behavior do play a role in explaining differences in measured inefficiencies. Scale economics are also examined and the findings indicate that the Greek banking industry experiences economies of scale, though they have declined throughout the observed period. This suggests that competitive viability may be an important factor for further considerations in the Greek banking industry.

Tripe (2004) uses DEA to investigate the efficiency of New Zealand banks with significant branch networks relative to their Australian counterparts, and relative to other Australian banks with retail branch networks during 1996 to 2003. The result shows that there is no significant difference between the efficiency of New Zealand banks and the
major Australian banks although the Australian regional banks are found to be rather less efficient.

III. Methodology

The major reason that DEA is more preferable than SFA is that DEA can be used even when conventional cost and profit functions that depend on optimizing reactions to prices cannot be justified. Since it is likely that regulations and other market imperfections distort prices in Thai banking sector complicating the application of SFA to price and quantity data, it seems that DEA is more suitable for examining the efficiency of Thai banking industry since DEA has advantages of avoiding possible misspecification on distribution assumptions of the error terms. A practical consideration to use DEA instead of SFA is that it avoids having to measure output prices, which are not available for transactions services and fee-based outputs. Other parametric methods such as SFA, TFA and DFA have disadvantages relative to the nonparametric methods of having to impose more structure on the shape of the frontier by specifying a functional form for it. There is a concern that the levels of the parametric efficiency estimates may be influenced by the somewhat arbitrary assumptions. The measurement of the core efficiency means that efficiency variations over time for an individual firm tend to be averaged out with the random error.

DEA generalized the Farrell (1957) single-output/single-input technical efficiency measure to the multiple-output/multiple-input case. DEA optimizes on each individual observation with the objective of calculating a discrete piecewise linear frontier determined by the set of Pareto-efficient decision-making units (DMUs). Using this frontier, DEA computes a maximal performance measure for each DMU relative to all other DMUs. The only restriction is that each DMU lies on the efficient (extremal)
frontier or be enveloped within the frontier. The DMUs that lie on the frontier are the best practice institutions and retain a value of one; those enveloped by the extremal surface are scaled against a convex combination of the DMUs on the frontier facet closest to it and have values somewhere between 0 and 1. Several different mathematical programming DEA models have been proposed in the literature. Essentially, each of these various models seek to establish which of $n$ DMUs determine the envelopment surface, or best practice efficiency frontier. The geometry of this envelopment surface is prescribed by the specific DEA model employed.

First, assume that there are $n$ banks to be evaluated. Each bank utilizes varying amounts of $m$ different inputs to produce $s$ different outputs. Specifically, bank $j$ uses amounts $X_j = \{x_{ij}\}$ of inputs $I = 1,\ldots,m$ and produces amounts $Y_j = \{y_{rj}\}$ of outputs $r = 1,\ldots,s$. We assume that the observed values are positive, so that $x_{ij} > 0$ and $y_{rj} > 0$. The $s \times n$ matrix of output measures is denoted by $Y$ and the $m \times n$ matrix of input measures is denoted by $X$.

In this study, we use a constrained-multiplier, CCR input-oriented DEA model to reduce the multiple-input, multiple-output situation for each bank to a scalar measure of efficiency. Consider the following ratio form of the model:

$$\begin{align*}
\text{Max} & \quad \frac{\sum v_{ik} x_{ik}}{\sum v_{ik} x_{ik}} \\
\text{subject to:} & \quad \frac{\sum u_{rk} y_{rj}}{\sum v_{ik} x_{ik}} \leq 1 \quad ; j = 1,\ldots,n. \\
& \quad \sum u_{rk} > \varepsilon \quad ; r = 1,\ldots,s. \\
& \quad \sum v_{ik} > \varepsilon \quad ; i = 1,\ldots,m. \\
& \quad \varepsilon > 0
\end{align*}$$

This model evaluates the relative efficiency of bank $k$ based on the performance of $j = 1,\ldots,n$ banks in the population, where the $y_{rj}$ and $x_{ij}$ variables in the model represent
the observed amounts of the $r^{th}$ output and the $i^{th}$ input, respectively, of the $j^{th}$ bank. Thus, the multiple-input/multiple output ratio being maximized in the objective function provides a measure of relative productive efficiency that is a function of the multipliers.

The multipliers are the unit weights for each of the outputs and inputs, designated by $u_{rk}$ and $v_{ik}$, respectively. These are the decision variables in the model, so that the objective function seeks to maximize the ratio of the total weighted output of bank $k$ divided by its total weighted input. For the constrained multiplier model, these weighted must be within an established range specified by the analyst. The $ε > 0$ in the model represents a non-Archimedean constant that is smaller than any positive-value real number.

Each bank’s maximum efficiency score will be less than or equal to 1 by virtue of the constraints. A value of $EFF_k = 1$ represents full efficiency and it follows that bank $k$ is a best practice bank. When $EFF_k < 1$, then some level of inefficiency is present. Bowlin (1998) states that these efficiency values provide not only a way to benchmark productive efficiency, but also make it possible to identify the sources and amounts of inefficiency in each input and output for every unit evaluated.

The fractional linear programming problem presented above can be transformed into an equivalent ordinary linear programming problem. The results of this transformation, which are described in Charnes, Cooper and Rhodes (1978) results in the following linear programming problem:

Max $EFF_k = ∑u_{rk}y_{rk}$

subject to: $∑u_{rk}y_{rj} - ∑v_{ik}x_{ij} \leq 0$

$∑v_{ik}x_{ik} = 1$

$-u_{rk} \leq -ε$

$-v_{ik} \leq -ε$
This formulation, while equivalent to the fractional problem presented earlier, can be interpreted as maximizing the sum of the weighted outputs (virtual output) for bank $k$ subject to unit virtual input for bank $k$ while maintaining the condition that virtual output cannot exceed virtual input for any bank. Charnes et al. (1985) note that this implies the conditions for Pareto optimality. These further increases in this value can be attained only if some of the $x_{ij}$ inputs are increased or if some of the $y_{ij}$ outputs are decreased.

The weights (the $u_{rk}$’s and $v_{lk}$’s) in the DEA model are specified to be within some prescribed range as stated in the Siems and Barr (1998) study. These upper and lower bounds were determined through a survey of experienced bank examiners regarding their knowledge of factors that are important in judging bank management quality. This survey was administered to 12 senior bank examiners at the Federal Reserve Bank of Dallas. The survey was intended to identify the correct set of the most important inputs and outputs, and then evaluate the importance of each variable in relation to the others. Examiners were asked “Which of the given list of criteria are most important in judging and influencing the quality of bank management?” The constraints for the model’s multipliers (weights) are as follows:

Table 1: Constraints for the Multipliers (Weights) in the DEA Model

<table>
<thead>
<tr>
<th>Input ($u_{rk}$)</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salary Expense</td>
<td>15.8%</td>
<td>35.9%</td>
</tr>
<tr>
<td>Operating Expense</td>
<td>3.1%</td>
<td>15.7%</td>
</tr>
<tr>
<td>Other Non-interest Expense</td>
<td>15.8%</td>
<td>35.9%</td>
</tr>
<tr>
<td>Interest Expense</td>
<td>17.2%</td>
<td>42.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output ($v_{lk}$)</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earning Assets</td>
<td>40.9%</td>
<td>69.5%</td>
</tr>
<tr>
<td>Interest Income</td>
<td>25.7%</td>
<td>46.9%</td>
</tr>
<tr>
<td>Non-interest Income</td>
<td>10.2%</td>
<td>20.2%</td>
</tr>
</tbody>
</table>

The DEA software that we use in this study is the Frontier Analyst® which takes a number of inputs and outputs, and performs a DEA analysis (using linear programming) to determine the relative efficiency of the firms processing the inputs and outputs. Some
of the firms will be deemed to be efficient and may be considered as representing the best practice firms. The software tries to optimize the rating of the other firms. This results in data about how much each firm needs to improve if it is to match the best performers. Typically, an inefficient firm will be trying to match characteristics from more than one efficient firm.

IV. Data and Hypotheses

The data used in this study are taken from the Stock Exchange of Thailand (SET) database which contains balance sheet and income statement for Thai commercial banks. We use year-end data for Thai commercial banks from 1990 to 2003. To evaluate productive efficiency, we incorporate the constrained-multiplier, input-oriented DEA model described in Siems and Barr (1998). This four-input, three-output model captures the essential financial intermediation functions of a bank and uses variables employed in similar studies (see Berger and Mester (1997)). Specifically, the model approximates the bank management decision-making process by incorporating the necessary input allocation and product mix decisions needed to attract deposits and make favorable loans and investments.

The four inputs generally represent resources required to operate a bank: salary and personnel expenses, operating expenses (on equipment, building, machinery, etc.), other non-interest expenses, and interest expenses. The three outputs primarily represent desired outcomes: earning assets, interest incomes, and non-interest incomes. All input and output variables are presented in percentage of total assets. Using this model, banks allocate resources and control internal processes by effectively managing their employees, facilities, expenses, and sources and uses of funds while working to maximize earning assets and total income. Banks that do the best (the best practice
banks) are on the efficient frontier. Banks with too much input or too little output relative to some subsets of their peers are productively inefficient to some extent.

As stated earlier, we employ a constrained-multiplier model which requires that the weights (the $u_{ik}$’s and $v_{ik}$’s) be within some prescribed range as shown in Table 1. Similar to Berger and Humphrey (1997), the four of input variables used in the model have relatively equal importance; only operating expenses (on equipment, building, machinery, etc.) has a much lower average weight range. For the three of output variables, earning assets is clearly the most important, followed by interest income and then non-interest income.

Overall hypothesis in this study is that more efficient institutions differ significantly from less efficient institutions in measurable way, and these results can be used for benchmarking. We expect that more efficient institutions tend to have lower salary and personnel expenses, operating expenses, other non-interest expenses and interest expenses. More efficient institutions also tend to have higher interest incomes, non-interest incomes and earning assets.

The 14-year range (1990-2003) of our data includes periods that were both profitable and difficult for financial institutions in Thailand. We are also interested in seeing if these changing conditions have different impacts on the performance measures of institutions of varying efficiencies. Our overall hypothesis in this regard is that more difficult banking conditions are likely to intensify the differences between more and less efficient institutions, while improved conditions are likely to close the gap between efficiency levels. To examine the data across time, we designate the first eight years pre-crisis from 1990 to 1997 of our study as “good” years in the Thai financial services industry, and the final six years post-crisis from 1998 to 2003 as “bad”.
V. Empirical Results

The DEA model was applied to publicly available year-end data reported by Thai commercial banks from 1990 to 2003. Table 2 and Figure 1 present a summary of the efficiency of Thai commercial banks across the study period separated by the three categories of bank’s ownership structure. An analysis of Thai banks efficiency reveals interesting differences among bank’s ownership. In most of the years, the Thai-owned banks and government-owned banks are most efficient, and the foreign-owned banks are less efficient at 5% level of significance. The differences of banks efficiency between Thai-owned banks and foreign-owned banks become wider after the 1997 Economic Crisis. However, the difference between Thai-owned banks and government-owned banks are not statistically significant at the 5% level. These may result from the fact that most of foreign-owned banks are the local-owned banks who were in a difficult situation before taken over by foreign investors or institutions. Therefore, the result does not imply that foreign-owned banks operate in poor management manner but that the efficiency was deteriorated before the 1997 Economic Crisis.

[Insert Table 3 here]
[Insert Figure 1 here]

As can be seen from the last column of Table 3 for the whole period of 1990-2003, Thai-owned banks have the highest average efficiency of 96.40%, followed by government-owned and foreign-owned banks with the average efficiencies of 93.0% and 86.44%, respectively. For the pre-crisis (good) period during 1990-1997, Thai-owned banks also have the highest average efficiency of 98.16%, followed by government-owned and foreign-owned banks with the average efficiencies of 94.5% and 92.16%, respectively. Interestingly, for the post-crisis (bad) period during 1998-2003, the ranking of the average efficiency scores are the same as that of the pre-crisis period. That is, Thai-
owned banks still rank first, government-owned banks rank second, and foreign-owned banks rank third.

To see the effect of the 1997 Economic Crisis on Thai commercial banks efficiency, we perform paired t-test on the average efficiency scores of the pre-crisis versus the post-crisis periods for each individual bank. The results indicate that banks efficiency scores after the 1997 Crisis are significantly lower than those before the crisis at the 5% level of significance. We obtain consistent results when we perform similar tests on average efficiency scores of the three categories of bank ownership structure. Moreover, the evidence indicates that the least efficient banks, including small and foreign-owned, are affected the most by the 1997 Crisis. That is, they have the deepest drop in the efficiency scores comparing to the other two groups.

To isolate the relative input and output characteristics of banks for further analysis, the commercial banks are separated into quartiles by their derived efficiency scores as reported in Table 3 and Figure 2. The important concern for this study was to evaluate the reliability of the DEA model over time. In other words, we would like to see whether the estimated efficiency scores perform as a consistent measure. A t-test of the efficiency scores reveals that in each year of the study the differences between means of the most and the least efficient groups are significant at the 5% level, suggesting a level of differentiation that permitted us to regard differences between the efficiency-ranked quartiles as meaningful. The level of statistical significance is also observed when comparing the means of each adjacent efficiency score quartile (except for the 2nd and 3rd quartiles the differences of which are not significant at the 5% level), suggesting that our convention of quartile-based analysis is appropriate.

[Insert Table 3 here]
[Insert Figure 2 here]
To segregate the relative input and output characteristics of banks for further analysis, the banks are separated into two types of category which are; 1) asset size (large size banks, medium size banks and small size banks)\(^3\) and 2) ownership structure (Thai-owned banks, foreign-owned banks, and government-owned banks). These two banks categories serve as a basis for our comparison between bank size and ownership structure with bank efficiency. In addition, these bank categories serve for comparison of bank size and ownership structure with the DEA model’s individual inputs (i.e. salary expense, operating expense, interest expense and other non-interest expenses) and outputs (earning assets, interest income, and non-interest income).

[Insert Figure 3 here]

An analysis of Thai banks efficiency by banks’ asset size also reveals interesting differences among banks’ size. In each year of the study, the larger institutions are more efficient, while the smaller are less efficient at the 5% significant level, as displayed in Figure 3. Further, the relative positions of the means of the large banks and the small banks remain statistically significant and rank distinct across the 14 years of the study. This result seems to underscore the potential for greater inefficiencies in the operation of smaller Thai commercial banks and also the advantage of economy of scales for the large banks.

\(^3\) We define banks’ asset size into 3 classes which are (1) large banks whose assets are more than 500,000 million bath (Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank), (2) medium size banks whose assets are between 120,000 to 500,000 million bath (Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai), and (3) small banks whose assets are less than 120,000 million bath (Bank of Asia, DBS Thai Danu, Standard Charter Nakornthon, and UOB Rattanasin).
A. Salary and Personnel Expenses V.S. Bank Efficiency

[Insert Figure 4 here]

Figure 4 panels A and B present the percentage of salary and personnel expenses to total assets separated by bank size and bank ownership. The evidence indicates that Thai banks efficiency is a reliable covariant with asset-weighted salary expense for the 14 years of our study. That is, the more efficient banks, which are large and Thai-owned banks, incur significantly lower percentage of salary and personnel expenses to total assets than the least efficient banks, which are small and foreign-owned banks, across that time. The difference between the most efficient banks and the least efficient banks is significant at the 5% level throughout the study period. From 1990 to 1998, salary expense as a percentage of total assets of both the most efficient and the least efficient banks trends gradually downward. From 1998 to 2003, the most efficient banks have steady percentage of salary and personnel expenses while the least efficient banks have upward trends.

The first eight years before the crisis seems consistent with our hypothesis i.e. the most efficient banks were the best at containing costs, in this case, salary and personnel expenses. The last five years results after the crisis are also clear that the least efficient banks control salary and personnel expenses less efficiently. The increase in percentage of salary and personnel expenses may be that the less efficiently managed banks have an early-retirement program to downsize the organization and also start paying higher salary to attract and retain better-qualified employees in a high competitive labor environment. Moreover, the small and foreign-owned banks’ total assets were reduced after the crisis while the salary and personnel expenses remained the same. Therefore, the percentage of salary and personnel expenses to total assets increased. At the same time, a lack of growth in salary expense among the most efficient banks may be indicative of efforts to
contain or attempt to reduce expenses in order to improve operating efficiencies and profitability.

B. Operating Expenses V.S. Bank Efficiency

[Insert Figure 5 here]

As shown in Figure 5 panels A and B, in each of the 14 years, the most efficient banks which are the large and Thai-owned banks have significantly lower percentage of operating expenses to total assets than do the least efficient banks which are the small and foreign-owned banks at the 5% significant level. These results are consistent with our expectation that the minimizing of operating expenses is among the characteristics that distinguish more efficient banks.

C. Other Non-interest Expense V.S. Bank Efficiency

[Insert Figure 6 here]

Figure 6 panels A and B present the percentage of other non-interest expenses to total assets separated by bank size and bank ownership. The evidence indicates that other non-interest expense (comprised of non-interest expenses excluding salary expenses) of the most efficient banks, which are the large and Thai-owned banks, are significantly less than the least efficient banks, which are the small and foreign-owned banks, at the 5% level of significance for all 14 years. On the other hand, there is no statistically significant difference between other non-interest expense of foreign-owned banks and government-owned banks at the 5% level of significance. The difference between the most and least efficient institutions trends moderately toward zero, for example,
economic conditions seem to have a dramatic effect on other non-interest expenses only for a short duration after the crisis.

D. Interest Expense V.S. Bank Efficiency

[Insert Figure 7 here]

As shown in Figure 7 panels A and B, almost consistent relationship is evident between bank efficiency and interest expense for both classifications by bank size and bank ownership. There appears to be a tendency for less efficient banks to have higher percentage of interest expenses to total assets compare to more efficient banks. The difference in interest expense between the most and least efficient banks is statistically significant at the 5% level. However, the paired t-test shows no statistically significant differences between the medium size banks and the small banks’ interest expenses. In 13 of these 14 years, the least efficient banks incurred higher average interest expenses than the most efficient banks, and in the only one year, the least efficient banks actually incurred the same average interest expenses as the most efficient banks in this study. The overall results seem to indicate the highly competitive nature of banks’ interest rate management. In line with our expectations, more and less efficient banks become less distinct on the interest expense measure after the 1997 economic shift. With very few exceptions, year-to-year changes in interest expense move in the same direction for both classifications of banks for each year of the study.
E. *Earning Assets V.S. Bank Efficiency*

[Insert Figure 8 here]

As Figure 8 panels A and B show, the differences in the percentage of earning assets to total assets between banks are dynamic over time. In the year before the 1997 Crisis, the least efficient banks have no statistically significant difference levels of earning assets than the most efficient banks at the 5% level of significance. The large, medium and small size banks have almost equivalent percentage of earning assets to total assets which is also the case for Thai-owned, foreign-owned and government-owned banks. However, during the years after the 1997 Crisis, the difference of more efficient banks and less efficient banks is clearer. The least efficient banks seem to have lower level of earning assets than those of the most efficient banks. Even though for the whole period of the study, the difference of earning assets to total assets between the most efficient banks and the least efficient banks are not statistically difference at the 5% level.

F. *Interest Income V.S. Bank Efficiency*

[Insert Figure 9 here]

As shown in Figure 9 panels A and B, there appears to be no consistent relationship between bank efficiency and interest income. However, of the 14 years under study, the difference between the most and least efficient banks is significant in five years after the 1997 Crisis (1999 to 2003). In these five years, the most efficient bank has higher interest income than that of the least efficient bank. The four-year period identified as the height of the banking crisis (1997-2000) witnessed two of the four years (1999-2000) of greatest difference in interest income between the most and least efficient banks.
After 2002, however, the difference between the most and least efficient banks on this output measure tends to be steady.

G. Non-interest Income V.S. Bank Efficiency

[Insert Figure 10 here]

Figure 10 panels A and B present the percentage of non-interest income to total assets separated by bank size and bank ownership. In each of the 14 years of our study, the least and the most efficient banks have no statistically significant differences in non-interest income at the 5% significant level. This finding suggests that there is no statistical evidence of Thai banks efficiency depends significantly on the non-interest income output. In other words, there is highly fluctuation in the nature of this income due to intense competition in this service-based income especially for the medium and small sized banks, and the government-owned and foreign-owned banks. This also suggests that less efficient financial institutions are more willing to increase earning by emphasizing this output.

VI. Conclusion

In this study, we employ a constrained-multiplier, input-oriented DEA model to evaluate the relative productive efficiency of commercial banks in Thailand across a 14-year period (1990-2003). The DEA model offers numerous benefits, including the ability to target areas of relative efficiency between banks. Perhaps most importantly, it allows an analysis of multiple aspects of a financial institution’s performance, unlike more common benchmarking methodologies that are focused only on one of many interrelated measures at a time. The DEA creates an analysis that is broader without sacrificing depth
of insight, and more pertinent and hence applicable to the real-world operations of complex financial institutions.

We divide Thai commercial banks into two categories which are bank’s assets size and bank’s ownership structure and analyze them based on their DEA-derived efficiency scores. We find that in each year of our 14-year review, the large and Thai-owned banks have statistically significantly higher efficiency scores than those of the small and foreign-owned banks. Additionally, there is a rank-distinct relationship between Thai banks’ efficiency on the salary and personnel expenses and operating expenses (both inversely related to efficiency), as well as on the earning assets (positively related to efficiency), particularly after the 1997 Economic Crisis. The relationship between efficiency and interest income and expense is not as pervasive, perhaps as a result of market competition, but there is still a noticeable tendency for efficiency to be positively correlated with interest income and negatively related to interest expense.

The differences of bank efficiency are much clearer after the 1997 Crisis that the least efficient banks’ efficiency were deteriorated much faster in terms of higher expenses and lower incomes. Overall efficiency of Thai commercial banks had decreased by 3% to 13% after the 1997 crisis. The least efficient banks which are small and foreign-owned banks are the most affected by the 1997 Crisis and their efficiency are reduced the most. Perhaps the least efficient banks have the most room for improvement, which enables them to impact their situation more effectively and recover more grounded as banking conditions improve. Besides, as the Thai banking industry consolidated and became more competitive, the differences in performance between the most and the least efficient banks would be expected to narrow. Thai banks can employ DEA models internally to benchmark their own input and output parameters with the peer group and find potential areas for improvement.
Table 2: Efficiency Scores of Thai Commercial banks by Ownership Structure

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Note:  
A). Thai-owned banks are the banks whose major shareholders are Thai and no major foreign shareholder of more than 51%.  
B). Foreign-owned banks are the banks whose major shareholders are foreign entities (more than 51%).  
C). Government-owned banks are the banks that belong to and under management of Thai government.
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<td>82.55</td>
<td>80.55</td>
<td>84.86</td>
<td>95.40</td>
<td>84.09</td>
<td>86.40</td>
<td>74.25</td>
<td>43.58</td>
<td>90.98</td>
<td>81.80</td>
<td>90.28</td>
<td>77.88%</td>
<td>81.43%</td>
</tr>
<tr>
<td>12</td>
<td>UOB Rattanasin</td>
<td>88.89</td>
<td>100.00</td>
<td>88.43</td>
<td>83.43</td>
<td>79.73</td>
<td>100.00</td>
<td>84.40</td>
<td>79.30</td>
<td>88.02</td>
<td>48.12</td>
<td>44.93</td>
<td>45.53</td>
<td>65.20</td>
<td>84.11</td>
<td>79.90</td>
<td>61.30%</td>
<td>76.57%</td>
</tr>
<tr>
<td>D. The Least Efficient Group</td>
<td>88.30</td>
<td>91.03</td>
<td>81.99</td>
<td>81.67</td>
<td>82.67</td>
<td>89.10</td>
<td>84.45</td>
<td>88.47</td>
<td>85.96</td>
<td>64.06</td>
<td>73.06</td>
<td>63.04</td>
<td>85.39</td>
<td>86.79</td>
<td>79.51</td>
<td>75.31%</td>
<td>81.40%</td>
<td></td>
</tr>
</tbody>
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Note: Ranking of the banks is based on the average bank’s efficiency for the whole study period (last column).
Figure 1: Average Efficiency Scores of Thai Commercial Banks by Ownership Structure

- Thai-owned Banks Efficiency
- Government-owned Banks Efficiency
- Foreign-owned Banks Efficiency

Note:  
A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.  
B) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu.  
C) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank Thai.

Figure 2: Average Efficiency Scores of Thai Commercial Banks by Quartile Ranking

- Most Efficient Banks  
- The 2nd Quartile  
- The 3rd Quartile  
- The Least Efficient Banks

Note:  
A) The most efficient group is Siam Commercial Bank, Bangkok Bank, and Krung Thai Bank.  
B) The 2nd quartile is Siam City Bank, Bank of Asia, and Thai Military Bank.  
D) The least efficient group is Bank Thai, DBS Thai Danu, and UOB Rattanasin.
Figure 3: Average Efficiency Scores of Thai Commercial Banks by Bank Size

Note: (1) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank.
(2) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai.
(3) Small banks: Bank of Asia, DBS Thai Danu, Standard Charter Nakornthon, and UOB Rattanasin.
Figure 4: Salary and Personnel Expenses and Bank Efficiency

Panel A: Salary & Personnel Expenses by Bank Size

Note:  
A) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank.  
B) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai  
C) Small banks: Bank of Asia, DBS Thai Danu, Standard Chartered Nakornthon, and UOB Rattanasin.

Panel B: Salary & Personnel Expenses by Bank Ownership

Note:  
A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.  
B) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank Thai.  
C) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu.
Figure 5: Operating Expense and Bank Efficiency

Panel A: Graph of Operating Expenses by Bank Size

Panel B: Operating Expenses by Bank Ownership

Note: A) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank.
B) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai
C) Small banks: Bank of Asia, DBS Thai Danu, Standard Chartered Nakornthon, and UOB Rattanasin.

Note: A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.
B) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank Thai.
C) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu.
Figure 6: Other Non-Operating Expense and Bank Efficiency

Panel A: Other Non-Operating Expenses by Bank Size

Panel B: Other Non-Operating Expenses by Bank Ownership

Note: A) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank.
B) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai.

Note: A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.
B) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank Thai.
C) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu
Figure 7: Interest Expenses and Bank Efficiency

Panel A: Interest Expenses by Bank Size

Panel B: Interest Expenses by Bank Ownership

Note: A) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank.
B) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai.

Note: A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.
B) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank Thai.
C) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu
Figure 8: Earning Assets and Bank Efficiency

Panel A: Earning Assets by Bank Size

Note: A) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank.
B) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai.

Panel B: Earning Assets by Bank Ownership

Note: A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.
B) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank Thai.
C) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu
Figure 9: Interest Incomes and Bank Efficiency

Panel A: Interest Incomes by Bank Size

Note: A) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank. 
B) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank That. 
C) Small banks: Bank of Asia, DBS Thai Danu, Standard Chartered Nakornthon, and UOB Rattanasin.

Panel B: Interest Incomes by Bank Ownership

Note: A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya. 
B) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank That. 
C) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu.
Figure 10: Non-Interest Incomes and Bank Efficiency

Panel A: Non-Interest Incomes by Bank Size

Panel B: Non-Interest Incomes by Bank Ownership

Note: A) Large banks: Bangkok Bank, Krung Thai Bank, Kasikorn Bank, and Siam Commercial Bank.
B) Medium banks: Bank of Ayudhya, Thai Military Bank, Siam City Bank, and Bank Thai.

Note: A) Thai-owned banks: Bangkok Bank, Siam Commercial Bank, Thai Military Bank, Kasikorn Bank, and Bank of Ayudhya.
B) Government-owned banks: Krung Thai Bank, Siam City Bank, and Bank Thai.
C) Foreign-owned banks: Bank of Asia, Standard Chartered Nakornthon, UOB Rattanasin, and DBS Thai Danu
References


