CHAPTER III

METHODOLOGY

3.1 Scope of the study

Before the financial crisis in 1997, both commercial banks and finance companies were majority-owned by Thai citizens (foreign participation was limited to not more than 25% for both Bank and Finance companies and Life-insurance companies). However, after the crisis, most needed to bring in a large amount of new capital that could not be raised from local investors, who were also affected by the crisis. The end result of this was to bring foreign strategic partners to enter domestic firms. As a consequence, foreign ownership in domestic bank and finance firms increased and regulations governing foreign shareholdings were relaxed, allowing holdings of up to 100% (Bank of Thailand, 2001). In this study, foreign-owned banks and finance companies are classified as companies whose shares are more than 50% held by foreign entities; for life-insurance companies[1], foreign firms are classified as companies that are not 100% Thai-owned. This study focuses on twelve commercial banks, eight finance companies and twenty-four life-insurance companies that operated during 1994-2003.

3.2 Variables and Data

3.2.1 Variable selection

The choice of the variable set in DEA is an empirical issue. Inclusion of many variables is not a viable option in DEA, since when the number of variables in the model increases, more and more production units are shown to be efficient. On the other hand, when relevant variables are omitted, DEA underestimates efficiency and the effect of this is more severe than when irrelevant variables are included. Lack of a standard structured approach to variable selection in DEA makes the task of variable selection even more difficult (Galagedera and Edirisuriya, 2002).

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[1] For Life-insurance companies, according to Life-insurance Act B.E. 2535 (1992) the amount of shares held by persons of Thai nationality shall not be less than 75% of the total amount of shares sold.

Berger and Humphrey (1997) commented on the difficulty of variable selection in performance appraisal of banks using the DEA technique saying there is no 'perfect approach' to the explicit definition and measurement of banks' input and outputs. In choosing the variables, there are some restrictions on the type of variables since there is a need for comparable data and a need to minimize possible bias arising from different accounting practices even among banks that fall under federal bank guidelines.

For the banking and finance sector, there are two common approaches to variable selection in performance appraisal in DEA: intermediation approach and production approach[2]. In the intermediation approach, where banks are considered as intermediaries, the role of deposits is considered as an input to the production process whereas in the production approach, where the banks are considered as service providers, the deposits are considered as an output involving the creation of value added for which customers bear an opportunity cost.

Casu and Molineux (1999) argued that the intermediation approach may be superior for evaluating the importance of frontier efficiency to the profitability of financial institutions because minimization of total costs is needed to maximize profits and not just minimization of production costs alone. Besides, interest expenses often account for one-half to two-thirds of total costs, and the production approach ignores this factor entirely.

The intermediation approach accommodates interest expenses. The choice of the appropriate input and output variable selection could be based on the aim of the analysis as well. Grifell-Tatjé and Lovell (1997) argued that when the interest in the analysis is on bank productivity, the production approach is preferred, as the other approaches are more focused on bank profitability.

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[2] Another approach is to treat financial products on their net contribution to the revenue of the bank. In this case a financial product may be classified as an input or an output depending on the net contribution.

3.2.2 Sample Data

The data used in this study are secondary data for twelve commercial banks and eight finance companies for the time period 1994–2003; for the twenty-four life insurance companies, due to limitation of data, we used the time period of 1995–2003 and data from annual financial statements. The data was compiled from I-SIMS, company financial statements and the Business Online Website (BOL).

3.3 Methodologies

In general, there are two principal thoughts on financial company behavior. One of these is the production approach where banks are regarded as using labor and capital to generate deposits and loans. The other is the intermediation approach to modeling financial company behavior where deposits are regarded as being converted into loans. These two models are expanded later in this section.

3.3.1 Production approach

The objective of the production approach for financial institutions assumes they desire to provide service to their customers at a minimum cost to the company or to maximize products and services for given levels of resources. The following production model describes the main categories of resources used and the products and services provided.

Table 3.1 A general technical efficiency model based on the production approach

Inputs	Outputs
• Full-time equivalent number of employees • Occupancy, furniture and equipment expense • Other non-interest expenses	• Number of demand deposits • Number of time deposits • Number of commercial loans

3.3.2 Intermediation approach

The purpose of the intermediation model, as the name suggests, is to measure the organizational efficiency of the process of transferring funds. The financial institutions are viewed as financial intermediaries that accept funds from various sources and then transfer these funds in the form of loans and other investments. In this model approach, deposits are normally treated as inputs, and the funds loaned and income generated are treated as outputs.

Table 3.2 A general technical efficiency model based on the intermediation approach

Inputs	Outputs
• Deposits • Other liabilities • Full-time equivalent number of employees • Occupancy, furniture and equipment expense • Other non-interest expenses	• Loans • Securities • Non-interest income which represents a proxy of fee-based products/services

Because of the data limitations, in this study, we choose relevant data from the financial statements to serve as proxies for the inputs and outputs noted above. Table 3.3 and Table 3.4 show the inputs and outputs applied in this study for the production and intermediation models for bank and finance companies.

Table 3.3 Bank and finance company technical efficiency model based on the Intermediation approach

Inputs	Outputs
• Personnel expenses • Property, plant and equipment expense • Total deposits is an input in the intermediation model (as opposed to an output in the production model).	• Total loans • Non-interest income

Table 3.4 Bank and finance company technical efficiency model based on the production approach

Inputs	Outputs
• Personnel expenses • Property Plant and Equipment expense	• Total deposits

For life insurance companies, we followed the production approach introduced by Lin (2002). The production approach for the life insurance industry treats insurers as institutions providing several products and services to their customers by engaging in risk reduction through pooling. They collect premiums from their clients and redistribute most of the funds to the policy holders who sustain losses. This approach is appropriate for assessing insurers' ability to satisfy claims brought by policy holders. Listed below are the inputs and outputs that we used for this study.

Table 3.5 Life-insurance company technical efficiency model based on the production approach

Inputs	Outputs
• Operating expenses • Property, plant and equipment expense	• Net underwriting income.

Another model is the investment approach. In this approach, insurers are viewed as financial intermediaries whose function is to issue contingent claims for policy holders and use the proceeds to purchase a portfolio of assets. They invest assets to maximize the rate of return on the capital and the value of ownership claims. The objective of this approach is to measure the ability of an insurer to maximize profits. However, data limitations kept this study to the application of solely the production approach to assess the technical efficiency of life insurance companies.

Table 3.6 Life insurance company technical efficiency model using production approach

Inputs	Outputs
• Net actuarial reserves • Investment expenses • Total investments	• Investment gains in bonds and mortgage • Investment gains in equities and real estate

3.4 Data Envelopment Analysis (DEA Methodology)

3.4.1 The DEA Model:

DEA is a non-parametric methodology for determining a relatively efficient production frontier, based on the empirical data from selected inputs and outputs of a number of entities, called Decision Making Units (DMUs). DEA requires, at a minimum, the following four basic components to perform an analysis:

(1) A set of similar DMUs (for example, DMUs which operate in a similar environment), denoted by DMU_j where j= 1,..., n.

(2) A set of inputs, denoted by $X_j = \{x_{ij}\}$ where i = 1,..., m for each DMU_j.

(3) A set of outputs, denoted by $Y_j = \{Y_{rj}\}$ where r = 1,..., m for each DMU_j.

(4) A large enough number of DMUs, to ensure appropriate degrees of freedom.

From the set of available data, DEA identifies reference points (relatively efficient DMUs) that define the efficient frontier and evaluate the inefficiency of other, interior points that are below that frontier.

Optimization Problem:

$$\text{Maximize:} \quad h_j\{u,v\} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \tag{3}$$

Subject to Constraints;

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \tag{4}$$

$$v_i \geq 0 \text{ for } i = 1....m \text{ and } u_r \geq 0 \text{ for } r = 1....s$$

Where	s	$= \{1,...,s\}$ is the set of outputs considered in the analysis
	m	$= \{1,...,m\}$ is the set of outputs considered in the analysis
	r	= Index of outputs
	i	= Index of inputs
	y_{rj}	= Amount of output r for unit j
	x_{ij}	= Amount of input i for unit j
	u_r	= Weight assigned to output r
	v_r	= Weight assigned to input i

The fractional problem (3), (4) can be rearranged into an equivalent linear programming problem: by letting $\sum_{i=1}^{m} v_i x_{ij} = 1$ we obtain an input-oriented CCR linear model. The rearrangement is performed by selecting the denominator of the ratio for the normalizing constraint, while using the numerator as the objective function.

Primal problem:

$$max\sum_{r=1}^{s}u_r y_{rj} \tag{5}$$

Subject to

$$\sum_{i=1}^{m}v_i x_{ij}=1$$

$$\sum_{r=1}^{s}u_r y_{rj}-\sum_{i=1}^{m}v_i x_{ij}\leq 0 \tag{6}$$

$$v_i\geq 0\ for\ i=1....m\ and\ u_r\geq 0\ for\ r=1....s$$

For the linear programming problem noted above, the dual problem for the given DMUj can be written as:

Dual problem:

$$\min h_j-\varepsilon\sum_{r=1}^{s}s_r^{+}-\varepsilon\sum_{i=1}^{m}s_i^{-} \tag{7}$$

Subject to

$$h_o x_{io}-\sum_{j=1}^{n}x_{ij}\lambda_j-s_i^{-}=0$$

$$\sum_{j=1}^{n}y_{rj}\lambda_j-s_i^{+}=y_{ro}$$

$$s_r^{+},s_i^{-}\geq 0 \tag{8}$$

$$\lambda_j\geq 0 \text{ for Constant return to scale model (CCR)}$$

$$\sum_{j=1}^{n}\lambda_j=1 \text{ for Variable return to scale model (BCC)}$$

It can be seen that the above model gives a piecewise linear production surface which, in economic terms, represents a production frontier. If h_j = 1, a DMUj has relative efficiency or 100% of efficiency score but if h_j < 1 the DMU has relative inefficiency. To illustrate, if we calculated h_j = 0.82 for a given DMU, we find that only 82% of the current levels of all inputs is needed to produce the same level of outputs. Stated another way, the DMU could produce the same amount of outputs with 18% of each of its inputs.

3.4.2 Strengths of DEA

Both ratio analysis and econometric methods have a number of different problems that prohibit them from being used effectively in certain situations (Athanassopoulos, 1995). Compared to commonly used performance measurements such as ratio and regression analysis, one of the main advantages of DEA is that it can handle multiple inputs and multiple outputs. A DEA model can handle any number of inputs and outputs, unlike other approaches which can have only multiple variables on only one side of the equation. Furthermore, it doesn't require any specification of the function form. Unlike parametric approaches, DEA does not require any prior knowledge of the relationship between inputs and outputs. In addition, it also focuses on the outliers; specifically, DEA identifies units which achieve the best results. Therefore DEA allows for the examination of best performers and their best practices. Regression, on the other hand, is concerned with the average performance units. Another advantage is that DEA identifies improvement targets for inefficient units based on groups of similar-behavior best performers (Avkiran, 1999).

Another feature of DEA is that it allows for the consideration of exogenous or qualitative data. Thus, variables over which the DMUs have no control can also be included into an analysis. As such, DEA offers numerous managerial implications and satisfies common concerns of fairness that are often raised by units being evaluated (Charnes, 1994).

3.4.3 Limitations of DEA

Since there are many strengths of DEA, however its own limitations should not be overlooked. DEA does not distinguish the noise and variation from the measure of inefficiency. Unlike some of the parametric approaches discussed in Chapter 2, DEA assumes that all deviations from the frontier are due to inefficiency only and does not make allowances for measurement error and other noise. (Seiford, 1990). Moreover, its frontier is defined by the outliers rather than on the whole sample and is thereby particularly susceptible to extreme observations and measurement error. Lastly, it provides only a relative efficiency score based on the set of DMUs studied. If certain key DMUs (which are highly efficient) are excluded then the scores provided will not be as accurate.

Nevertheless, the advantages of DEA outweigh its limitations in the overall assessment, especially if allowances are made for its weaknesses when formulating the model.