Technical and Scale Efficiencies of Thai Commercial Banks after the 1997 Financial Crisis

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ABSTRACT

This paper studies technical and scale efficiencies of Thai commercial banks during the post financial crisis period from year 1997 to 2006. The data envelopment analysis is used to measure technical, pure technical, and scale efficiencies of each bank. The overall average technical efficiency is measured to be 90.73 percent. The results indicate that the average pure technical efficiency is greater than the average scale efficiency for most of the years, which suggests that the technical inefficiency of Thai commercial banks is mainly due to the scale inefficiency rather than pure technical inefficiency. Further, decreasing returns to scale is found to be the dominant source of scale inefficiency. The relationships between efficiencies and bank characteristics are also investigated in the study. Banks with higher foreign ownership usually have lower technical, pure technical and scale efficiencies. Large banks have lower technical and scale efficiencies than small banks. Older banks have higher technical and scale efficiencies. Private- and government-owned banks have nearly the same levels of technical, pure technical and scale efficiencies.

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1. Introduction

In year 2004, the Ministry of Finance and Bank of Thailand issued the Financial Sector Master Plan. This is another regulation issued after the 1997 financial crisis. One goal of the new plan aims at improving the efficiency of Thai financial institutions. Under the new regulation, each financial institution is able to apply for commercial banking or retail banking licenses. Obviously, these two are operating at different scales. Hence, the Thai financial institution must choose its optimal operating scale. This motivates the author to study the efficiency, especially the scale efficiency of the current Thai commercial banks.

The contribution of the paper is that it studies the scale efficiency of Thai commercial banks from a different point of view. In this paper, scale efficiency is viewed as one component of the technical efficiency. Therefore, this is the first paper that decomposes the Thai commercial bank's technical efficiency into pure technical efficiency and scale efficiency.

This paper applies the data envelopment analysis to measure and decompose the technical efficiency of Thai commercial banks. The study period is 1997-2006, which includes the financial crisis period and post crisis period. After the bank is identified as scale inefficient, the paper also investigates the sources of the scale inefficiency. The possible sources are decreasing returns to scale and increasing returns to scale.

The final part of the paper studies the correlation between technical efficiency, pure technical efficiency, or scale efficiency and possible correlated factors. Eight factors are selected to run the OLS regression. The crisis period dummy, foreign ownership dummy, large and medium size dummies, age of the bank, private-owned bank dummy, and the bank's return on assets and return on equity.

The rest of the paper is organized as follows. Section two reviews the literature. Section three describes the methodology and data. Empirical results are discussed in section four. Section five concludes.

2. Literature Review

Since the data envelopment analysis (DEA) appeared in the literature (Charnes, Cooper and Rhodes, 1981; Banker, Charnes and Cooper, 1984), it has been widely applied in different fields (Gattoufi, Oral, Kumar and Reisman, 2004). It has also gained much attention in the financial area (Berger and Humphrey, 1997).

Many papers apply the DEA in measuring the X-efficiency of financial institutions, whereas not many papers investigate the decomposition of the banking efficiency. Only countable papers decompose the bank efficiency into technical and scale efficiencies. The DEA is commonly used to decompose the overall technical efficiency into pure technical efficiency and scale efficiency.

The efficiency of Turkish banking industry over the 1988-1996 period is studied by Isik and Hassan (2002). The results point out that the dominant source of the technical inefficiency in Turkish banking industry is the scale inefficiency rather than the pure technical inefficiency. The overall technical, pure technical and scale efficiencies of the banking industry over 1988-1996 are 0.816, 0.920 and 0.883 respectively. Further the main source of scale inefficiency is found to be that the majority of Turkish banks have increasingly experienced decreasing returns to scale. A second-stage correlates of efficiency analysis is also conducted in the paper. For instance, the bank size and scale efficiency are found to be strongly negatively related.

Fukuyama (1993) studies the technical and scale efficiencies of Japanese commercial banks. The efficiency scores are measured for a sample of cross-sectional data in 1990. The mean technical, pure technical and scale efficiencies are found to be 0.8509, 0.8645 and 0.9844 respectively. This indicates that the main source of the technical inefficiency is from the pure technical inefficiency rather than the scale inefficiency. It is found that most banks experience increasing returns to scale.

Aly, Grabowski, Pasurka and Rangan (1990) investigate the efficiencies of 322 U.S. independent banks for year end 1986. The results show that the

overall technical efficiency of the sample is at a low level of 75 percent. The pure technical and scale efficiency components are at 77 percent and 97 percent levels respectively. It implies that the important source of technical inefficiency is from the pure technical inefficiency rather than the scale inefficiency, which is similar to the result of Japanese banks (Fukuyama, 1993). Further analysis indicates that the size is significantly positively related to the pure technical efficiency.

A few papers have studied Thai commercial banks with the DEA approach. For instance, Leightner and Lovell (1998) use the DEA to investigate the productive efficiency of both Thai and foreign commercial banks operating in Thailand over the 1989-1994 period. Chunhachinda and Srisawat (2007) apply a constrained multiplier, input-oriented DEA to evaluate the productive efficiency and performance of 12 Thai commercial banks over the 1990-2003 period. Large Thai-owned banks are found to be the most efficient while the small foreign-owned banks are the least efficient. Li (2007) measures and compares the DEA efficiencies of Thai commercial banks over the period 1990 - 2005. It is found that efficiency levels of the post-crisis period are significantly lower than those of the pre-crisis period. Cost, allocative and technical efficiencies of Thai commercial banks over the period 2001-2006 are studied by Li (2008). The cost efficiency is decomposed into allocative and technical efficiencies using the DEA technique. The average cost, allocative and technical efficiencies are 79.75%, 88.42% and 90.10% respectively. Further, relationships between three efficiencies and bank characteristics such as age, size, foreign ownership, return on assets and return on equity are also studied in the paper. To the author's knowledge, none of the papers has examined the scale efficiency of Thai commercial banks using the DEA approach.

3. Methodology and Data

3.1 Efficiency measurement

The technical efficiency is first measured, then it is decomposed into pure technical efficiency and scale efficiency. The DEA approach is utilized to measure and decompose the technical efficiency.

The technical efficiency of a particular bank is calculated relative to the frontier which is based on the assumption of constant returns to scale. Two outputs and three inputs are selected to construct the frontier. The selection criterion is based on the assumption that the bank's basic activity is intermediation (Sealey and Lindley, 1977). Therefore two outputs are selected as loans (net of allowances for doubtful accounts) and other earning assets (total earning assets minus loans). Three inputs are chosen as number of employees, physical capital and total liabilities. The linear programming problem is constructed as follows:

$$\begin{aligned} \min \quad & T_B \\ \textit{subject to} \quad & \sum_{n=1}^{N} x_{in}\lambda_n \le T_B x_{iB} \qquad i = 1, 2, 3 \\ & \sum_{n=1}^{N} y_{jn}\lambda_n \ge y_{jB} \qquad j = 1, 2 \\ & \lambda_n \ge 0 \qquad\qquad n = 1, \ldots, N \end{aligned} \tag{1}$$

In the above problem, T_B is the technical efficiency score of a particular bank B which is being studied; x_{in} is the i^{th} input of the n^{th} bank; $_1$ to $_N$ is the scalar vector representing the weights of each bank observation during the year; y_{jn} represents the j^{th} output of the n^{th} bank; and N is the number of banks observed in a year, which is ranged from 11 to 14. Each bank's technical efficiency score is measured annually. Thus, technical efficiency score of 1 represents the best-practice bank during the year.

To decompose the technical efficiency into pure technical and scale efficiency, another frontier needs to be constructed. The pure technical

efficiency of a particular bank is calculated relative to the frontier that is based on the assumption of variable returns to scale. Two outputs and three inputs are selected the same as the above problem to construct the frontier. The linear programming problem is as follows:

$$
\begin{aligned}
\min \quad & PT_B \\
\textit{subject to} \quad & \sum_{n=1}^{N} x_{in}\lambda_n \le PT_B x_{iB} \qquad i = 1, 2, 3 \\
& \sum_{n=1}^{N} y_{jn}\lambda_n \ge y_{jB} \qquad j = 1, 2 \qquad (2) \\
& \sum_{n=1}^{N} \lambda_n = 1 \qquad n = 1, ..., N \\
& \lambda_n \ge 0 \qquad n = 1, ..., N
\end{aligned}
$$

where PT_B is the pure technical efficiency score of a particular bank B which is being studied; x_{in} is the i^{th} input of the n^{th} bank; $_1$ to $_N$ is the scalar vector representing the weights of each bank observation during the year; y_{jn} represents the j^{th} output of the n^{th} bank; and N is the number of banks observed in a year, which is ranged from 11 to 14. Each bank's pure technical efficiency score is measured annually. Hence, pure efficiency score of 1 represents the best-practice bank during the year.

To measure each bank's scale efficiency, the following equation is used:

$$S_B = T_B / PT_B \qquad (3)$$

where S_B is the scale efficiency of the particular bank B; it is the ratio of the bank's technical efficiency to the bank's pure technical efficiency. S_B score of 1 indicates that the bank is scale efficient and it is operating at constant returns to scale, whereas the score below 1 represents the scale inefficiency.

To investigate the possible source of scale inefficiency, a further linear programming problem is solved to construct another frontier which is based on the assumption of non-increasing returns to scale.

$$
\begin{aligned}
\min \quad & NIRS_B \\
subject\ to \quad & \sum_{n=1}^{N} x_{in}\lambda_n \le NIRS_B x_{iB} \qquad i = 1, 2, 3 \\
& \sum_{n=1}^{N} y_{jn}\lambda_n \ge y_{jB} \qquad j = 1, 2 \qquad (4) \\
& \sum_{n=1}^{N} \lambda_n \le 1 \qquad n = 1, ..., N \\
& \lambda_n \ge 0 \qquad n = 1, ..., N
\end{aligned}
$$

where $NIRS_B$ is the scalar of bank B relative to the non-increasing returns to scale assumption; B represents the particular bank that is being studied; if $NIRS_B = T_B$, then the source of scale inefficiency of bank B is due to decreasing returns to scale; and if $NIRS_B > T_B$, then the source of scale inefficiency of bank B is due to increasing returns to scale;

All of the above linear programming problems are solved by using the DEA computer program DEAP version 2.1 (Coelli, 1996).

3.2 Correlated factors

After the technical, pure technical and scale efficiencies of each bank are measured, the correlated factors (bank characteristics) are studied to investigate the correlation between each efficiency score and correlated factors. OLS is applied to run the regression.

There are eight factors selected: crisis, foreign, large, medium, age, private, return on assets (ROA), and return on equity (ROE). Crisis is the dummy that is equal to 1 if the bank observation is in year 1997 to 2000, and 0 otherwise. This dummy is included to control the financial crisis bias. Dummy

foreign is taken into account due to the changes of foreign ownership of Thai commercial banks. It is equal to 1 if the foreign ownership of the bank is equal to or higher than 50 percent, and 0 otherwise. Different degrees of foreign ownership may lead to different efficiency levels. Large and medium are two size dummies. Banks are classified into three groups based on their assets sizes: large, medium and small. Banks with different sizes may have different scale and technical efficiency levels. Age is the natural logarithm of the age of the bank. This variable is included to study whether the efficiency level is related to the age of the bank. Private dummy is equal to 1 if the bank is privately owned and 0 if the bank is government-owned. This variable can show whether the private- and government-owned banks have the same efficiency levels. Finally, ROA and ROE are included to study the correlation between the efficiency level and the bottom line of the bank.

3.3 Data

The bank specific data are compiled from Commercial Banks in Thailand (Bangkok Bank, 1997 to 2007), and the website page www.setsmart.com.

The year end balance sheet items are collected from year 1996 to 2006, then the year averages of each item of each bank are computed from its beginning and ending balances. The year averages of each balance sheet item, instead of the year end balances, of each bank will be used in this study. The bank year observations with the negative equity are deleted because the negative equity will cause difficulty of interpreting the ratio of ROE. The income statement items and other variables are collected from year 1997 to 2006. There are altogether 128 bank year observations. The crisis dummy covers the period 1997-2000 since the annual total profit of the banking industry was negative (Li, 2007). There are 49 bank year observations during this period. 79 bank year observations are in period 2001-2006. All of the financial data have been inflation adjusted by the GDP deflator with the base year as 1988 (International Monetary Fund, various issues).

4. Empirical Results

4.1 Efficiency measurement

The annual average technical, pure technical and scale efficiencies of Thai commercial banks are listed in Table 1. The overall average technical efficiency of Thai commercial banks over the period 1997-2006 is 90.73 percent. The pure technical efficiency on average is 97.48 percent. Further the scale efficiency is 93.08 percent on average. It can be seen that after decomposing the technical efficiency into pure technical and scale efficiency, the Thai commercial bank's pure technical efficiency is higher than the scale efficiency for most of the years. This implies that the Thai commercial banks' technical inefficiency is mainly due to the scale inefficiency rather than the pure technical inefficiency, which is consistent with the case of Turkish banks (Isik and Hassan, 2002) and opposite to the cases of Japanese and American banks (Fukuyama, 1993; Aly, Grabowski, Pasurka and Rangan, 1990).

Table 1: Annual average technical, pure technical and scale efficiencies of Thai commercial banks

Year	Technical efficiency	Pure technical efficiency	Scale efficiency
1997	0.952	0.986	0.965
1998	0.936	0.991	0.944
1999	0.897	0.971	0.924
2000	0.882	0.987	0.895
2001	0.888	0.966	0.917
2002	0.871	0.986	0.885
2003	0.872	0.953	0.914
2004	0.932	0.958	0.973
2005	0.950	0.975	0.975
2006	0.893	0.975	0.916
Overall average	**0.9073**	**0.9748**	**0.9308**

Table 2: Sources of scale inefficiency of Thai commercial banks

Year	Number of banks with DRS (Decreasing returns to scale)	Number of banks with CRS (Constant returns to scale)	Number of banks with IRS (Increasing returns to scale)	Total number of banks
1997	8	3	3	14
1998	6	3	2	11
1999	4	4	4	12
2000	5	4	3	12
2001	3	6	4	13
2002	8	4	1	13
2003	9	3	1	13
2004	6	5	1	12
2005	8	6	0	14
2006	9	4	1	14
Total number of banks	66	42	20	128

To investigate the sources of Thai commercial banks' scale inefficiency, Table 2 is constructed to reveal the relevant information. It shows that the main source of scale inefficiency is decreasing returns to scale, and the other source is increasing returns to scale, which is again consistent with the case of Turkish banks (Isik and Hassan, 2002). There are altogether 66 (out of 128) bank year observations having the decreasing returns to scale, and 20 bank year observations having the increasing returns to scale. 42 bank year observations (about 33 percent) have the constant returns to scale, which indicates that only one-third of Thai commercial banks are operating at the socially optimal scale.

4.2 Correlated factors

There are three regressions to test the relationships between efficiencies and bank characteristics. The results of the OLS regression are in Table 3.

The dependent variable is the technical efficiency in the first regression. Five variables are significantly related to the technical efficiency at different significance levels. Foreign is significantly negatively related to the technical efficiency at the 1 percent significance level, which means that the bank with higher foreign ownership usually has lower technical efficiency. The possible reason could be that the bank with higher foreign ownership might have had lower technical efficiency already before its foreign ownership was increased. Large and medium dummies are significantly negatively related to the technical efficiency, which suggests that the small bank has the highest technical efficiency level. Age is positively related to the technical efficiency. The older bank has higher technical efficiency. This can be explained by the notion of learning by doing. ROE is negatively related to the technical efficiency. The higher rate of return on equity is associated with the lower technical efficiency, which could mean that the higher ROE was obtained at higher cost.

The pure technical efficiency is the dependent variable in the second regression. Only two variables are significant in this case. Foreign and ROE are negatively associated with the pure technical efficiency. The same reasons mentioned above can explain these similar results.

When the dependent variable is changed to the scale efficiency in the third regression, there are four variables significant: foreign, large, age and ROA. Foreign is negatively related to the scale efficiency. Banks with higher foreign ownership has lower scale efficiency. Large banks have lower scale efficiency than small banks, which is consistent with the case of Turkish banks (Isik and Hassan, 2002). Age is positively related to the scale efficiency. Older banks have higher scale efficiency. ROA is negatively related to the scale efficiency. Higher return on assets is associated with the higher scale inefficiency.

To summarize, banks with higher foreign ownership usually have lower technical, pure technical and scale efficiencies. Large banks have lower technical and scale efficiencies than small banks. Older banks have higher technical and scale efficiencies. ROE is negatively related to technical and pure technical efficiencies. ROA is negatively related to the scale efficiency.

Table 3: Regression analysis of efficiencies

	Dependent variable		
	Technical efficiency	Pure technical efficiency	Scale efficiency
Independent variables			
C	0.848***	0.961***	0.881***
	(0.000)	(0.000)	(0.000)
CRISIS	-0.023	0.007	-0.029
	(0.355)	(0.457)	(0.227)
FOREIGN	-0.107***	-0.030**	-0.078**
	(0.005)	(0.049)	(0.034)
LARGE	-0.105**	-0.009	-0.098**
	(0.012)	(0.592)	(0.015)
MEDIUM	-0.068*	-0.024	-0.046
	(0.091)	(0.143)	(0.241)
AGE	0.039***	0.007	0.033***
	(0.001)	(0.122)	(0.003)
PRIVATE	0.014	0.006	0.011
	(0.641)	(0.591)	(0.698)
ROA	-0.247	0.018	-0.261*
	(0.119)	(0.779)	(0.090)
ROE	-0.001**	-0.001***	0.000
	(0.049)	(0.000)	(0.752)
R-squared	0.171	0.233	0.120

Note: C is the constant term. Crisis is equal to 1 if the bank observation is in year 1997 to 2000, and 0 otherwise. Foreign is equal to 1 if the foreign ownership of the bank is equal to or higher than 50 percent, and 0 otherwise. Large is equal to 1 if the bank is classified as the

large bank based on its asset size and 0 otherwise. Medium is equal to 1 if the bank is classified as the medium bank based on its asset size and 0 otherwise. Age is the natural logarithm of the age of the bank. Private dummy is equal to 1 if the bank is privately owned and 0 if the bank is government-owned. ROA is the bank's return on asset ratio. ROE is the bank's return on equity ratio. P-values are in parentheses. *, **, and *** indicate significance at the 0.10, 0.05, and 0.01 levels, respectively.

Crisis and private dummies are not significant in any regression. The result of crisis dummy suggests that the cutoff point of year 2000 may be inappropriate from the technical or scale efficiency point of view. The result of private dummy indicates that private- and government-owned banks have nearly the same levels of technical, pure technical and scale efficiencies.

5. Conclusion

This study first uses data envelopment analysis to measure the technical efficiency of Thai commercial banks over the period 1997-2006. The result shows that the overall average technical efficiency of Thai commercial banks is 90.73 percent. Then the technical efficiency of each bank is decomposed into pure technical and scale efficiencies. The overall average pure technical efficiency of Thai commercial banks is 97.48 percent; and the scale efficiency is 93.08 percent on average. It can be concluded that the main reason of the technical inefficiency of Thai commercial banks is the scale inefficiency.

In the next part of the paper, the sources of scale inefficiency of Thai commercial banks are identified through another linear programming problem. The major source is found to be decreasing returns to scale (66 out of 86 cases of scale inefficiency), and the next source is increasing returns to scale (20 out of 86 cases of scale inefficiency). Only one-third of Thai commercial banks are operating at the long-run socially optimal level.

In the final part of the paper, the correlation between the efficiency and possible correlated factors are investigated through the OLS regression. It is found that the bank with higher foreign ownership usually has lower technical, pure technical and scale efficiencies. Large banks have lower technical and

scale efficiencies than small banks. Older banks have higher technical and scale efficiencies. ROE is negatively related to technical and pure technical efficiencies. ROA is negatively related to the scale efficiency. The results also indicate that private-owned and government-owned banks have nearly the same levels of technical, pure technical and scale efficiencies.

The information from this study may be useful for Thai commercial banking regulators and authorities to consider how to encourage Thai commercial banks to operate at the socially optimal level instead of the bank's particular optimal level.

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