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Efficiency analysis of banks in ASEAN countries
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Abstract

Purpose – The purpose of this paper is to explore various efficiency aspects of banks in Association of Southeast Asian Nations (ASEAN) in light of their remarkable growth in recent years.

Design/methodology/approach – The authors used various data envelopment analysis technique to measure the relative efficiency for a sample of 39 banks in four ASEAN countries over 2000-2010.

Findings – The analyses reveal three findings: first, Malaysian banks are more efficient comparatively to the other three ASEAN countries. Second, large-sized banks in ASEAN are less cost efficient. Third, government banks in the ASEAN region exhibit a substantial improvement in efficiency throughout the years, in contrast to the non-government banks.

Originality/value – Efficiency analysis of banks in ASEAN countries, particularly covering this large period, that is, from 2000 to 2010 is very limited, in fact nil. Hence, this paper contributes to the finance and banking areas by providing a detail analysis of banks' performance in the ASEAN region. This paper thus provides powerful insights to policy makers and bank managers in setting appropriate strategy for financial institutions in the region.

Keywords Benchmarking, Banking, DEA, ASEAN, Efficiency, Bank performance

Paper type Viewpoint

1. Introduction

The banking industry is the main channel for monetary transmission and the main source of funds for businesses in the developing countries (Fase and Abma, 2003). Furthermore, an efficient banking system is the key for overall financial development for economic growth in these countries (Andersen and Tarp, 2003). In view of that, evaluating the relative efficiency of banks in the developing countries is thus important. Knowing the performance of their regional counterparts will enable banks to keep themselves at par with their regional competitors. The information also allows the policy makers to formulate appropriate policies and regulation to support the development of the domestic banking industry ahead of their competitors. In the context of Association of Southeast Asian Nations (ASEAN), there are two more distinctive reasons. First, ASEAN is the fourth largest trading region in the world[1]. The competition in the ASEAN banking industry is becoming more intense due to increasing pace of financial market liberalization. Banks which are more efficient will have a niche advantage over the less efficient ones; while the inefficient ones may face failure and eventually driven off the market. Second, the banking industry in ASEAN has also become more integrated, aligned to the objective of achieving 1-ASEAN by 2015. In parallel to the direction of 1-ASEAN to foster greater economic integration among the nations, it is crucial for potential investors who are interested on ASEAN market to know the performance of the banks in the ASEAN region. Despite the fact that such a study is important, there are only a limited studies found in the literature[2]. Our paper aims to fill in this gap.

This paper addresses whether there are significant differences in bank efficiency across the main players in the ASEAN region, that is, Indonesia, Malaysia, the Philippines and Thailand[3]. By comparing bank efficiency across these major economic forces in the ASEAN region, there are two specific questions which we seek

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to answer. One, how do ASEAN banks perform in terms of technical efficiency (*TE*) and cost efficiency (*CE*)? Two, how do bank institutional characteristics, including firm size and ownership type, whether foreign owned or government owned, affects its relative efficiency? These two questions provide insights to the banks, regulators and investors to improve their resource utilization in the industry, as well as across borders.

The contributions of this paper are twofold. First, it contributes in terms of filling up the research gap where past researches on comparative banks studies had mostly focussed on developed countries, that is, the USA and Europe. Since findings for these developed countries might not be directly transferable to countries in other region such as ASEAN due to different institutional arrangements and environment, more work is necessary to obtain a clearer picture of banks' performance in the ASEAN region. Second, this study contributes practically by undertaking a systematic comparison of various types of efficiency of the banking sector in the ASEAN countries. We use a few data envelopment analysis (DEA) techniques to discriminate against various efficiency sources such as technical, operational, scale and cost efficiencies to provide a more indepth analysis of banking performance in the ASEAN region. Our findings would be beneficial to bank managers to adopt appropriate policies to enhance their efficiency. This will help to sustain the banking market in the long run.

The rest of the paper is organized as follows. Section 2 reviews relevant literature. Section 3 explains the DEA technique which we employed, our data and the sources. Section 4 presents empirical analysis. Section 5 discusses the obtained results. Section 6 makes some concluding remarks.

2. Literature review

This section reviews the literature on comparison of bank efficiency across countries. This line of research had been mostly focussed on developed countries and generally they differ in terms of method used in estimating the efficiency and results obtained from the studies. The methods had been revolved around two techniques, that is DEA and stochastic frontier approach.

In the line of DEA approach, Berg *et al.* (1993) applied it to compare banks efficiency across European countries such as Norway, Sweden and Finland. They employed three outputs (i.e. total loans, total deposits and number of branches) and two inputs (i.e. labor, measured in man-hours per year and capital, measured by book values of machinery and equipment). From the results, they found that the largest Swedish banks were the most efficient and they are in the best position to expand in a future common Nordic banking market. Using the same approach, Pastor *et al.* (1997) analyzed the productivity, efficiency and differences in technology of different European and US banking systems. They used loans, deposits and both short-term and equity investment as outputs and non-interest expenses, other than personnel expenses as inputs. Their results suggest that France, Spain and Belgium have the most efficient banking systems, whereas the UK, Austria and Germany have the least efficient. By looking at the productivity indices, they also found that banks in Austria, Italy, Germany and Belgium are more productive than those in the USA, the UK, France and Spain. A few more recent studies also provided cross-country evidence, for example, Casu and Molyneux (2003) examine the large EU banking sector and found that there has been a small improvement in the banking efficiency levels since the EU's Single Market Programme. Lozano-Vivas *et al.* (2002) examine the *TE* differences of commercial banks across ten EU countries using the basic DEA model and later introduced a "complete" DEA model to incorporate other banking

variables. They found that each country's banking behavior are influenced by the country-specific conditions. Beccalli *et al.* (2006) extended the market-based accounting to examine the EU banking sector and found that cost efficient banks tend to outperform their inefficient counterparts in stock market. Pasiouras (2008) examined the technical and scale efficiencies of 95 countries using DEA and found that country-level characteristics will affect the efficiency through its effect on banking institutional development (e.g. bank size and ownership structure). Tanna (2009) used DEA technique to examine efficiency of banks across 75 countries and provided cross-country evidence that banks experience episodes of technical regression and progression.

On the other hand, for the stochastic frontier approach, Fecher and Pestieau (1993) had applied it to evaluate *TE* for the financial services sectors of 11 Organization for Economic Co-operation and Development countries. Employing aggregate value added, net of indirect taxes, as a measure of a country's financial services sector output, employment in the financial services sector and capital as inputs, they found that Japan has the most efficient financial services, while Denmark has the least efficient. Allen and Rai (1997) applied stochastic frontier approach to compare *CE* across 15 developed countries grouped into universal and separated banking. They defined universal banking as integration of commercial and investment banking while separate banking as separation of these two functions. Using two outputs (i.e. traditional banking assets such as loans and investment assets) and three inputs (i.e. labor, capital and borrowed funds), their results showed that large banks in separated banking exhibit the largest measure of cost inefficient as well as significant levels of diseconomies of scale and financial institutions in Japan, Australia, Austria, Germany, Sweden and Canada are the most efficient, whereas financial institutions in France, Italy, the UK and the USA are the least efficient. On a more recent development, Cavallo and Rossi (2002) used stochastic frontier approach to compare the efficiency of the European banking systems in view of the constitution of the European Monetary Union. Their analysis highlighted significant efficiency gaps among the performances of banks in different countries and of different institutional types; and in particular, they found that the Mittel-European model, that is, the universal banking system operates closest to the efficient frontier. Weill (2004) use both parametric and non-parametric technique to measure *CE* of banks across five European countries and found that although different techniques may produce in some cases opposing findings, they do not yield noticeably different results in terms of identifying the components of efficiency growth of EU banks during the period of their study. Fries and Taci (2005) analyzed the *CE* of banks in 15 East European countries during the post-communist transition and found that a country's progress in banking reform and *CE* is non-linear. In addition, they also found that foreign-owned banks which have a larger share of total assets have lower costs and privatized banks with majority foreign ownership are the most efficiency while those with domestic ownership are the least. Fiordelisi (2008) applied stochastic frontier approach to measure banks efficiency in 11 transition countries and they found that government-owned banks are not appreciably less efficient than domestic private banks.

On the ASEAN context, Karim (2001) had used cost function to analyze the efficiency of banks. They used banks cost (i.e. sum expenses on wages and salaries, land buildings and equipment and interest on deposits) as inputs, and revenues (i.e. dollar amounts of commercial and industrial loans, dollar amount of other loans and dollar amounts of deposits) as outputs. They found that larger banks in ASEAN tend to have higher *CE* than smaller banks, and suggested the policy of banking sector

consolidation in the ASEAN countries. In a more recent development, Barry *et al.* (2010) used the DEA approach to measure efficiency of banks in this region. They used personnel expenses, interest expenses and other operating expenses as inputs and net loans, total securities and other earning assets as outputs. Their results also showed that the efficiency differs in terms of bank structures (e.g. size) and the efficiency scores are relatively lower for the Philippines.

It is apparent from the literature that although numerous studies have attempted to compare bank efficiency across countries in the developed countries, studies focussing on assessing efficiency of banking industries in the ASEAN region are very limited. Further, the results are still inconclusive on the relationship between bank institutional characteristics (i.e. size and ownership structure) and efficiency; whether larger banks are more efficient, and whether private or foreign-owned banks are more efficient.

3. Technique and data

DEA, a non-parametric technique was to estimate the efficiency of the ASEAN banks because of its advantage of not requiring assumptions about functional form or the properties of a random error term. Following the DEA technique, efficiency is measured for each bank by constructing dominating or reference sets of efficient banks in the industry. As this paper aims to provide a systematic analysis of the various sources of efficiency, this section will therefore first explain the concept of efficiency. Then, this is followed by explanation of the DEA technique and the various models in DEA for measuring different types of efficiency.

3.1 DEA efficiency

There were two school of thoughts for the concept of efficiency, that is, the engineering and the economics. From the engineering perspective, efficiency is equate to the ratio of output over input. In this paper, as the efficiency is being investigated in the business perspective, our focus on the discussion of the concept of efficiency in this subsection will be based on the economics perspective. Economists generally associate efficiency to how well the system uses the resources so as to maximize the production of goods and services. The term "economic efficiency" is often used to represent the meaning of efficiency. Economic efficiency can be decomposed into technical and allocative components. A firm is said to be economic efficient if the firm can produce the maximum output from a given level of input (technically efficient) and use the right combination of inputs with the minimum cost of inputs (allocative efficient).

The analysis of efficiency can be carried out in two ways, input orientation and output orientation. Input-oriented efficiency is the optimal combination of inputs to achieve a determined level of output while output-oriented efficiency is the optimal output that could be produced from a given level of inputs. The input-oriented and output-oriented measures are equivalent in *TE* when the return to scale is constant. The input-oriented efficiency is illustrated in Figure 1.

From Figure 1, two inputs, K and L are used to produce a given set of output. The point Q' is the optimal combination of inputs to produce a specific level of output y at minimum cost as it is both technically and allocatively efficient. The isoquant SS' captures the minimum combination of inputs needed to produce a given set of output. Therefore, every combination of inputs along the isoquant is considered as technically efficient. The point M is defined as a technically inefficient combination of inputs because fewer inputs could produce the same level of output. The technical inefficiency

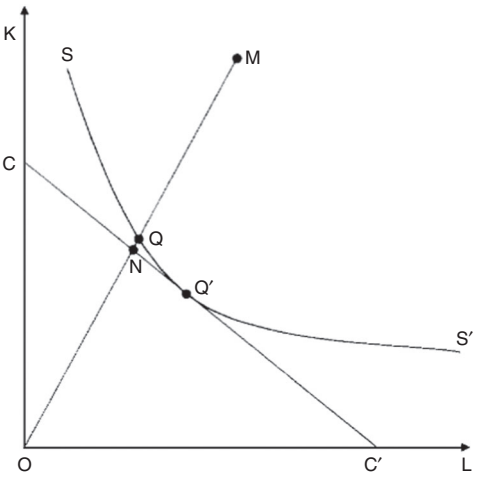

Figure 1.
Technical and allocative efficiency

level associated to combination M can be computed by the ratio QM/OM and thus the input-oriented TE is given by OQ/OM.

For a given information of market price of inputs, the isocost line CC' reflect the combination of inputs that require the same level of cost. The least cost combination of inputs is at point Q'. In order to achieve the same level of cost, the inputs would need to move to point N. Therefore the allocative inefficiency is given by the ratio NQ/OQ while the allocative efficiency (AE) is defined by the ratio ON/OQ. By considering both technical and allocative component, the overall efficiency or economic efficiency is given by the multiplicative interaction of the two components, that is:

$$\text{Overall efficiency} = TE \times AE = OQ/OM \times ON/OQ = ON/OM \tag{1}$$

The techniques to estimate the efficiency can be classified into parametric and non-parametric. For the parametric approaches, it consists of deterministic and stochastic model. Deterministic model envelope all the observations, identifying the distance between the observed production and the optimal production, defined by the frontier and the available technology. However, deterministic model will take into account the uncontrollable factors that should not be considered as TE. On the other hand, stochastic model consider both the specification failures and uncontrollable factors independently of the technical inefficiency component by introducing a double-sided random error into the specification of the frontier model. DEA is the non-parametric approach for the estimation of efficiency. DEA is a mathematical programming that provides a way for the construction of production frontier and used to compute the efficiency scores relative to those constructed frontiers. There is no best choice of method for the estimation of efficiency score as both the parametric and non-parametric approaches also have their advantages and disadvantages. Therefore, the choice of estimation method is depend on the condition under study.

Next, various DEA models will be discussed; the intention of discussion is to explain the various DEA models and the corresponding efficiency scores as to what they

represent in a banking context. As such the mathematical formulation and the technical portion will be brief. Readers are advised to refer to Ali and Seiford (1993) and Charnes *et al.* (1978) for more details of the technique. The efficiency models used in our assessment of banks performance include the *TE* and scale efficiency (*SE*) model, slack-based efficiency and mix efficiency (*ME*) model, cost and allocation efficiency model.

3.1.1 TE and SE models. Note that from the above non-linear program, after linearized through a change in coefficients, the linearized dual form of the model is typically known as the CCR model (or envelopment model). This CCR model is typically presented in the DEA literature to assess the *TE*:

$$\begin{aligned} &\min_{\theta_{CCR},\lambda} \theta_{CCR} \\ \text{s.t.} \quad &\sum_{k=1}^{n} \lambda_k y_{ik} - y_{io} \geqslant 0 \forall i \in \{1,2,\ldots,s\}, \\ &\sum_{k=1}^{n} \lambda_k x_{jk} - \theta_{CCR} x_{jo} \leqslant 0 \forall j \in \{1,2,\ldots,m\} \\ &\lambda_k \geqslant 0 \forall k \in \{1,2,\ldots,n\} \end{aligned} \tag{2}$$

where θ_{CCR} is the dual variable to be minimized and λ is a vector in K^n comprising of the scalars λ_k ($k \in \{1, 2, \ldots, n\}$). From the banking context, this CCR efficiency logically determines whether a bank or DMU (Note: in this paper, DMUs are the banks can achieve the same or more output while requiring less input. If more output with less input can be achieved, the DMU/bank being evaluated is judged to be relatively inefficient; and vice versa). Thus, it follows that $0 < \theta_{CCR} \leqslant 1$. When a convexity constraint is added to (2) to enable a variable return to scale frontier, as shown in the model below, it is known as the VRS model:

$$\begin{aligned} (TE) \qquad &\min_{\theta_{CCR},\lambda} \theta_{VRS} \\ \text{s.t.} \quad &\sum_{k=1}^{n} \lambda_k y_{ik} - y_{io} \geqslant 0 \forall i \in \{1,2,\ldots,s\}, \\ &\sum_{k=1}^{n} \lambda_k x_{jk} - \theta_{VRS} x_{jo} \leqslant 0 \forall j \in \{1,2,\ldots,m\} \\ &\lambda_k \geqslant 0 \forall k \in \{1,2,\ldots,n\} \\ &\sum_{k=1}^{n} \lambda_k = 1 \end{aligned} \tag{3}$$

As the difference between (2) and (3) lies in the scale assumption (the prior is constant return to scale, while the later is variable return to scale), hence, the *SE* can be obtained through (4):

$$(SE) = \theta^*_{CCR} / \theta^*_{VRS} \tag{4}$$

3.1.2 Slack-based efficiency and ME model. The efficiency values evaluated from previous model (in section 3.1.1) are under the assumption that the input-output proportions remain unchanged. This is because, the previous models are based on radial concept, that is proportionate increase (decrease) in any inputs will affect a similar proportionate amount of increase (decrease) in the outputs. To relax this assumption, the model can be modified into a "non-radial" model (Tone, 2001), which is known as the slacks-based measure (*SBM*) of efficiency:

$$
\begin{aligned}
(SBM)\qquad & \min_{\mathbf{s}^+,\mathbf{s}^-,\lambda} \theta_{SBM} = \frac{1}{\|M\|}\sum_{j=1}^{\|M\|}\frac{x_{jo}-s_j^-}{x_{jo}} \\
\text{s.t.}\quad & \sum_{k=1}^{n}\lambda_k y_{ik} - s_i^+ = y_{io}\forall i \in \{1,2,\ldots,s\}, \\
& \sum_{k=1}^{n}\lambda_k x_{jk} + s_j^- = x_{jo}\forall j \in \{1,2,\ldots,m\} \\
& \sum_{k=1}^{n}\lambda_k = 1 \\
& \lambda_k \geqslant 0\forall k \in \{1,2,\ldots,n\} \\
& s_i^+ \geqslant 0\forall i \in \{1,2,\ldots,s\} \\
& s_j^- \geqslant 0\forall j \in \{1,2,\ldots,m\}
\end{aligned}
\tag{5}
$$

where s_i^+ and s_j^- are the slack variables associated with output deficits and input excesses, respectively. $\mathbf{s}^+$ and $\mathbf{s}^-$ vectors comprising s_i^+ ($\forall i \in \{1,2,\ldots,s\}$) and s_j^- ($\forall j \in \{1,2,\ldots,m\}$). Note above is input oriented that evaluates the optimal weight without constraints on fixed input-output proportions. In other words, the objective of the model relating to our research problem is to find an optimum input mix which minimized the input excesses of the banks. *ME* is then defined as the ratio of *TE* and *SBM* that is:

$$
(ME) = \theta^*_{SBM}/\theta^*_{VRS} \tag{6}
$$

ME is a degree of balances of inputs are used (or outputs are produced) together. In other words, we can estimate of how well the set of inputs used together, regarding to the level and mix of inputs in order to efficiently produce the given level of output from the estimated *ME*.

3.1.3 CE and AE model. In the assessment of productive efficiencies, cost and allocative efficiencies have also gained prominence. Particularly when cost or price data are present, managers are keen to know how to achieve lower production costs in banks while keeping *TE* measure constant. As our data consist of operations costs, we can consider the behavioral objective which is cost minimization. The *CE* model is

shown below:

$$(CE) \quad \min_{\overline{\mathbf{x}},\lambda} \theta_{CE} = \sum_{j=1}^{s} \overline{x}_{jo}$$

$$\text{s.t.} \quad \sum_{k=1}^{n} \lambda_k y_{ik} - y_{io} \geqslant 0 \ \forall i \in \{1, 2, \ldots, s\}, \tag{7}$$

$$\sum_{k=1}^{n} \lambda_k \overline{x}_{jk} - \overline{x}_{jo} \geqslant 0 \ \forall j \in \{1, 2, \ldots, m\}$$

$$\lambda_k \geqslant 0 \ \forall k \in \{1, 2, \ldots, n\}$$

where $\overline{x}_{jo}$ given by $\overline{x}_{jo} = c_{jo} x_{jo}$, is the level of input factor scaled by the factor cost c_{jo} for input factor j of bank o. $\overline{x}_{jk}$ is the level of input factor scaled by the factor cost c_{jk} for input factor j of bank k given by $\overline{x}_{jko} = c_{jk} x_{jk}$. $\overline{\mathbf{x}}$ is the vector comprising of $\overline{x}_{jo}$ ($\forall j \in \{1, 2, \ldots, s\}$).

One can then calculate the *AE* by dividing the *TE* from the *CE* as shown in Equation (8). The *TE* value is obtained from (3) and substituted into (8) as follows:

$$(AE) = \theta^*_{CE} / \theta^*_{VRS} \tag{8}$$

3.2 Data descriptions

The first and very crucial step in conducting a DEA analysis is the determination of inputs and outputs. In order to choose the variables, we follow the intermediation approach, the reasons are as follows. The advantages of the intermediation approach (Elyasiani and Mehdian, 1990) are first, it is more inclusive of the total banking cost as it includes interest expense on deposits and other liabilities; second, it appropriately categorizes deposits as inputs; and third, it has an edge over other definitions for data quality considerations. Hence, our bank total cost will be our inputs; total cost include sum expenses on wages and salaries, equipment, other physical capital (e.g. building, land, etc.), and interest on deposits. Meanwhile, the outputs are total dollar amount of loans (including commercial, industrial and other loans), total dollar amounts of deposits and dollar amounts of investments and securities. The input price will include expenses on wages and salaries per employee (unit price of labor), expenses on equipment, land and building (unit price of physical capital) and expenses on interest per dollar of deposits (unit price of financial capital).

To assess the efficiency of ASEAN banks, we use data from year 2000 to 2010. This range enables us to study the efficiency of the banks during the post-crisis period as well as assess the vulnerability of ASEAN market to the recent global economic crisis, that is, the US subprime crisis. The data set were obtained from WORLDSCOPE. For our study, the sample banks are almost all the commercial banks in Indonesia, Malaysia, the Philippines and Thailand. Data on banks in Brunei, Cambodia, Laos, Myanmar and Vietnam are unavailable. While data on most of the Singapore banks are available, they cannot be used since there are no data on wages. After the banks with missing values of outputs and/or inputs were dropped, the final sample consists a total

of 39 banks to be analyzed, that is, 16 banks in Indonesia, four banks in Malaysia, 12 banks in Philippines and seven from Thailand. According to Golany and Roll (1989), the number of DMUs should be at least twice of the total number of input and output factors (i.e. $2 \times (4 + 3) = 14$) considered when applying the DEA model. Note, the number of DMUs in our case fulfills this criterion.

The descriptive statistics of input and output factors of the selected banks are given in Table I. All dollar amounts are in US dollars. The average asset size of the banks in the whole sample (both local and foreign banks) over the 2000-2010 time period

	Mean	SD	Minimum value	Maximum value
A. All sample				
Assets	12,354,030	15,392,461	29,578	103,308,654
Loans	11,625,714,175	39,167,437,514	3,118,976	327,316,569,000
Deposits	15,510,560,187	50,195,582,457	271,895	362,212,154,000
Investment	847,821,540	2,301,990,480	156,502	15,821,849,000
Total cost	1,356,567,955	4,170,115,279	74,317	31,959,684,000
Interest on deposit	847,821,540	2,301,990,480	156,502	15,821,849,000
Price of input	31,180	58,430	30	331,917
B. Malaysia				
Assets	24,710,361	21,653,990	1,038,477	103,308,654
Loans	59,251,956	48,556,018	3,118,976	214,549,379
Deposits	60,178,003	52,566,533	1,117,180	236,909,788
Investment	14,697,913	12,293,390	500	55,848,052
Total cost	2,655,552	2,494,901	74,317	12,534,267
Interest on deposit	1,876,468	1,276,824	156,502	4,929,827
Price of input	56	14	30	90
C. Indonesia				
Assets	7,384,645	10,645,351	29,578	49,436,454
Loans	39,606,456,571	64,945,079,640	96,603,000	327,316,569,000
Deposits	52,928,517,620	82,250,278,884	13,906,000	362,212,154,000
Investment	18,156,064,425	28,723,726,283	19,886,000	121,576,477,000
Total cost	4,644,000,908	6,713,125,922	30,347,000	31,959,684,000
Interest on deposit	2,909,136,843	3,517,658,067	10,917,000	15,821,849,000
Price of input	106,476	61,667	28,128	331,917
D. Philippines				
Assets	4,796,264	5,157,216	351,705	22,801,979
Loans	109,184,419	124,400,888	7,650,165	563,296,000
Deposits	166,649,839	181,897,227	8,360,611	774,713,000
Investment	57,678,272	57,539,539	1,334,609	230,453,000
Total cost	13,347,193	13,658,381	1,022,216	63,671,000
Interest on deposit	6,109,327	5,281,308	395,218	19,824,871
Price of input	643	194	304	1,408
E. Thailand				
Assets	18,994,128	14,292,884	877,765	53,395,215
Loans	505,601,844	372,040,132	24,180,200	1,308,917,391
Deposits	537,378,805	414,745,717	271,895	1,360,715,521
Investment	104,532,333	95,878,763	3,784,000	428,918,000
Total cost	30,357,645	21,212,503	3,125,300	75,174,000
Interest on deposit	12,580,989	8,266,669	954,800	33,237,597
Price of input	568	157	291	919

Table I.
Descriptive statistics for sample banks: 2000-2010 (in US$ thousands)

is US$12.4 billion and the maximum is US$103.3 billion. The average bank asset size for Malaysia is the biggest in our sample of the ASEAN countries. Malaysia's banks average asset size is US$24.7 billion with a maximum asset size of US$103.3 billion. On the other hand, the average bank asset size for the Philippines of US$4.8 billion is the smallest in our sample of the ASEAN banks with a maximum asset size of US$22.8 billion. Hence, on average, Malaysia's banks are the biggest in our ASEAN sample, followed by Thailand, Indonesia and the Philippines.

4. Empirical analysis

In the following section, we divide the results discussion into three sections. First, we will discuss the evolution of the ASEAN banking sector efficiencies throughout year 2000-2010. Second, we will assess the efficiency of ASEAN banking sector over periods by dynamic analysis and discuss the efficiency change in relation to asset size and ownership structure. In this study, input-orientation estimation of efficiency is used, that is optimal combination of inputs to achieve a determined level of output as there is no fixed level of input for the ASEAN banks.

4.1 Evolution of ASEAN banking sectors efficiencies

Note that in estimating the *TE* score, variable return to scale was used due to the reason that in the real world, imperfect competition, government regulations and constraints on finance, etc. (Coelli *et al.*, 2005) may not allow all banks to operate at an optimal scale.

From Table II, the *TE* of all banks are very high with the mean of 0.869. Among the four countries, Malaysian banks possess the highest mean *TE* which is 0.960 (sufficiently close to 1). For year 2000, 2001 and 2007, Malaysian banks achieve *TE* of 1.000. However, Malaysian banks recorded a slight decrease (6.96 percent) from year 2002 to 2005. From year 2006, the *TE* of Malaysian banks show some increase and successfully reach *TE* of 1.000 in year 2007. *TE* decrease with 4.84 percent from 0.974 (year 2008) to 0.929 (year 2009). From year 2009 to 2010, Malaysian banks successfully manage their *TE* and there is a marked increase in the efficiency despite the recent global financial crisis. In other words, it infers that that Malaysian banks have better ability to produce maximum output from the minimum quantity of inputs, compared to its peers countries. Indonesian and Thailand banks have almost the same mean *TE*s which are 0.909 and 0.908, respectively. Indonesian banks possess *TE* of 1.000 for year 2000 and 2001, and marked some changes from year 2002 to 2010. Within the nine years, year 2007 has the lowest *TE*, which is 0.770. Probable reasons of the fluctuations in the *TE* for Indonesian banks could be due to the relative effectiveness of the economic policy and country's financial regulation to overcome the rising cost of operations and labor costs throughout the years. Similarly, the fluctuating trend in *TE* can be observed in Thailand banks; its *TE* in year 2000 is 0.951 and eventually in year 2009, it drops to 0.841. Apart from one country's regulatory system, the impact of new technology could also affect the *TE* of the banks. The twentieth century is the era of e-banking where various types of internet technology is gradually implemented in the banking industry. Certain banks, for instances, those banks in the less developed countries may need more time to assimilate with all the new technologies that imposed in their banks. For Philippines banks, they possess the lowest mean *TE* among the four countries. However, it is obvious that *TE* of Philippines banks is gradually increasing with 35.65 percent from year 2000 ($TE = 0.690$) to 2010 ($TE = 0.936$). Overall, the *TE* of the four countries is relatively positive despite some fluctuations throughout the years 2000-2010.

Year	*TE*	*SE*	*ME*	*CE*	*AE*
Panel A: all banks					
2000	0.882	0.976	0.959	0.618	0.69
2001	0.864	0.969	0.951	0.739	0.846
2002	0.893	0.949	0.933	0.768	0.844
2003	0.889	0.927	0.927	0.661	0.723
2004	0.857	0.899	0.936	0.746	0.864
2005	0.854	0.903	0.936	0.738	0.854
2006	0.862	0.843	0.928	0.7	0.803
2007	0.803	0.797	0.93	0.69	0.852
2008	0.897	0.819	0.932	0.683	0.754
2009	0.866	0.801	0.945	0.65	0.737
2010	0.896	0.776	0.945	0.637	0.694
Mean	0.869	0.878	0.938	0.694	0.787
Panel B: Malaysian banks					
2000	1	0.994	0.998	0.707	0.707
2001	1	0.988	1	0.815	0.815
2002	0.983	0.97	0.96	0.842	0.854
2003	0.931	0.977	0.949	0.727	0.78
2004	0.907	0.941	0.923	0.801	0.882
2005	0.919	0.954	0.955	0.858	0.928
2006	0.965	0.968	0.961	0.917	0.946
2007	1	0.759	1	0.864	0.864
2008	0.974	0.846	0.961	0.842	0.861
2009	0.929	0.915	0.991	0.848	0.893
2010	0.959	0.968	0.975	0.782	0.805
Mean	0.96	0.934	0.97	0.818	0.849
Panel C: Indonesian banks					
2000	1	1	1	0.836	0.836
2001	1	1	1	1	1
2002	0.938	0.874	0.952	0.859	0.901
2003	0.986	0.753	0.947	0.833	0.836
2004	0.959	0.707	0.935	0.829	0.844
2005	0.925	0.665	0.877	0.811	0.872
2006	0.837	0.618	0.943	0.719	0.842
2007	0.77	0.793	0.915	0.701	0.886
2008	0.879	0.614	0.912	0.663	0.742
2009	0.85	0.598	0.944	0.652	0.743
2010	0.849	0.594	0.925	0.622	0.701
Mean	0.909	0.747	0.941	0.775	0.837
Panel D: Philippines banks					
2000	0.69	0.945	0.89	0.352	0.535
2001	0.647	0.923	0.889	0.466	0.739
2002	0.737	0.944	0.873	0.526	0.713
2003	0.725	0.931	0.874	0.329	0.471
2004	0.685	0.956	0.943	0.593	0.87
2005	0.696	0.96	0.928	0.527	0.764
2006	0.799	0.94	0.903	0.539	0.684
2007	0.79	0.733	0.966	0.628	0.801
2008	0.9	0.949	0.962	0.607	0.673

Table II.
ASEAN banks efficiency results 2000-2010

(*continued*)

Year	*TE*	*SE*	*ME*	*CE*	*AE*
2009	0.882	0.934	0.96	0.582	0.654
2010	0.936	0.955	0.96	0.599	0.637
Mean	0.772	0.925	0.922	0.523	0.686
Panel E: Thailand banks					
2000	0.951	0.987	0.992	0.786	0.828
2001	0.95	0.997	0.958	0.926	0.971
2002	0.935	0.983	0.955	0.896	0.94
2003	0.948	0.976	0.942	0.822	0.851
2004	0.915	0.979	0.947	0.791	0.853
2005	0.91	0.975	0.973	0.795	0.866
2006	0.909	0.931	0.92	0.743	0.815
2007	0.817	0.887	0.891	0.714	0.864
2008	0.906	0.967	0.928	0.782	0.86
2009	0.841	0.97	0.896	0.652	0.779
2010	–	–	–	–	–
Mean	0.908	0.965	0.94	0.791	0.863

Table II.

In terms of *SE*, Thailand banks marked the highest mean *SE* which is 0.965, follow by Malaysian banks 0.934, Philippines banks 0.925 and Indonesian banks (0.747). In general, the *SE*s of all banks are consistent, all the values are above 0.550. However, further examination on the results reveal that the *SE* of each country (except Philippines) decrease slowly from year 2000 to 2010. For Malaysia banks, it decrease 2.69 percent, Indonesian banks decrease 68.35 percent, and Thailand banks decrease 1.75 percent. Philippines banks overall show a stable trend which fluctuates within 0.950.

For *ME*, Malaysia banks have the highest mean *ME* which is 0.970. With high *ME*, it shows that Malaysian banks are flexible in changing its input proportions. Follow by Indonesian and Thailand banks, they possesses *ME* of 0.94. It is very important for a bank to have high *ME* as with high *ME*, it means that the bank is very flexible in input changes (e.g. labor, capital, technology) and this can help to reduce the organization's reliance on specific inputs and cushions it against unexpected shock competition. Lastly, Philippines banks reach a *ME* of 0.922 which is considerable as high efficiency too. Generally, all banks have high *ME* with mean *ME* of 0.938.

In terms of *CE*, Malaysia banks again recorded the highest mean *CE* which is 0.818. Second highest mean *CE* is Thailand banks with *CE* of 0.791. Third highest mean *CE* is Indonesian banks followed by Philippines banks with ($CE = 0.775$) and ($CE = 0.523$), respectively. The *CE* of Malaysian banks show some increases throughout year 2000-2010. Indonesian and Thailand banks have slight decrease in *CE* from year 2000 to 2010. Indonesian banks decrease from *CE* of 0.836 (in year 2000) to *CE* of 0.622 (in year 2010) which is 34.4 percent decreasing. For Thailand banks, their *CE* decrease at approximately 20.55 percent. On the other hand, Malaysian banks and Philippines banks successfully increase their *CE* with 10.60 and 70.17 percent, respectively.

Interestingly, banks which are more cost efficient are also more allocative efficient concurrently. Indonesian and Thailand banks show a fall in their *AE* from year 2000 to 2010, whereas for Malaysian and Philippines banks, both of them show improving trend in their *AE* rank from year 2000 to 2010. However, there is a room for the selected ASEAN countries to improve their *AE* in the coming years in order to achieve higher *CE*. Further examination on the efficiency scores using statistical analysis is provided in the Appendix. The results

also indicated that overall, the efficiencies differs across countries, with Malaysia banks exhibiting the highest mean *AE* while Indonesia banks' scale and technical efficiencies are significantly lower than the other three selected ASEAN countries in the region.

4.2 Dynamic analysis of efficiency development over periods

In this section, we divide the years into three periods, that is, period I (year 2000-2004), period II (year 2004-2007) and period III (year 2008-2010) (Note that the reason of dividing into periods is to provide a clearer understanding on the management of banks due to the fact that the results of management can hardly be reflected in one-year time, but rather in a few years (e.g. three to four years)). Another reason is to minimize the effect of consolidation and diversification that happen in the financial institutions. Coincidentally, the periods that we have chosen can reflect the post Asian financial crisis period, that is, 2000-2004, the US financial market turmoil (or the subprime crisis period), that is, 2004-2007 and the late global financial crisis (2007-2010) which also includes the Europe financial crisis.

4.2.1 Efficiency changes of ASEAN banks in relation to asset size. The DMUs (banks) are categorized according to the size and the mean efficiency of each type of efficiencies score are calculated to further study how the bank size (Note: in this case we use asset size as the proxy) affects the efficiencies of ASEAN banks. The sizes of banks are defined based on the total asset and there are three different groups which consist of less than 25 million, 25 million-50 million and greater than 50 million. Note that the categorization is based on the fundamentals of the market pool in the studied region. In the period I, no medium-size banks were available and no large-sized banks were available. A probable explanation for this maybe due to the increasing and expansion of the financial market in the ASEAN region.

In general, medium-size banks are the most efficient while small-size banks are the least efficient except in terms of *SE* which show that the efficiency increases with banks sizes, that is, the larger the bank size, the more scale efficient is the bank. Another interesting point is that, small and medium-size banks exhibit the highest *ME* score (Note: this can be obtained from a cross-lateral examination of the efficiencies scores for each asset category). This implies that small and medium ASEAN banks are flexible in utilizing the input proportions. Besides that, large bank have highest *SE* score, indicates that large bank are operate in "optimal size." On the other hand, for the three different sizes of bank, *CE* exhibits the lowest value among the various types of efficiencies scores. This indicates that all the ASEAN banks, regardless of the sizes of bank, are least efficient in minimizing their operations cost associated with producing the output (i.e. the services of the banks).

In terms of *TE*, the efficiency score for small bank slightly decreased from period I to II; however, it later showed a significant increase in year 2008 (13.76 percent). For banks with medium size, the *TE* score does not show any significant changes; it slightly decreased from year 2001 to 2004, then it increased in the consecutive two years, and after that it decreased again in year 2007. For large banks, the *TE* efficiency score slightly decreased from year 2005 to 2009 except for year 2006-2007, it showed a significant increase in efficiency score (20.31 percent). In terms of *SE*, small banks do not show significant changes from period I to III. For medium-size banks, the *SE* score started to decrease from year 2006 and it show significant decrease at year 2009 (11.95 percent) and 2010 (14.34 percent). For large bank, *SE* decreased from year 2005 to 2007 then increased in period III. Similar to the *SE* trend, for *ME*, small and medium-sized

banks do not show any significant changes during the period of study. For large banks, the *ME* score increased significantly (11 percent) from year 2006 to 2007.

The *CE* and *AE* experienced larger changes compared to *SE*, *TE* and *ME* for small and larger size banks along the period of study. For small-size banks, in period I, there is a marked increase for both *CE* and *AE*. In year 2003, both *CE* and *AE* decreased significantly (*CE*-15.56 percent and *AE*-16.24 percent) for small-size banks. For medium-size banks, *CE* decreased significantly in year 2003 (10.82 percent) while *AE* did not show any significant changes along the period of study. For large bank, *CE* decreased from period II to III except for year 2007, it increased significantly (29.19 percent) while *AE* decreased significantly only at year 2010 (12.64 percent). Another interesting point is that, during the period 2006-2007, that is, the US subprime crisis period, the efficiencies score decreased for small and medium-size banks. However, for large-size bank, the impact of the global financial crisis did not exert much effect on the efficiency scores of the banks. This implies that small and medium-sized ASEAN banks were more vulnerable to economic crisis, compared to the larger banks (Table III).

4.2.2 Efficiency changes in ASEAN banks and type of ownership. In general, the government banks are more efficient than non-government banks in the ASEAN region during the periods of study. By comparing all types of efficiency (*TE*, *SE*, *ME*, *CE* and *AE*) between government banks and non-government banks, it was found that, except for *SE* and *ME*, the rest of the types of efficiency for government banks are higher than non-government ones. The efficiency for government banks is initially high during period I but it drops during period II then recover again during period III. Meanwhile, the efficiency for non-government banks is considered as stable throughout the years but its *CE* is relatively low compared to government banks' *CE*. One possible reason for this is because the non-government banks were not eligible to enjoy some incentives or privileges that were offered to the government banks. For example, the tax rate for non-government banks is relatively higher than government banks. In the following paragraphs, we will discuss each type of efficiency in association to the type of ownership.

From Table IV, the *TE* of government banks is 5.78 percent higher that non-government banks. In period I, the *TE* for government banks fall around 23.1 percent (from 1.000 to 0.769) while the *TE* for non-government banks fall 2.61 percent (from 0.882 to 0.859). In period II, the *TE* for government banks has increased about 9.88 percent (from 0.769 to 0.845) but for non-government banks, it has decreased about 6.87 percent (from 0.859 to 0.800). Meanwhile, in period III, the *TE* of government banks continues to increase approximately 13.73 percent (from 0.845 to 0.961) and the *TE* of non-government banks also increase 10.88 percent (from 0.800 to 0.887). The results signify that government banks are able to resolve the lack of efficiency in a more rapid manner in contrast to non-government banks. Alternatively, this infers that the efficiency of non-government banks are relatively stable despite technological changes. This could probably due to foreign ownership constituted in this type of bank, whereby the impact of any technological changes had been experienced much earlier in the developed countries, thus when the technological impact permeates to the developing region, the effect on the banks' efficiency is reduced.

The *SE* of government banks and non-government banks are almost same. In period I, the *SE* of government banks is consistent which only has a slight drop of 0.41 percent (from 0.964 to 0.960) but the *SE* of non-government banks falls around 8.09 percent (from 0.976 to 0.897). In period II, the *SE* of government banks drops around 11.77 percent (from 0.960 to 0.847) and for non-government banks, it drops around

	Year	*TE*	*SE*	*ME*	*CE*	*AE*
Size 1 (< 25 million)						
Period I	2000	0.882	0.976	0.959	0.618	0.690
	2001	0.857	0.971	0.948	0.735	0.847
	2002	0.886	0.949	0.932	0.760	0.840
	2003	0.886	0.920	0.920	0.642	0.703
Period II	2004	0.855	0.888	0.934	0.740	0.859
	2005	0.846	0.887	0.928	0.720	0.842
	2006	0.842	0.815	0.921	0.677	0.794
	2007	0.771	0.768	0.928	0.664	0.851
Period III	2008	0.877	0.783	0.922	0.632	0.717
	2009	0.837	0.776	0.933	0.588	0.694
	2010	0.873	0.765	0.932	0.563	0.630
	Mean	0.856	0.863	0.933	0.667	0.770
Size 2 (25 million-50 million)						
Period I	2000	–	–	–	–	–
	2001	1.000	0.928	1.000	0.821	0.821
	2002	0.977	0.949	0.935	0.878	0.897
	2003	0.911	0.973	0.972	0.783	0.855
Period II	2004	0.868	0.986	0.955	0.790	0.900
	2005	0.920	0.998	0.986	0.866	0.933
	2006	0.995	0.996	0.982	0.857	0.861
	2007	0.978	0.993	0.900	0.829	0.846
Period III	2008	0.981	0.945	0.979	0.906	0.923
	2009	0.994	0.832	0.981	0.905	0.909
	2010	0.974	0.713	0.990	0.923	0.944
	Mean	0.960	0.931	0.968	0.856	0.889
Size 3 (> 50 million)						
Period I	2000	–	–	–	–	–
	2001	–	–	–	–	–
	2002	–	–	–	–	–
	2003	–	–	–	–	–
Period II	2004	–	–	–	–	–
	2005	0.853	0.993	0.992	0.756	0.886
	2006	0.831	0.991	0.901	0.669	0.804
	2007	1.000	0.923	1.000	0.864	0.864
Period III	2008	0.942	0.986	0.933	0.775	0.811
	2009	0.905	0.988	0.988	0.766	0.826
	2010	0.932	0.999	0.958	0.682	0.722
	Mean	0.910	0.980	0.962	0.752	0.819

Table III.
ASEAN banks efficiency score according to asset size year 2000-2010

11.48 percent (from 0.897 to 0.794). In period III, the *SE* for both government and non-government banks continues to drop about 18.42 percent (from 0.847 to 0.691) and 0.76 percent (from 0.794 to 0.788). It is evident from the results that throughout the years, both government and non-government banks are highly competing to be scale efficient.

As in *SE*, the *ME* of government and non-government banks also behaves in a similar manner. In period I, the *ME* of the government banks decreases 13.1 percent (from 1.000 to 0.869) while for non-government banks, it has only a slight decrement of 2.19 percent (from 0.959 to 0.938). In period II, the *ME* of both government banks and non-government banks can be considered as stable because the changes are 0.69 percent (from 0.869 to 0.875) and 0.53 percent (from 0.938 to 0.933), respectively.

		TE	*SE*	*ME*	*CE*	*AE*
Government						
Period I	2000	–	–	–	–	–
	2001	1.000	0.964	1.000	0.911	0.911
	2002	0.977	0.949	0.935	0.878	0.897
	2003	0.909	0.899	0.897	0.657	0.723
Period II	2004	0.769	0.960	0.869	0.578	0.751
	2005	0.853	0.993	0.992	0.756	0.886
	2006	0.831	0.991	0.901	0.669	0.804
	2007	0.845	0.847	0.875	0.684	0.766
Period III	2008	1.000	0.651	1.000	0.823	0.823
	2009	1.000	0.498	1.000	0.946	0.946
	2010	0.961	0.691	0.985	0.825	0.857
	Mean	0.915	0.844	0.945	0.773	0.836
Non-government						
Period I	2000	0.882	0.976	0.959	0.618	0.690
	2001	0.849	0.969	0.945	0.720	0.839
	2002	0.886	0.949	0.932	0.760	0.840
	2003	0.889	0.928	0.928	0.661	0.723
Period II	2004	0.859	0.897	0.938	0.751	0.867
	2005	0.854	0.900	0.935	0.737	0.853
	2006	0.862	0.839	0.929	0.700	0.803
	2007	0.800	0.794	0.933	0.691	0.857
Period III	2008	0.888	0.834	0.926	0.671	0.748
	2009	0.855	0.826	0.940	0.626	0.720
	2010	0.887	0.788	0.939	0.612	0.672
	Mean	0.865	0.882	0.937	0.686	0.783

Table IV. ASEAN banks efficiency score by type of ownership year 2000-2010

In period III, the *ME* of government banks increases around 12.57 percent (from 0.875 to 0.985) whiles the *ME* of the non-government banks stays consistent because it only increased 0.64 percent (from 0.933 to 0.939).

In terms of *CE*, government banks are more cost efficient than non-government banks which is 12.68 percent higher (0.773 for government banks and 0.686 for non-government banks). In period I, government banks encounter a huge decrease in *CE*, which is 36.55 percent (from 0.911 to 0.578). In contrast, the non-government banks have a significant increase in *CE*, which is 21.52 percent (from 0.618 to 0.751). This result is consistent to the findings of past literature (Karim, 2001) whereby during this period which is the post Asian financial crisis, most government banks were trying to recover from the downturn of the Asian market, hence, focussing on cost was not their main priority as compared to other more crucial objectives such as improving financial health and reducing debt level. In period II, the *CE* of government banks is increased about 18.34 percent (from 0.578 to 0.684) while for non-government banks, it has decreased 7.99 percent (from 0.751 to 0.691). This again is consistent with most findings that government banks in ASEAN improves gradually after the Asian financial crisis, and during the US subprime crisis, the impact of the US financial market turmoil on the financial institution in ASEAN has not severely affected the ASEAN government banks in contrast to the severe impact exerted on the foreign banks. In period III, government banks have improved their *CE* at approximately 20.61 percent (from 0.684 to 0.825). On the other hand, the *CE* of non-government banks had declined for 11.43 percent (from 0.691 to 0.612).

In terms of *AE*, the *AE* for government banks is 6.77 percent higher than non-government banks (0.836 for government and 0.783 for non-government). In period I, the government banks had decreased 17.56 percent in *AE* (from 0.911 to 0.751) but the non-government banks had increased 25.65 percent in *AE* (from 0.690 to 0.867). In period II, *AE* for government banks merely increased for 2 percent (from 0.751 to 0.766) and for non-government banks, it slightly decreased for 1.15 percent (from 0.867 to 0.857). In period III, government banks have improved their *AE* for 11.88 percent (from 0.766 to 0.857). In contrast, the *AE* of non-government banks is significantly decreased which is 21.59 percent (from 0.857 to 0.672). These findings reflects the impact on the non-government banks which was resulted from the collapse of large financial institutions, bailout of banks by national governments (e.g. USA) and downturns in stock markets in the developed countries.

5. Discussion

The importance of efficiency analysis to the banking institutions in ASEAN cannot be understated owing to its implications on the various aspects of efficiencies. From the DEA models presented in prior sections, we found that, Thailand banks are the most scale efficient, however, they do not perform as well in terms of other types of efficiency. The reason of the discrepancy between *SE* and the other types of efficiency is due to the indivisible effect of the intangible resources. The attainment of full efficiency is bounded by not merely the physical resources (e.g. equipment, building), but also the expansion of the intangible resources (e.g. quality of labor, knowledge, management capability, etc.). If the capacity of the banks did not fit the expect demand exactly, for example, if the bank is operating under congestions (constraints), it may appear to be more efficient. In addition, there is also time lag between the initial investments in resources, for example, employees need to undergo training before they are ready to contribute to service. Hence, the banks will need to implement its training in advance even though the early recruitment causes inefficiency in the short term due to underutilization. Therefore, the less positive results obtained by the inefficient banks in the ASEAN countries do not necessarily depict a negative scenario in their respective countries, but, it could probably due to the learning growth effect in the organizations. Alternatively, the results which indicated that Malaysia banks are generally more efficient in terms of technical, cost, mix and allocation, infers that banks in Malaysia have a good management team reacting to the changing market conditions.

Of particular interest is the *CE* of the small- and medium-sized banks in ASEAN. Putting service issues aside, *CE* determines the competitiveness of the banks to a large extent. There appears to be a "asset-specific" effect in that banks having more assets (or capital), that is, large-size banks are less cost efficient compared to those having less assets. One possible reason could be the following: capital soundness though may act as banks' efficiency stimulant, but, it may also pose great danger as it will encourage manager to pursue riskier projects and be less attentive to *CE*. The degree of *AE* among these banks is also quite similar considerably. The significant connection between *CE* and *AE* highlights that the softer aspect such as good managerial judgment make a significant difference to the overall cost competitiveness of the banking institutions in ASEAN.

Finally, some disparities in the efficiency were observed between the government and non-government banks. Though foreign ownership banks were highly ranked in efficiency in most past literatures, the findings from our study managed to reveal some significant insights on the characteristics of these banks. The results clearly showed that government banks are able to cushion the impact of the volatile economic conditions, as can be observed from the minimal changes in efficiency of the banks during the US

subprime crisis as well as the late global financial crisis. In contrast, non-government banks (or foreign banks) in ASEAN are more vulnerable to the contagious effect of the financial market turmoil which originated from the developed countries that has spread throughout the world. This further indicates that while financial liberalization and effective policies have enable most ASEAN government banks to gain and improve their overall efficiency substantially throughout the years, greater integration among economies (e.g. increase the government shares in foreign entities or joint ownership or banks) would help to further improve financial stability in this region.

6. Conclusions

This paper contributes to the existing ASEAN banks literature by presenting a comprehensive assessment of efficiencies of banks in selected ASEAN countries using the DEA technique. It shows how the banks in ASEAN perform in various efficiency aspects. The results indicate that it is rather difficult for one bank to be both technical and cost efficient. Nevertheless, this may not be impossible to achieve if the bank knows its sources of inefficiencies and implements measures to improve the inefficient areas.

While the DEA application to banking efficiency context may not be new, past researches had primarily focussed within the *TE* of banks and in developed countries. In contrast, our study had discriminated against various efficiency sources, which further detailed the overall cost competitiveness of the banks in relation to asset size and type of ownership. This study also focusses on underdeveloped market, that is, ASEAN which is a huge potential market for banking investors.

Results from our analysis reveal that most of the banks in ASEAN are generally technical, scale and mix efficient. However, they are less cost efficient due to macro-economy effect such as increasing operating cost and rising cost of labor. As the financial market in ASEAN has become more open and liberalized, the efficiency results is very useful to bank managers to enable them to know the performance of their organizations in the region. This can guide them to adopt appropriate policies to enhance the bank's efficiency. In addition, the efficiency results also help to guide investors, government and policy makers to accurately gauge the performance of the banks, further alienating excessive speculation, thus, aiding the financial market in ASEAN to sustain and remain competitive in the long run.

Future research study can include methodological enhancement on the capabilities of existing DEA models to include fuzzy and missing data. In addition, we may also construct a stochastic frontier with a disturbance term representing shifts in the frontier due to random factors and compare the results obtained against those of a deterministic frontier.

Notes

1. ASEAN market consists of about 578 million people and a combined gross domestic product of US$1.47 trillion (US$1 = RM3.51) (from ASEAN Statistics, 2009; Statistics for 2009).
2. Most studies focussed on the developed countries, for example USA and Europe. To the best of the authors' knowledge, one comparative study existed, that is, Karim (2001), he compared the performance of selected ASEAN banks and the period covered is between 1989 and 1996.
3. We exclude Singapore for two reasons: first we do not have the data on wages (see section 3.2); second, Singapore is a developed country, and its role as entrepots means that the role of its banks is slightly different from its ASEAN counterparts. We think that they should not be comparable to their peers in the other ASEAN countries.

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Appendix

The efficiency scores and corresponding *p*-values are as tabulated in Table AI. Statistical analysis, ANOVA is used to analyze the differences in the mean efficiency scores, as the number of DMUs (banks) in each country are not equal in size. Tukey-Kramer multiple comparisons procedure is then used to determine which of the country means are significantly different. Note: any interval that does not include 0 is considered significant.

For *SE*, Tukey-Kramer procedure showed that Indonesia banks' efficiency is significantly different from the other countries. For *AE*, Malaysia banks' efficiency significantly differ from the rest.

Type of efficiency	*p*-value
TE	7.28E−07***
SE	2.99E−10**
ME	0.231
CE	0.246
AE	0.039**

Notes: **p-value is significant at 0.05 level; ***significant at 0.001 level

Table AI. *p*-values of the different efficiency scores

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