POSITIONING ANALYSIS OF ISLAMIC BANK VIS-À-VIS CONVENTIONAL BANK IN INDONESIA USING PARAMETRIC SFA AND DFA METHODS

Ascarya[1], Noer A. Achsani[2], Diana Yumanita and Guruh S. Rokhimah

ABSTRACT

This study will measure and compare the efficiency of Conventional and Islamic banks in Indonesia using parametric approach stochastic frontier approach (SFA) and distribution free approach (DFA). These measurements will provide comprehensive and robust results of efficiency of individual bank compare to its peer group.

The results using parametric SFA show that in 2002, conventional banks (0.79) were slightly more efficient than Islamic banks (0.77), while in 2003, the efficiency of Islamic banks improved to 0.84 and the efficiency of conventional banks worsen to 0.76, so that Islamic banks have become more efficient than conventional banks. Conventional and Islamic banks have been improving and converged to the highest level of efficiency (1.00) since 2004. The DFA results show that conventional banks (0.89) are only slightly more efficient than Islamic banks (0.87). Conventional public bank (0.93) is the most efficient, while Islamic regional bank (0.84) is the least efficient. Moreover, efficient banks (conventional and Islamic) do not always have lower OCOI (operating costs divided by operating income), while banks with better OCOI usually are more profitable (have better return on assets or ROA). Therefore, technically, Islamic banks have shown their readiness to compete head to head with their conventional counterparts. However, other aspects, such as, number of networks and branches, service quality, convenience, products and services provided, human resources, and pricing, should have become the next priorities for improvements.

JEL Classification: C10, C33, G21, G28

***Keywords**: Islamic Banking, Efficiency, Stochastic Frontier Approach, Distribution Free Approach*

---

[1] Center for Central Banking Education and Studies, Bank Indonesia Jl. M.H. Thamrin 2, Sjafruddin Prawiranegara Tower, 20th fl., Jakarta 10110, Indonesia Email: ascarya@bi.go.id; achsani@yahoo.com; diana_yumanita@bi.go.id; guruh_sr@bi.go.id

[2] Visiting researcher from International Center for Applied Finance & Economics (InterCAFÉ), Department of Economics, Faculty of Economics and Management, Bogor AgricultureUniversity.

1. INTRODUCTION

1.1 Background

Islamic banks have been in existence since early 1960s. The first Islamic bank established in 1963 as a pilot project in the form of rural savings bank in a small town of Egypt, Mit Ghamr. After that, Islamic banking movement came back to life in mid 1970s. The establishment of Islamic Development Bank in 1975 triggered the development of Islamic banks in many countries, such as Dubai Islamic Bank in Dubai (1975), Faisal Islamic Bank in Egypt and Sudan (1977), and Kuwait Finance House in Kuwait (1977).

Joharris (2007) predicted that there are over 276 Islamic financial institutions (IFI) in the world, spread over 70 countries - sprawling from London, New York and Zurich to the Middle East, Africa and Asia with capitalization in excess of US$13 billion. These include banks, mutual funds, mortgage companies and takaful providers. The pool of money held by Muslim is predicted more than US$3.0 trillion. At present, there is an estimated US$1 trillion Islamic fund in the market. Moreover, global Islamic capital market is growing at 15% - 20% per annum, including deposits in Islamic banks which are estimated to be over US$560 billion. A large part of the banking and Takaful concentration is in Bahrain, Malaysia, and Sudan. A significant part of mutual funds concentrate in the Saudi Arabian and Malaysian markets in addition to the more advanced international capital markets.

In Indonesia, Islamic financial institutions started to emerge in early 1980s with the establishment of *Baitut Tamwil-Salman* in Bandung dan *Koperasi Ridho Gusti* in Jakarta. The first Islamic Bank in Indonesia, Bank Muamalat Indonesia, established in 1992. The development of Islamic bank has been accelerated since Bank Indonesia (the central bank of Indonesia) allowed conventional banks to open Islamic branch. This Islamic branch can offer Islamic banking products and services separated from its conventional parent with its own infrastructure, including staff and branches.

By June 2008, the Islamic banking system in Indonesia is represented by 3 Islamic banks, 28 Islamic branches, and 124 Islamic Rural Banks, with 743 offices and more than 1250 office channeling spread throughout the country. They offer comprehensive and wide range of Islamic financial products and services and cater 2.08% of the banking market share. It is expected that the Islamic banking industry in Indonesia would reached 5% of the banking market share in 2011.

Despite these impressive achievements, Islamic banking in Indonesia has experiencing a slower growth in the past two years. There are many factors that could be attributed to this slower growth. One of these factors is the competitiveness of Islamic Banks within the banking system, since, under dual banking system, they have to compete head to head with conventional banks.

One important aspect of competitiveness is efficiency. Inefficiency would become a great disadvantage to face a fierce competition in the banking industry. To win the competition, Islamic banks should know the strengths and weaknesses of themselves as well as of their competitor. Know yourself and know your competitor is a halfway to success. Therefore, analysis of the efficiency of Islamic banks in comparison with conventional banks is very important to provide a big picture of the strengths and weaknesses of Islamic banks and their competitors.

Despite of the importance, there are very limited studies comparing the efficiency of Islamic and conventional banks within a country using parametric and nonparametric approach, especially in Indonesia. Therefore, there should be a study that measure efficiency of Islamic and conventional banks using parametric and nonparametric approaches in Indonesia to provide comparison and to improve the robustness of previous measurements. These measures could also be used as a guide for Islamic banks to improve their weaknesses to be able to compete head to head with conventional banks and to achieve the intended goals to improve the market share. Moreover, the goal to strengthen Islamic banking structure could be achieved.

1.2 Objective

The objective of this study is to measure and compare the efficiency of conventional and Islamic banks in Indonesia using parametric approach stochastic frontier approach (SFA) and distribution free approach (DFA). These measurements will provide comprehensive and robust results of efficiency of individual bank compare to its peer group.

1.3 Scope of Study

Islamic banks included in this study are all full fledged Islamic banks and business unit Islamic banks in Indonesia, while conventional banks included in this study, to be comparable, are those with asset less than one million US Dollar in real term. The measurement will compare the efficiency of conventional and Islamic banks in Indonesia using parametric approach (SFA and DFA).

1.4 Data and Methodology

The time frame of this study is 2002 – 2006. The data used in this study are the data of published annual financial statements (balance sheets and income statements) of conventional and Islamic banks in Indonesia, with total asset less than one million US Dollar in real term.

This study will apply stochastic frontier approach (SFA) and distribution free approach (DFA). SFA and DFA are two well known parametric approaches to measure efficiency using cross section or panel data of multiple inputs and outputs of business units. The advantage of these approaches is that they can eliminate the impact of disturbance to efficiency. The efficiency produced is a relative efficiency based on observed data.

1.5 Benefit of the Study

The results of this study will be very useful for many stakeholders of conventional and Islamic banks in Indonesia, especially the regulator (Bank Indonesia), to formulate appropriate policy recommendations to improve the synergy between conventional and Islamic banks in facilitating intermediation to the real sector. Moreover, conventional and Islamic banks in Indonesia will also benefit from this study to see where they are in the competitiveness of the banking system.

2. LITERATURE REVIEW

Banking efficiency has been a very important issue in a transition economy. All countries in transition have been encounter at least with one banking crisis, and many with more than one crisis (Jemrić and Vujčić, 2002). Banking efficiency is also an important issue in a developing open economy, since most of them have also been faced a banking crisis in the past, and Indonesia is no exception. There are many studies about banking efficiency using parametric methods, such as SFA and DFA. Moreover, those studies are applied to conventional as well as Islamic banks.

SFA and DFA have been used for some studies to measure the X-efficiency of commercial bank or other financial institutions such as studies that were conducted by Allen and Rai (1996), Semih and Philippatos (2001), Hadad *et al*. (2003), Saaid *et al.* (2003), Hussein (2004), Hassan (2003 and 2006). The firs tree studies measure the efficiency of conventional banks, while the last four studies measure the efficiency of Islamic banks. Allen and Rai (1995) measured operational efficiency in banking internationally during 1988-1992 using SFA and DFA, Yildirim and Philippatos (2005) measured the efficiency of banks in Europe during 1993-2000 using SFA and DFA to evaluate impact of transition economies to bank's efficiency, while, Hadad *et al*. (2003) used SFA and DFA methods to measure the efficiency of banks in Indonesia during 1995-2003. Meanwhile, Saaid *et al.* (2003) measured Islamic banking x-efficiency (technical and allocative efficiencies) in Sudan using SFA, Hussein (2004) compared the efficiency of Islamic and conventional banks in Bahrain during 1985-2001 using SFA (profit efficiency), Hassan (2003) measured the efficiency of Islamic banks in Pakistan, Iran, and Sudan during 1994-2001 using SFA (cost and profit efficiencies) and DEA (cost, allocative, technical, pure technical, and scale efficiencies), while Hassan (2006) measured the efficiency of Islamic banking industry in the world during 1995-2001 using SFA (cost and profit efficiencies) and DEA (cost, allocative, technical, pure technical, and scale efficiencies).

Table 2.1 Summary of Parametric Approach Applied

No	Author	Functional Form	Input	Output
1	Allen & Rai '96	Translog	Price of labor, price of capital, price of borrowed funds	Loans, investment assets

2	Hadad et al. '03	Translog	Price of labor, price of funds	Loans to the bank, loans to the stakeholder (exclude bank), securities
3	Yildirim & Philippatos '05	Multiproduct Translog	Price of borrowed funds, price of labor, price of physical capital	Loans, investment, deposit
4	Saaid *et al.* '03	Translog	Price of labor, price of fixed capital, price of deposit	Investment asset
5	Hussein '04	Fourier Flexible	Price of labor, price of fund, price of physical capital	Financing; investment, off-BS items
6	Hassan '03 & '06	Translog	Price of labor, price of capital, price of fund	Total loan, other earning assets, off-BS items

Functional form:

No	Functional Form
1	<u>Cost Efficiency:</u> $\ln TC = \alpha_o + \sum_{i=1}^{2} \alpha_i (p_i) + \sum_{j=1}^{2} \beta_j \ln(y_j) + 0.5 \sum_{i=1}^{2} \sum_{k=1}^{2} \alpha_{ik} (p_i)(p_k) + 0.5 \sum_{j=1}^{2} \sum_{h=1}^{2} \beta_{jh} \ln(y_j) \ln(y_h) + \sum_{i=1}^{2} \sum_{j=1}^{2} \delta_{ij} y_i \ln p_j + \sum_{l=1}^{4} \gamma_l YR_l + \varepsilon$ ***TC*** total operating and interest costs, p_i price of inputs (p_1 price of labor, p_2 price of fixed capital, p_3 price of borrowed funds), y_i output amounts (y_1 traditional banking assets [loan], y_2 investment assets), ***YR*** dummy of time period, $\varepsilon = v + u$, v random error, u inefficiency
3	<u>Cost Efficiency:</u> $\ln(C / w_3 z) = \alpha + \sum_{l=1}^{2} \alpha \ln(w_1 / w_3) + 0.5 \sum_{l=1}^{2} \sum_{h=1}^{2} \omega_{lh} \ln(w_1 / w_3) \ln(w_1 / w_3) + \sum_{k=1}^{3} \beta_k \ln(y_k / z)$ $+ 0.5 \sum_{k=1}^{3} \sum_{j=1}^{3} \beta_{kj} \ln(y_k / z) \ln(y_k / z) + \sum_{k=1}^{3} \sum_{l=1}^{2} \delta_{lk} \ln(y_k / z) \ln(w_1 / w_3) + \varphi_1 \ln Z$ $+ 0.5 \varphi_2 (\ln Z)^2 + \sum_{k=1}^{3} \tau_k \ln(y_k / z) \ln Z + \sum_{l=1}^{2} \varsigma_l \ln(w_l / w_3) \ln Z + \ln e_{ti} + \ln u_{it}$ <u>Profit Efficiency:</u> $\ln(C / w_3 z)$ is replaced by $\ln(P / w_3 z)$ and the inefficiency term is $-u$. C total interest, personnel and other operational expenses, w_i input prices, y_i output amounts, z equity capital, e random error, u inefficiency
4	<u>Cost Efficiency:</u> $\ln TC = \alpha_0 + \sum_{i=1}^{3} \ln w_1 + 0.5 \sum_{i=1}^{3} \sum_{j-1}^{3} \gamma_{ij} \ln w_i w_{j+} \sum_{i=1}^{3} \gamma_{ij} \ln w_{i+} \beta \ln y + 0.5 \beta_{yy} (\ln y)^2 + \varepsilon$ ***TC*** total cost, w_i price of inputs (w_1 price of labor, w_2 price of fixed capital, w_3 price of deposit), y investment asset, $\varepsilon = v + u$, v random error, u inefficiency
5	<u>Profit Efficiency:</u> $\ln \pi = \alpha_0 + \sum_{l=1}^{3} \alpha_i \ln Q_i + \sum_{j=1}^{3} \beta_j \ln P_j + 0.5 \sum_{i=1}^{3} \sum_{k=1}^{3} \gamma_{ik} \ln Q_i \ln Q_k + 0.5 \sum_{j=1}^{3} \sum_{h=1}^{3} \theta_{jh} \ln P_j \ln P_h$ $+ \sum_{i=1}^{3} \sum_{j=1}^{3} \varphi_{ij} \ln Q_i \ln P_j + \sum_{i=1}^{3} [\rho_i \cos(Q_i) + \omega_i \sin(Q_i)]$ $+ \sum_{i=1}^{3} \sum_{j=1}^{3} [\phi_i \cos(Q_i + Q_j) + \lambda_{ij} \sin(Q_i + Q_j)] + \ln v_{a\pi} + \ln u_{a\pi}$ π net profit, Q_i output amounts (Q_1 financing, Q_2 investments, Q_3 off-balance sheet items), P_i price of inputs (P_1 price of labor, P_2 price of fund, P_3 price of physical capital), v random error, u inefficiency, $\varepsilon = v + u$

6	Cost Efficiency: $\ln C_b = \alpha_o + \sum_{i=1}^{3} \beta_i \ln(y_i) + \sum_{k=1}^{3} \gamma_k \ln(p_k) + 0.5 \sum_{i=1}^{3} \sum_{j=1}^{3} \beta_{ij} \ln(y_i) \ln(y_j) + 0.5 \sum_{l=1}^{3} \sum_{m=1}^{3} \gamma_{lm} \ln(p_l) \ln(p_m) + \sum_{i=1}^{3} \sum_{k=1}^{3} \rho_{ik} \ln y_i \ln p_k + \varepsilon_b$ Profit Efficiency: $\ln(\pi + a) = \alpha_o + \sum_{i=1}^{3} \alpha_i \ln Y_{ist} + \sum_{i=1}^{3} \beta_i \ln P_{ist} + 0.5 \sum_{i=1}^{3} \sum_{j=1}^{3} \sigma_{ij} \ln Y_{ist} \ln Y_{jst} + 0.5 \sum_{k=1}^{3} \sum_{l=1}^{3} \delta_{kl} \ln P_{kst} \ln P_{lst} + \sum_{k=1}^{3} \sum_{i=1}^{3} \mu_{ki} \ln P_{kst} \ln Y_{ist} + v_{st} + u_{st}$ ***C*** variable cost, $\boldsymbol{Y_i}$ output amounts ($\boldsymbol{Y_1}$ total loan, $\boldsymbol{Y_2}$ other earning assets, $\boldsymbol{Y_3}$ off-balance sheet items), $\boldsymbol{P_i}$ price of input ($\boldsymbol{P_1}$ price of labor, $\boldsymbol{P_2}$ price of capital, $\boldsymbol{P_3}$ price of fund), $\boldsymbol{\pi}$ net profit, $\boldsymbol{v}$ random error, $\boldsymbol{u}$ inefficiency, $\boldsymbol{\varepsilon = v + u}$

From those studies, it can be summarized that most studies apply cost and profit efficiencies of SFA using translog or its derivatives functional form. The dependent variable is cost or profit, respectively, while the independent variables are input prices and output amounts. Off-balance sheet items are added as output to improve the efficiency estimates, especially for Islamic banking, since restricted investment accounts are not recorded in the balance sheet and considered as off-balance sheet items.

3. METHODOLOGY

Three well known approaches that widely applied to measure efficiency are parametric Stochastic Frontier Analysis (SFA) and Distribution Free Analysis (DFA), as well as nonparametric Data Envelopment Analysis (DEA). SFA, DFA and DEA applications are derived from the theory of efficiency. Therefore, this chapter will first discuss the theory of efficiency, the measurement of efficiency, the connection of SFA, DFA and DEA to efficiency theory, and then discuss SFA and DFA in details. Moreover, bank's efficiency can be measured from its functions. Three approaches to measure the efficiency of bank's functions are intermediation approach, production approach, and modern or asset approach. The theory of efficiency in general, its relation to SFA, DFA and DEA, and the measurement of bank's efficiency can be described in figure 3.1.

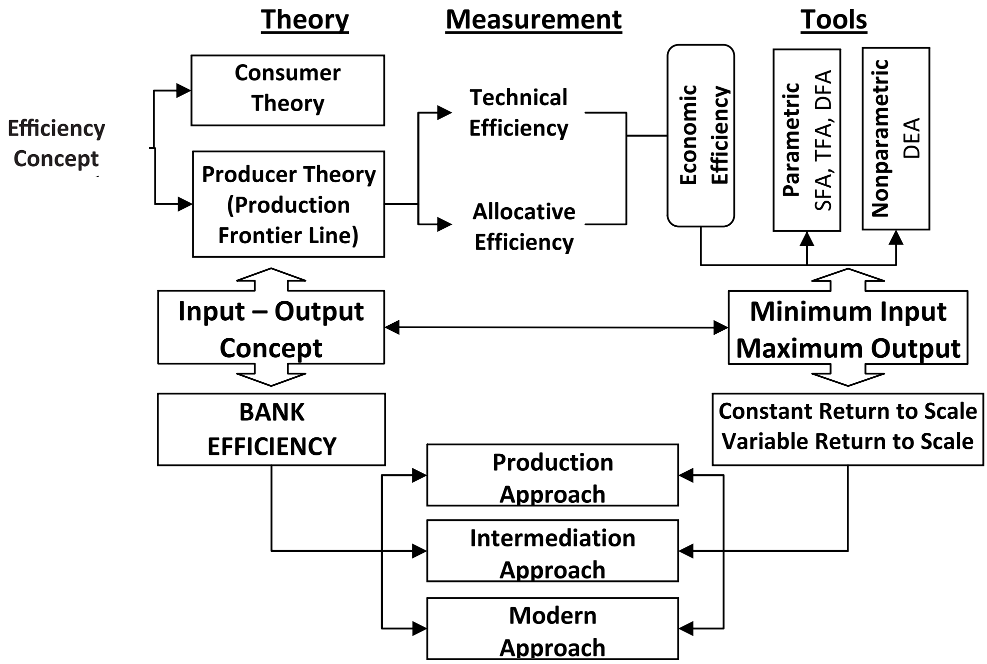


Figure 3.1 Theory of Efficiency

3.1 The Theory of Efficiency

The concept of efficiency rooted from the microeconomic concept, namely, consumer theory and producer theory. Consumer theory tries to maximize utility or satisfaction from individual point of views, while producer theory tries to maximize profit or minimize costs from producer point of views.

In the producer theory, there is a production frontier line that describes the relationship between inputs and outputs of production process. This production frontier line represents the maximum output from the use of each input. It also represents the technology used by a business unit or industry. A business unit that operates on the production frontiers is technically efficient. Figure 3.2 shows the production frontier line.

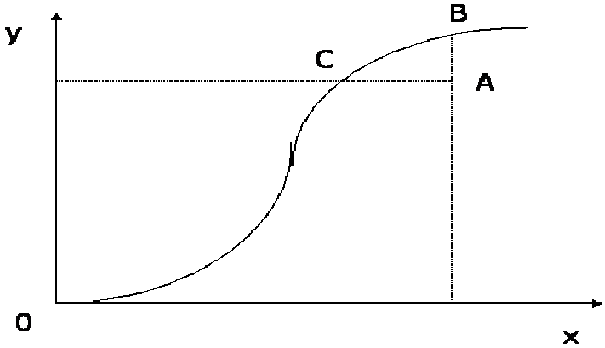


Figure 3.2 Production Frontier Line

Considered from economic theory, there are two different types of efficiency, namely technical efficiency and economic efficiency. Economic efficiency has macro economic point of view, while technical efficiency has micro economic point of view. The measurement of technical efficiency limited to technical and operational relationship in a conversion process of input to output. Whereas, in economic efficiency price can not be considered as given, since price can be influenced by macro policy (Sarjana, 1999). According to Farell (1957), efficiency comprises of two components, namely:

a. Technical efficiency describes the ability of a business unit to maximize output given certain amount of input.

b. Allocative efficiency describes the ability of a business unit to utilize inputs in optimal proportion based on their price.

When the two types of efficiency combined, it will produce economic efficiency. A company is considered to be economically efficient if it can minimize the production costs to produce certain output within common technology level and market price level.

Kumbhaker and Lovell (2000) argue that technical efficiency is only one of many components economic efficiency as a whole. Nevertheless, in order to achieve economic efficiency a company should produce maximum output with certain amount of input (technical efficiency) and produce output with the right combination within certain price level (allocative efficiency).

3.2 The Measurement of Efficiency

In the past few years, performance measurement of financial institution has increasingly focused on frontier efficiency or X-efficiency (rather than scale efficiency), which measures deviation in performance of a financial institution from the best practices or costs-efficient frontier that depicts the lowest production costs for a given level of output. X-efficiency stems from technical efficiency, which gauges the degree of friction and waste in the production processes, and allocative efficiency, which measures the levels of various inputs.

Frontier efficiency is superior for most regulatory and other purposes to the standard financial ratios from accounting statements, such as, return on asset (ROA) or cost/revenue ratio, that are commonly employed by regulators, managers of financial institutions, or industrial consultants to assess financial performance. This is because frontier efficiency measures use programming or statistical techniques that removes the effects of differences in input prices and other exogenous market factors affecting the standard performance ratios in order to obtain better estimates of the underlying performance of the managers (Bauer *et al.*, 1998).

Frontier efficiency has been used extensively in regulatory analysis to measure the effects of merger and acquisition, capital regulations, deregulation of deposit rates, removal of geographic restrictions on branching and holding company acquisitions, etc., on financial institution performance. Furthermore, Bauer *et al.* (1998) argue that the main advantage of frontier efficiency over other indicators of performance is that it is an objectively determined quantitative measure that removes the effects of market prices and other exogenous factors that influence observed performance.

Tools to measure efficiency could be parametric and non-parametric. Parametric approach to measuring efficiency uses stochastic econometric and tries to eliminate the impact of disturbance to inefficiency. There are three parametric econometric approaches, namely:

1. Stochastic frontier approach (SFA);
2. Thick frontier approach (TFA); and
3. Distribution-free approach (DFA).

These approaches differ in the assumptions they make regarding the shape of the efficient frontier, the treatment of random error, and the distributions assumed for inefficiencies and random error. The parametric methods have disadvantages relative to the non-parametric methods of having to impose more structure on the shape of the frontier by specifying a functional form for it. However, an advantage of the parametric methods is that they allow for random error, so these methods are less likely to misidentify measurement error, transitory differences in cost, or specification error for inefficiency (Bauer *et al.*, 1997).

Meanwhile, non-parametric linear programming approach to measuring efficiency uses non-stochastic approach and tends to combine disturbance into inefficiency. This is built based on discovery and observation from the population and evaluates efficiency relative to other units observed. One of the non-parametric approaches, known as data envelopment analysis (DEA), is a mathematical programming technique that measures the efficiency of a decision making unit (DMU) relative to other similar DMUs with the simple restrictions that all DMUs lie on or below the efficiency frontier (Seiford and Thrall, 1990). The performance of a DMU is very relative to other DMUs, especially those that cause inefficiency. This approach can also determine how a DMU can improve its performance to become efficient.

DEA was first introduced by Charnes, Cooper, and Rhodes in 1978. Since then its utilization and development have grown rapidly including many banking-related applications. The main advantage of DEA is that, unlike regression analysis, it does not require an a priori assumption about the analytical form of the production function so imposes very little structure on the shape of the efficient frontier. Instead, it constructs the best practice production function solely on the basis of observed data, and therefore the possibility of misspecification of the production technology is zero. On the other hand, the main disadvantage of DEA is that the frontier is sensitive to extreme observations and measurement error (the basic assumption is that random errors do not exist and that all deviations from the frontier indicate inefficiency). Moreover, there exists a potential problem of "self identifier" and "near-self-identifier".

3.3 Parametric Approaches: SFA and DFA

The parametric methods of SFA and DFA have been widely used to analyze efficiency of banking industry, especially in the US and other well-developed countries (see, among others, Berger, Hunter and Timme (1993), Berger and Humphrey (1997), Berger and Mester (1997) for an extensive review of literature on efficiency of financial institution). The two methods have also been used in the previous researches on the efficiency of banking industry in the transition countries. For more details see for example Yildirim and Philippatos (2003) for central and east European countries, Bhattacharya *et al.* (1997) and Srivastava (1999) for India, Hasan and Marton (2000) for Hungary, and Isik and Hassan (2002) for Turkey.

3.3.1 The Cost and Profit Frontiers

Before going into the details about measuring efficiency, it is important to discuss the concept of cost and profit efficiencies. For further readings, please refer to Berger and Mester (1997), Yildirim and Philippatos (2003), Hussein (2004), Hassan (2003 and 2006) and Hasan (2007). Cost efficiency measure the performance of banking firm relative to the best-practice bank that produces the same output bundle under the same exogenous condition. The cost frontier is determined by estimating the following cost function:

$$C=C(y,w,z,u,e)$$

where $\boldsymbol{C}$ measures total costs for bank, $\boldsymbol{y}$ is a vector of outputs, $\boldsymbol{w}$ is vector of input prices, $\boldsymbol{z}$ represents the quantities of fixed bank parameters, $\boldsymbol{u}$ is the inefficiency term that captures the difference between the efficient level of cost for given output levels and input prices and actual cost, and $\boldsymbol{e}$ is the random error term.

Assuming the inefficiency and random error term are multiplicatively separable from the rest parameters, the above cost function can be expressed in logarithmic form as follows:

$$\ln C = f(y,w,z)+\ln u+\ln e$$

After estimating a particular cost function, the cost efficiency for bank i is measured as the ratio between cost ($\boldsymbol{C}_{\mathbf{min}}$) necessary to produce that bank's output and the actual cost ($\boldsymbol{C}_{\mathrm{i}}$) :

$$COSTEFF_i = \frac{C_{min}}{C_i} = \frac{\exp[f(y,w,z)]x \exp(\ln u_{min})}{\exp[f(y,w,z)]x \exp(\ln u_i)} = \frac{u_{min}}{u_i}$$

Where, $\boldsymbol{u}_{\mathbf{min}}$ is the minimum $\boldsymbol{u}_{\mathbf{i}}$ across all the samples.

Profit efficiency measures how close a bank is attaining the possible profit as a best-practice firm on the frontier for given levels of input and output prices and other exogenous variables. Previous studies offered two different approaches for calculating profit maximization objective, namely standard and alternative profit function. However, as the situation in Indonesia and Malaysia, Berger and Mester (1997) suggested that the alternative profit specification is preferred over the standard specification when (a) there are differences in the quality of banking services, (b) markets are not perfectly competitive, (c) outputs are not completely variable and (d) output prices are not available.

The alternative profit frontier is formulated as follows:

$$P=P(y,w,z,u,e)$$

Where, ***P*** is the variable profits of the firm. Furthermore, in line with the formulation of cost function, the profit function can be expressed in log terms as follows:

$$\ln (P + \theta) = f(y,w,z) + \ln e - \ln u$$

Where **θ** is a constant added to every bank's profit to make it positive, so that the natural log can be obtained. Profit efficiency is measured by the ratio between the actual profit of a bank and the maximum possible profit that is achieved by the most efficient bank.

$$PROFEFF_i = \frac{P_i}{P_{max}} = \frac{\exp[f(y,w,z)]x \exp(\ln u_i)\ u_i - \theta}{\exp[f(y,w,z)]x \exp(\ln u_{max}) - \theta}$$

Where, $\boldsymbol{u}_{\mathbf{max}}$ is the maximum $\boldsymbol{u}_{\mathbf{i}}$ of all banks in the sample.

3.3.2 The SFA and DFA

The Stochastic Frontier Approach (SFA) SFA asserts that managerial or controllable inefficiencies can only increase costs (reduce profits) above (below) best-practice frontier and that random fluctuations or uncontrollable factors can increase or reduce cost (profits). Therefore, the model assumes that inefficiency measures, (**ln *u***), which represent the departure from efficient frontier follow an asymmetric half-normal distribution, while random fluctuations are distributed as two-sided normal with a zero mean and variance $\boldsymbol{\sigma}^2$.

The Distribution Free Approach (DFA) tries to avoid the arbitrary assumptions of the stochastic frontier approach, where panel data are available. This approach also separates the composite error term into inefficiency and statistical noise component. However, it assumes that there exists a core inefficiency for banks, which persists over time while the random error part vanishes out over time (Berger 1993 in Yildirim and Philippatos 2003). According to DFA, inefficiency estimate of a bank is determined by the difference between average residual of the bank ***i***, (**ln *u***), and the average residual of the bank on the frontier (**ln u_{min}**), assuming that the random errors will cancel out over time. The estimated average residual is than transformed into a measure of efficiency:

$$EFF_i = \exp(\ln u_{min} - \ln u_i)$$

Where, **ln u_{min}** is the average residual for the bank with the lowest average cost residual. The most efficient bank will be given score 1, and then the others will get score between 0 – 1.

3.3.3 Functional Form

Following Yildirim and Philippatos (2003), we employ the multiproduct translog functional form to estimate cost and alternative profit frontiers. The cost frontier function is represented by:

$$\ln(C/w_3 z) = \alpha_0 + \sum_{l=1}^{2} \alpha_l \ln(w_i / w_3) + 0.5 \sum_{l=1}^{2} \sum_{h=1}^{2} \omega_{lh} \ln(w_l / w_3) \ln(w_i / w_3)$$

$$+ \sum_{k=1}^{3} \alpha_l \ln(y_k / z) + 0.5 \sum_{k=1}^{3} \sum_{j=1}^{3} \beta_{kj} \ln(y_k / z) \ln(y_j / z)$$

$$+ \sum_{k=1}^{3} \sum_{l=1}^{3} \delta_{lk} \ln(y_k / z) \ln(w_l / w_3) + \varphi_1 \ln Z + 0.5 \varphi_2 (\ln Z)^2$$

$$+ \sum_{k=1}^{3} \tau_l \ln(y_k / z) \ln Z + \sum_{l=1}^{2} \varsigma_l \ln(w_l / w_3) \ln Z + \ln e_{ti} + \ln u_{it}$$

where w_i and y_i are input prices and output amounts and z is the equity capital. We impose the regular restrictions of symmetry and linear homogeneity for input prices in estimating the parameters as follows:

$$\beta_{kj} = \beta_{jk}, \ \omega_{lh} = \omega_{hl} \ ; \ \sum_{l=1}^{3} \alpha_l = 1, \quad \sum_{h=1}^{3} \alpha_h = 1, \quad \sum_{l=1}^{3} \delta_{lk} = 1$$

Cost and input prices are normalized by the price of capital before taking logarithms to impose linear input price homogeneity.

The alternative profit frontier estimation employs essentially the same specification as cost function with some minor changes. For the profit frontier estimation, the dependent variable **ln(*C/w₃z*)** is replaced by **ln(*P/w₃z*)** and the inefficiency term is ***–u***. Cost, profit and output variables are normalized by equity capital (***z***) to control the heteroscedasticity, scale and other estimation biases in addition to providing a more economic meaning.

3.4 Measuring the Activity of Banks

The efficiency measurement, parametric or non-parametric, of financial institution like banks can be approached from their activities. There are three main approaches to explain the relationship between input and output of banks. Two approaches, namely, production (or operational) approach and intermediation approach, apply the classical microeconomic theory of the firm, while one approach, namely modern (or assets) approach applies modified classical theory of the firm by incorporating some specificities of banks' activities, namely risk management and information processing, as well as some form of agency problems, which are crucial for explaining the role of financial intermediaries (Freixas and Rochet, 1998).

3.4.1 Production Approach

The production approach describes banking activities as the production of services to depositors and borrowers using all available factors of production, such as labor and physical capital. This approach, initiated by Benston (1965) and Bell and Murphy (1968), considers banks as producer of deposit accounts to depositors and loans to borrowers. Therefore, this approach defines input as number of workforce, capital expenses on fixed assets and other materials, and defines output as the sum of all deposit accounts or other related transactions.

According to Freixas and Rochet, (1998), the production approach suits well the case of a local branch that is "financially transparent" in the sense that the money collected from depositors is fully transferred to some main branch. Similarly, all the money lent to borrowers is made available by the same main branch. The only outputs of the local branch are its services to depositors and borrowers, and its only inputs are labor and physical capital.

Parametric measurement of production approach has some difficulties. *First*, disaggregation of costs prevents the study of scale and scope economies. *Second*, production approach suffers from a basic problem on what the relevant measure of output volumes is. *Third*, Cobb-Douglas specification for monotonicity of average cost prevents the existence of an efficient size.

The first difficulty has been addressed by Baumol, Panzar, and Willig (1982) and the existence of Functional Cost Analysis (FCA) program that allowed separate cost functions to be estimated for all product lines. Disaggregated cost data for five categories of banking activities identified are demand deposits, term and savings deposits, real estate loans, consumer loans, and business loans. Cost functions of the Cobb-Douglas type (one per activity $\boldsymbol{i}$) are as follows:

$$\log C_i = \varepsilon_i \log Q_i + a_i \log w_i + (1 - a_i) \log r_i + const$$

$\boldsymbol{i}$ = 1, …, 5, $\boldsymbol{C_i}$ (total cost), $\boldsymbol{Q_i}$ (volume of output), $\boldsymbol{w_i}$ (wage rate), $\boldsymbol{r_i}$ (interest)

The second difficulty is to choose output volume among the number of accounts, the number of operations on these accounts, or the dollar amounts. Among these three output volumes, the dollar amounts are more readily available. To correct possible biases, heterogeneity factors for homogenizing the data (size, activity, and composition of accounts) are introduced.

The third difficulty, the monotonicity of average cost (increasing if ε_i > 1, decreasing if ε_i < 1, and constant if ε_i = 1), has been addressed by Benston, Hanweck, and Humprey (1982) by applying a more convenient specification of translog cost function, in which the logarithm of the cost is quadratic with respect to the logarithms of output and input prices. They find that a U-shaped average cost function with an efficient size between 10 and 25 million dollars of deposits, which is surprisingly small (Freixas and Rochet, 1998).

Moreover, Gilligan and Smirlock (1984), Gilligan, Smirlock, and Marshall (1984), Berger, Hanweck, and Humprey (1987), and Kolari and Zardhooki (1987) use a multiproduct cost function, which allows the discussion of scope economies and cost complementarities. But, the results are not conclusive (Freixas and Rochet, 1998).

3.4.2 Intermediation Approach

The intermediation approach describes banking activities as intermediary in charge of transforming the money borrowed from depositors (surplus spending units) into the money lent to borrowers (deficit spending units). In other words, deposits that are typically divisible, liquid, short-term, and risk less are transformed into loans that are typically indivisible, illiquid, long-term, and risky. Therefore, this approach defines input as financial capital (the deposits collected and the funds borrowed), and defines output as the volume of loans and investment outstanding.

According to Freixas and Rochet, (1998), the intermediation approach is complimentary to the production approach and is more appropriate to the case of a main branch, which is not directly in contact with customers. In this case, the total volume of loans granted by the local branches is in general different from the total volume of deposit collected. Therefore, the main branch may have to borrow (or invest) on financial markets.

Results of parametric measurement of the intermediation approach do not differ substantially from those of the production approach. But, this approach also has some difficulties. *First*, there is problematic behavior in determining deposits as output or input. There is not enough supporting argument in selecting the variables and their positions. *Second*, there is problematic behavior of the multi-product translog cost function when some of the outputs tend toward zero (the logarithms become infinite).

On the first problem, one interesting findings are given by Hancock (1991) who runs a linear regression of bank's profit on the real balances of the items in bank's balance sheet without presuming a priori which correspond to outputs and which to inputs. When these coefficients are positive they correspond to outputs (intuitively, the bank's profit increases when they increase), and when they are negative they are correspond to inputs. She found that loans and ***demand deposits are outputs***;

whereas labor, physical capital, materials, and cash are inputs. However, Hughes and Mester (1993) found that ***deposits are inputs.***

On the second problem, several contributions have tried to correct it. For example, Hunter, Timme, and Yang (1990) use another specification (Minflex-Laurent) of the cost function, and McAllister and McManus (1992) adopt nonparametric approach.

3.4.3 Modern Approach

The modern approach tries to improve the first two approaches by incorporating risk management, information processing, and agency problems into the classical theory of the firm. This approach introduces a possible discrepancy between bank's manager and owner in profit maximization behavior. If bank's managers are not risk neutral, they will typically chose a level of financial capital that is different from the cost minimizing one.

Parametric measurement of the modern approach done by Hughes and Mester (1994) find that, for larger banks, an increase in size (holding default risk and asset quality constant) significantly lowers the price of uninsured funds (too big to fail). Moreover, Berger and De Young (1997) find support for the "bad luck hypothesis" (problem loans cause banks to increase spending on monitoring). Also, "decreases in bank capital ratios generally precede increases in non-performing loans…evidence that thinly capitalized banks may respond to moral hazard incentives by taking increased portfolio risks" (Freixas and Rochet, 1998).

4. DATA ANALYSIS

4.1 Data Description

The data needed for this empirical analysis comes from financial statements of conventional and Islamic banks in Indonesia in the period of 2002 – 2006. There are six types of conventional banks, namely public bank listed on capital market, conventional domestic foreign exchange bank, conventional domestic bank, conventional regional bank, conventional mixed bank owned by domestic and foreign investors, and conventional foreign bank owned by foreigner. While Islamic banks in Indonesia are of three types, namely, full-fledged Islamic bank, conventional bank that have separate Islamic branch or Islamic business unit, and Islamic Regional Development Branches. The data of type and number of banks included in this study can be read in table 4.1.

Table 4.1 Data of Conventional and Islamic Banks

SFA and DFA	2002	2003	2004	2005	2006
Conventional	**52**	**52**	**52**	**52**	**52**
Public	3	3	3	3	3
Domestic fx	14	14	14	14	14
Domestic	10	10	10	10	10
Regional	17	17	17	17	17

Mixed	2	2	2	2	2
Foreign	6	6	6	6	6
Islamic	**7**	**7**	**7**	**7**	**7**
Domestic Full Fledged	2	2	2	2	2
Domestic Full Branch	4	4	4	4	4
Regional Full Branch	1	1	1	1	1

4.2 Results and Analysis

The efficiency of conventional and Islamic banks in Indonesia is measured in several ways by applying parametric SFA and DFA methods. In SFA, to make a comparable measurement, conventional and Islamic banks are pooled together annually to form a common frontier. All banks for each year (2002-2006) are pooled to measure efficiency. In DFA, panel data is needed, so that all series of 2002-2006 of all banks are pooled together.

The overall results of SFA and DFA measurements can be read in table 4.2 in the appendix. SFA annual results show that since 2004 conventional and Islamic banks have reached the highest efficiency of 1.0. Meanwhile, DFA aggregate results show that the average efficiency of conventional bank (0.89) is slightly better than that of Islamic bank (0.87).

Table 4.2 Summary of Parametric SFA and DFA Efficiencies

BANK	SFA					DFA
	2002	2003	2004	2005	2006	
Conventional	**0.790**	**0.760**	**1.000**	**1.000**	**1.000**	**0.89**
Public	0.803	0.777	0.997	0.999	0.999	0.93
Domestic fx	0.784	0.774	0.997	0.999	0.999	0.91
Domestic	0.716	0.756	0.997	0.999	0.999	0.88
Regional C	0.833	0.771	0.997	0.999	0.999	0.87
Mixed	0.830	0.730	0.997	0.999	0.999	0.89
Foreign	0.757	0.683	0.997	0.999	0.999	0.90
Islamic	**0.770**	**0.840**	**1.000**	**1.000**	**1.000**	**0.87**
Full Fledged	0.625	0.805	0.997	0.999	0.999	0.86
Full Branch	0.825	0.838	0.997	0.999	0.999	0.88
Regional I	0.860	0.900	0.997	0.999	0.999	0.84

Parametric SFA method requires time series data, so that the results can be grouped for each year of observation. The summary can be seen in figure 4.1.

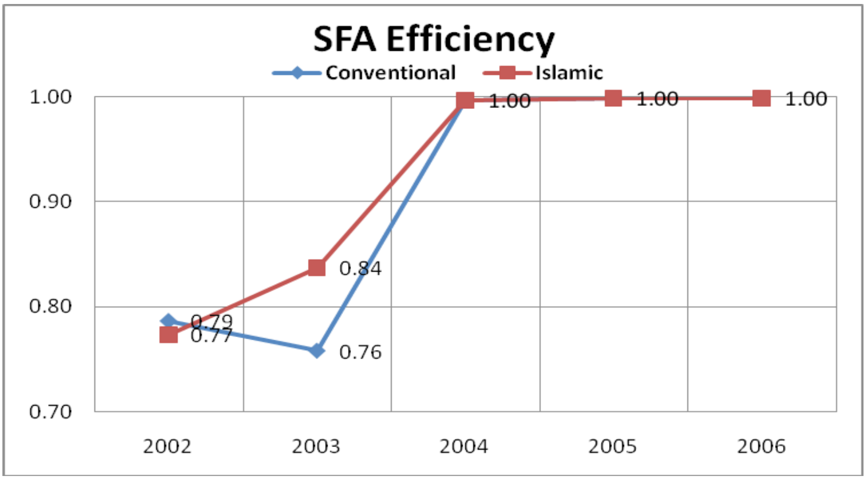
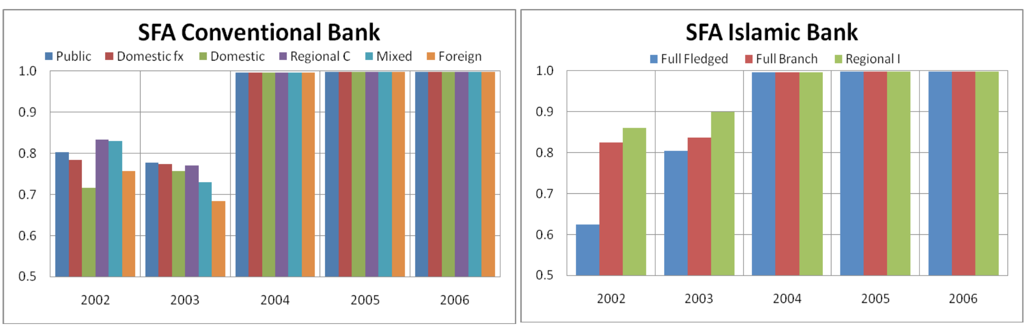


Figure 4.1 Efficiency of Conventional and Islamic Banks in Indonesia using SFA

The results in figure 4.1 show that in 2002, the average efficiency of conventional banks (0.79) is slightly better than that of Islamic banks (0.77). But in 2003, the average efficiency of Islamic banks (0.84) has improved to 0.84, while the average efficiency of conventional banks has worsened to 0.76. In 2004, average efficiencies of both banks have improved to the top level of 1.00, and have not been changed until 2006.

Figure 4.2 shows bank efficiency of each group using SFA method. In 2002, regional conventional bank was the most efficient (0.83) among conventional banks in Indonesia, while regional Islamic bank was the most efficient (0.86) among Islamic banks. In 2003, public conventional bank was the most efficient (0.78) among worsened conventional banks, while regional Islamic bank was still the most efficient (0.90) among improved Islamic banks.

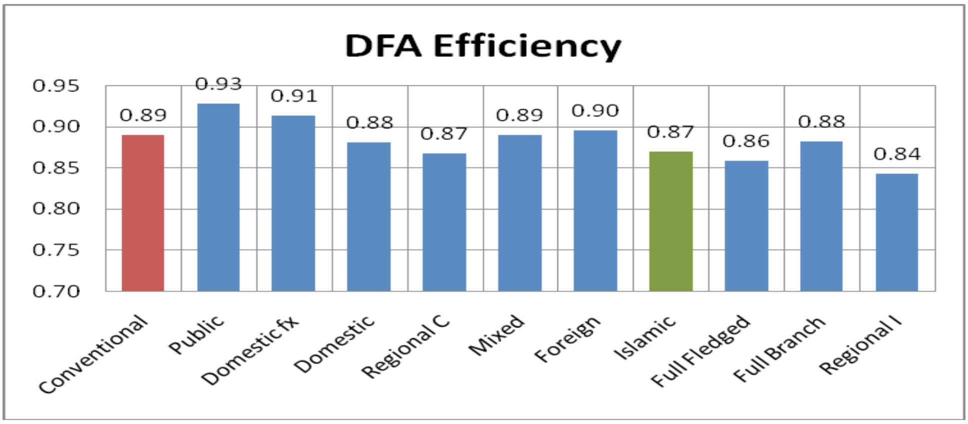


Note: Public: conventional public bank listed on capital market; Domestic fx: conventional domestic foreign exchange bank; Domestic: conventional domestic bank; Regional C: conventional regional bank; Mixed: conventional bank owned by domestic and foreign investors;

Foreign: conventional foreign owned bank; Islamic: average Islamic bank; Full Fledged: Islamic full fledged bank; Full Branch: Islamic full branch bank; Regional I: Regional Islamic bank.

Figure 4.2 Group Efficiency of Conventional and Islamic Banks in Indonesia using SFA

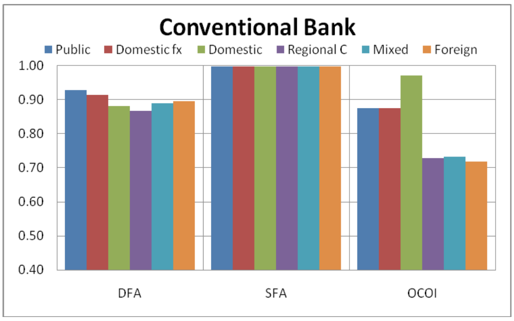
Meanwhile, parametric DFA method requires panel data with minimum complete 5 period series. Therefore, only 52 conventional banks and 7 Islamic banks can be included in the sample. The results show that conventional banks have exhibited slightly better efficiency (0.89) than that of Islamic banks (0.87) in the period of observation (2002-2006).

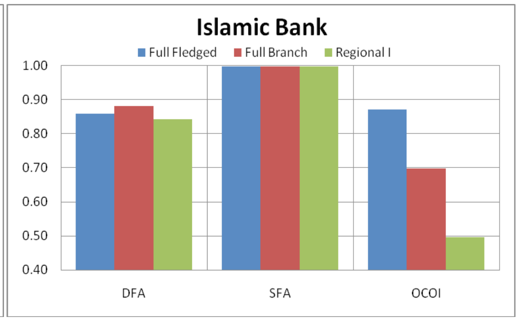


Note: Conventional: average conventional bank; Public: conventional public bank listed on capital market; Domestic fx: conventional domestic foreign exchange bank; Domestic: conventional domestic bank; Regional C: conventional regional bank; Mixed: conventional bank owned by domestic and foreign investors; Foreign: conventional foreign owned bank; Islamic: average Islamic bank; Full Fledged: Islamic full fledged bank; Full Branch: Islamic full branch bank; Regional I: Regional Islamic bank.

Figure 4.3 Group Efficiency of Conventional and Islamic Banks in Indonesia using DFA

Figure 4.3 shows bank efficiency of each group using DFA method. The figure shows that conventional public bank is the most efficient (0.93), while regional Islamic full branch is the least efficient (0.84). Overall, conventional banks are slightly more efficient than Islamic banks.





Note: Public: conventional public bank listed on capital market; Domestic fx: conventional domestic foreign exchange bank; Domestic: conventional domestic bank; Regional C: conventional regional bank; Mixed: conventional bank owned by domestic and foreign investors; Foreign: conventional foreign owned bank; Islamic: average Islamic bank; Full Fledged: Islamic full fledged bank; Full Branch: Islamic full branch bank; Regional I: Regional Islamic bank.

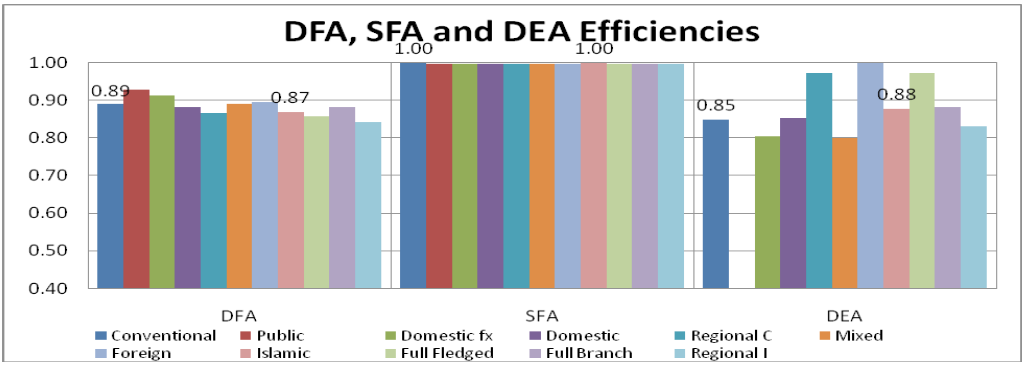
Figure 4.4 Efficiency of Conventional and Islamic Banks in Indonesia using DFA and SFA 2006 vs. OCOI 2006 Ratio

Comparing parametric measures of banks efficiencies and their respective traditional OCOI (operating costs divided by operating expenses) in figure 4.4 shows that efficient conventional banks do not always have low OCOI ratio. Moreover, banks that have better (lower) OCOI usually have better profitability (ROA), as can be read in table 4.3 in the appendix. Moreover, Islamic full branch is most DEA efficient which also have low OCOI and high ROA.

Table 4.3 Summary of Parametric SFA and DFA vs. OCOI and ROA Ratios

BANK	DFA	SFA	OCOI	ROA
Conventional	**0.890**	**1.000**		
Public	0.929	0.999	0.875	1.560
Domestic fx	0.914	0.999	0.875	1.648
Domestic	0.881	0.999	0.971	0.832
Regional C	0.867	0.999	0.729	3.760
Mixed	0.890	0.999	0.733	2.685
Foreign	0.896	0.999	0.719	3.355
Islamic	**0.870**	**1.000**		
Full Fledged	0.859	0.999	0.871	1.655
Full Branch	0.882	0.999	0.698	1.085
Regional I	0.843	0.999	0.495	4.500

If we compare the results of parametric measurement with non-parametric measurement in Ascarya *et al*. (2008), we will see the variation of results.



Note: Conventional: average conventional bank; Public: conventional public bank listed on capital market; Domestic fx: conventional domestic foreign exchange bank; Domestic: conventional domestic bank; Regional C: conventional regional bank; Mixed: conventional bank owned by domestic and foreign investors; Foreign: conventional foreign owned bank; Islamic: average Islamic bank; Full Fledged: Islamic full fledged bank; Full Branch: Islamic full branch bank; Regional I: Regional Islamic bank.

Figure 4.5 Efficiency of Conventional and Islamic Banks in Indonesia using DFA, SFA 2006, and DEA 2006

Figure 4.5 and table 4.4 show the comparison of parametric and non-parametric measures of efficiencies. It can be concluded that different approaches have given somewhat different results. DFA gives average efficiency for the observation period, where conventional banks are slightly more efficient than Islamic banks. SFA gives annual efficiency for each year of observation, where conventional and Islamic banks converge to highest efficiency in 2006. Meanwhile, DEA gives annual efficiency for each year of observation with the breakdown of overall efficiency into technical and scale efficiencies. Islamic banks are slightly more efficient than conventional banks.

Table 4.4 Summary of Parametric SFA and DFA vs. Non-parametric DEA

BANK	DFA	SFA	DEA		
			OE	TE	SE
Conventional	**0.890**	**1.000**	**0.850**	**0.884**	**0.962**
Public	0.929	0.999			
Domestic fx	0.914	0.999	0.804	0.862	0.934
Domestic	0.881	0.999	0.853	0.876	0.975
Regional C	0.867	0.999	0.974	1.000	0.974
Mixed	0.890	0.999	0.799	0.874	0.915
Foreign	0.896	0.999	1.000	1.000	1.000
Islamic	**0.870**	**1.000**	**0.877**	**0.890**	**0.985**
Full Fledged	0.859	0.999	0.973	1.000	0.973
Full Branch	0.882	0.999	0.882	0.889	0.993
Regional I	0.843	0.999	0.831	0.845	0.981

In general, SFA and DEA measures of efficiency provide similar trend of improving efficiency, especially since 2004. However, DEA measure gives more detailed results for deeper analysis.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

- Overall, it can be concluded that different approaches have given somewhat different results. DFA gives average efficiency of the period observed (2002-2006), while DFA gives the result of annual efficiency. These two different figures cannot be compared head to head, but they can complement each other for better analysis.
- DFA gives average efficiency for the observation period, where conventional banks are slightly more efficient than Islamic banks. Conventional public bank is the most efficient (0.93), while regional Islamic full branch is the least efficient (0.84). Therefore, older and bigger banks have better DFA efficiency than younger and smaller banks.
- SFA gives annual efficiency for each year of observation, where in 2002 conventional banks (0.79) were slightly more efficient than Islamic banks (0.77), while in 2003, the efficiency of Islamic banks improved to 0.84 and the efficiency of conventional banks worsen to 0.76, so that Islamic banks have become more efficient than conventional banks. Conventional and Islamic banks finally converged to highest efficiency (1.00) since 2004.
- Efficient banks (conventional and Islamic) do not always have lower OCOI (operating costs divided by operating income), while banks with better OCOI usually are more profitable (have better ROA).
- Given the DFA and SFA results, it seems that, technically, Islamic banks have shown their readiness to compete head to head with their conventional counterparts. However, other aspects should have also been considered, prepared and improved to be at par with their conventional counterparts. Those aspects, among others, are number of networks and branches, service quality, convenience, products and services provided, human resources, and pricing.

5.2 Recommendations

- Islamic banks in Indonesia are still young and small, so that socialization and expansion should be the number one priority to make Islamic bank familiar to public and to reach economies of scale and critical mass in the shortest time possible. Other than organic expansion that naturally slow, to accelerate expansion Islamic banks in Indonesia (i.e. the government) should also have the political will, commitment, and courage to expand inorganically by converting one state owned conventional bank into Islamic bank, preferably the one that have large networks.
- To be able to compete in the dual banking system, Islamic banks should strive to be at par in products and services, service quality, convenience, human resources, pricing, and networks with their conventional counterparts. These aspects should become next priorities for improvements.

REFERENCES

Allen, L. and A. Rai. "Operational Efficiency in Banking: An International Comparison," *Journal of Banking and Finance*," 20, 655-72 (1996).

Ascarya, D. Yumanita, and G.S. Rokhimah. "Efficiency Analysis of Conventional and Islamic Banks in Indonesian using Data Envelopment Analysis", *Paper,* Airlangga University International Seminar and Symposium on Implementations of Islamic Economics to Positive Economics in the World as Alternative of Conventional Economics System: Toward Development in the New Era of the Holistic Economics, Airlangga University, Surabaya, Indonesia, August 1-3 (2008).

Banker, R.D., A. Charnes, and W.W. Cooper. "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis," *Management Science* **30** (9), 1078-92 (1984).

Bauer, P.W., A.N. Berger, G.D. Ferrier, and D.B. Humphrey. "Consistency Conditions for Regulatory Analysis of Financial Institutions: A Comparison of Frontier Efficiency Methods", Federal Reserve, *Financial Services Working Paper*, 02/97 (1997).

Berger, A.N., W.C. Hunter, and S.G. Timme. "The Efficiency of Financial Institutions: a Review and Preview of Research Past, Present, and Future," *Journal of Banking and Finance*, **17**(2-3),221-50 (1993).

Berger, A.N., D. Hancock, and D.B. Humphrey. "Bank efficiency derived from the profit function," *Journal of Banking and Finance*, **17**, 317-47 (1993).

Berger, A.N. and R. DeYoung. "Problem Loans and Cost Efficiency in Commercial Banks," *Journal of Banking and Finance*, 21, 1-29 (1997).

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

Berger, A.N. and L.J. Mester. "Inside the black box: What explains differences in the efficiencies of financial institutions?," *Journal of Banking and Finance*, **21**, 895-947 (1997).

Bhattacharya, A., C.A.K. Lovell, and P. Sahay. "The impact of liberalization on the productive efficiency of Indian commercial banks," *European Journal of Operations Research*, **98**, 332-45 (1997).

Charnes, A., W.W. Cooper, and E. Rhodes. "Measuring the efficiency of decision making units," *European Journal of Operational Research*, **2**, 429-44 (1978).

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

Farrell, M.J. "The Measurement of Productive Efficiency," *Journal of The Royal*

Statistical Society, 120, 253-81 (1957).

Freixas, X. and J.C. Rochet. *Microeconomics of Banking*, The MIT Press, Cambridge, Massachusetts, London, England, 1998.

Hadad, M. D. *et al.* "Pendekatan Parametrik Untuk Efisiensi Perbankan Indonesia", *Research Paper*, no. 4/5, Biro Stabilitas Sistem Keuangan Bank Indonesia, (2003).

Hasan, I. and K. Marton. "Development and Efficiency of the Banking Sector in a Transitional Economy: A Hungarian Experience," *Journal of Banking and Finance* **27** (12), 2249-2271 (2003).

Hasan, Z. "Evaluation of Islamic Banking Performance: On the Current Use of Econometric Models," in Iqbal, Munawar, Salman Syed Ali and Dadang Muljawan (eds). *Advances in Islamic Economics and Finance*, Vol.1, Islamic Research and Training Institute, Islamic Development Bank, Jeddah, Saudi Arabia, 2007.

Hassan, M.K. "Cost, Profit and X-Efficiency of Islamic Banks in Pakistan, Iran and Sudan," *Paper*, International Conference on Islamic Banking: Risk Management, Regulation and Supervision, Bank Indonesia – Islamic Research and Training Institute, Jakarta, 30 September – 2 October (2003).

Hassan, M.K. "The X-Efficiency in Islamic Banks," *Islamic Economic Studies*, Vol.13, No.2, February (2006).

Isik, I. and M.K. Hassan. "Cost and Profit Efficiency of the Turkish Banking Industry: An Empirical Investigation," *The Financial Review*, **37**(2), May,: 257-80 (2002).

Jemrić, I. and B. Vujčić. "Efficiency of Banks in Croatia: A DEA Approach," Croatian National Bank *Working Paper*, 7 February (2002).

Kumbhaker, S.C. and C.A.K. Lovell. *Stochastic Frontier Analysis*, Cambridge University Press, United Kingdom, 2004.

Saaid, A.E., S.A. Rosly, M.H. Ibrahim, and N. Abdullah. "The X-Efficiency of the Sudanese Islamic Banks," *IIUM Journal of Economics and Management*, 11(2), 123-141 (2003).

Yildirim, H.S. and G.C. Philippatos. "Efficiency of Banks: Recent Evidence from the Transition Economies of Europe 1993-2000," *Paper*, School of Administrative Studies, York University, Toronto, ON Canada (2003).