Efficiency measurement and determinants of Indonesian bank efficiency

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Abstract

This study reveals *new* findings on efficiency performance using data envelopment analysis and stochastic frontier analysis, SFA, to measure the overall efficiency of Indonesian banks over a recent unstudied period. SFA helps to determine factors affecting cost inefficiency and profit efficiency performance. Though productivity declined by just 2.2 percent, which is a result close to the efficient frontier by a small margin, is an improvement over what was a huge decline during the 1997-99 crisis and prior to the IMF-World Bank intervention to resuscitate the economy in 1998-2001. Banks' cost inefficiency is found to be higher than profit efficiency, a result consistent with literature. Indonesian banks are about twice as inefficient as banks in developed countries in the overuse of inputs, thus there is huge challenge for management to improve efficiency. On testing for the sources of bank efficiency via SFA, bank size and non-performing loans or credit risk affect cost and profit efficiency negatively, a result consistent with similar findings from other countries. There has not been much attention paid to productivity measurement, and our findings provide a benchmark for future studies for comparison.

Keywords: Cost and Profit Efficiency, Size, Risks, DEA, SFA, Indonesian Banks, Total Tactor Productivity, TFP

JEL Classification: G21

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1. Introduction

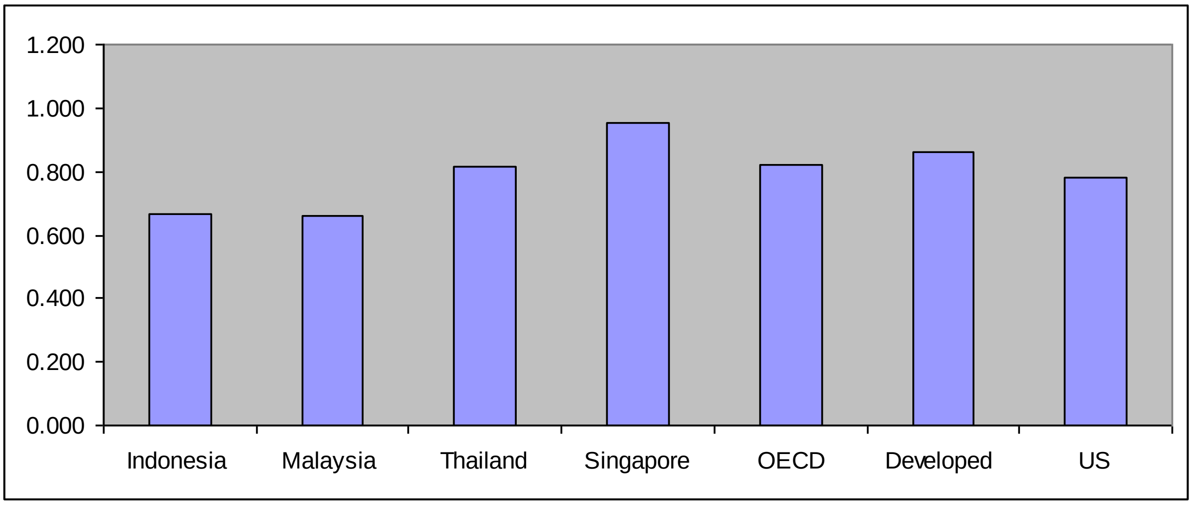
This study reports new findings on the economic efficiency of Indonesia's listed banks over a recent period of five years, a period of substantial economic changes yet studied by researchers using the current favoured model of productivity. Observers of Indonesian economy know there was a period of serious economic and political crises following the 1997 financial and the 1998-2001 political crises, which set back by several years much of the economic gains over 22 years of development.

International institutions led by the IMF and the World Bank restructured the banking sector and the economy, which effort is yielding results over the last few years amid the world-wide economic instabilities that continue to affect Indonesian banking sector as well. A populist government has begun to rein in anti-growth factors such as corruption and maladministration within a democratic agenda, which is beginning to revive investments that had gone off this economy during the three years of crisis period. According to annual statistics over the recent years, job creation has surpassed 4 million, which is just enough to absorb new entrants to the job market each year, and the economic growth is on track for 7-8 per cent trend stimulated by domestic demands. It is worthwhile, thus, to examine how the banking sector, exposed as it is in recent years to instabilities from external forces and domestic reforms, has performed over a recent period. There is no study of this aspect of banks for comparison. This is the motivation for this study.

The banking sector constitutes a significant industry for the Indonesian financial system, and the Indonesian economy is the largest of the 11-member ASEAN economic group, one that is becoming a free-trading bloc. Bank assets account for about 80 per cent of the national assets indicating how bank-dependent is this economy. A number of studies have been published on the economic (not financial) efficiency of banking sectors of Malaysia, Singapore and Thailand, which are members of the same economic grouping (see Sufian, 2007 and 2009, Omar *et al*., 2006, and Chansarn 2008). Another study of world-wide banking efficiency (Berger and Humphrey 1997) provides a set of comparative statistics on banking technical efficiency in developed countries: see Figure 1.

Figure 1: Average efficiency of banks and financial firms of selected countries

The average efficiency scores are obtained from the periods shown in the parentheses except for the OECD and Developed Countries. Indonesia (1993-2003) Average efficiency 0.665; Malaysia (1992-2003) Average efficiency 0.663; Thailand (1992-2003) Average efficiency 0.816; Singapore (1992-2003) Average efficiency 0.954; 11 OECD Countries (Berger and Humprey 1997) Average efficiency 0.820; 8 Developed Countries (Berger and Humprey 1997) Average efficiency 0.86; and US bank (Berger and Humprey 1997) Average efficiency 0.780.



Note: Figures obtained from published studies for the periods before year 2002 although the studies were published in later years.

These figures for the four Asia Pacific economies indicate that there is a wide variation in efficiency among the countries. While Indonesia and Malaysia appear to have similar levels of average efficiency scores, both Singapore and Thailand have higher scores. The developed countries and the OECD group included in another study indicate an average score which is higher than those for Indonesia. One question addressed is to examine if the mean scores have changed in recent years, given the reforms and also world-wide instabilities affecting this open economy.

Despite the importance of banking performance, there are just few studies of the Indonesian economy. In addition, studies on banking efficiency are not only limited in number, but also in the methods applied to estimate performance. There are few studies using the current more acceptable production frontier methodology: Harada and Ito (2005), Viverita (2008), Hadad *et al.* (2008; 2009) and Margono and Sharma (2010), of which the last two employed stochastic frontier analysis SFA method only. To our knowledge, there is yet a study to examine the efficiency using both non-parametric and parametric approaches as well as cost and profit efficiency measures to identify the possible factors influencing performance. Prior studies are about identifying some basic performance scores only.

Therefore, this study aims to identify efficiency performance of listed banks employing non-parametric/parametric approaches by generating tests on overall efficiency measure as well as technical efficiency, allocative efficiency, and productivity growth over time as measures of performance. We also estimate cost and profit efficiency and then proceed to identify two factors influencing productivity performance.

The rest of the paper is organized as follows: Section 2 reviews the relevant literature. It includes a brief description of theory of efficiency and productivity, followed by a review of empirical evidence from previous studies. Section 3 describes the methodology: we use a data set on individual banks from the post-crisis period 2004-08. Section 4 presents the results of the study on bank efficiency and variables. Section 5 concludes this paper.

2. Frontier Theory Literature

In this section, we provide a very brief discussion of the frontier methods to identify banking performance. Since this literature is widely publicised following the works of many of whom Berger is notable, we do not include a technical discussion of the individual methods as these can be verified by reference to the articles cited in this section.

Bank efficiency is commonly estimated using several old and new methods. A common and widely used method is the use of financial ratios, bank's liquidity, profitability, risk, and asset quality ratios. Ratios provide tools for managing information in order to analyse a firm's financial condition as its performance (Shapiro *et al.*, 2000, p.36). These can provide a profile of a firm's economic characteristics, competitive strategies, operating, financial, and investment decisions by relating these to other firms or industry (White *et al.*, 1998, p. 41).

However, since financial ratios consist of one variable compared to another, it will not give enough information about various dimensions of a bank's performance, particularly to identify effects from interactions of one ratio with another. Therefore, this method fails to consider multiple inputs a firm uses to deliver some outputs to generate performance. Besides, some ratios are inherently unreliable because the accounting basis on which the numbers are computed may vary from year to year since top management is known to smooth earnings of a bank. Nevertheless, there are significant publications using this approach (see: Milbourne and Cumberworth 1991, Sufian 2007, Eridisinghe and Zhang 2008, Wang and Lee,2008).

The limitation of financial ratios to accommodate multiple inputs and multiple outputs in measuring performance is overcome by the frontier methods to measure economic efficiency. The original source of several popular methods in this line of newer research can be traced to early works of Farrel (1957) and Malmquist (1953). Farrel defined a simple measure of efficiency that could deal with multiple inputs, not just at a time, but also over a period of time by measuring the *change in economic efficiency* over any two periods, mostly over any two years, by aggregating the measures for a group of firms as the measure of performance gain or loss over several years or just two years. One of the most well-known and early approach to efficiency is the *Data Envelopment Analysis* (DEA). Several new methods have since been devised and are increasingly applied since the late 1970s to study banking performance. This method, ideally suited for services industry, has become entrenched in the last 20 years as the preferred method to measure banking performance although financial ratio methods are also found in good journals.

Another approach that is used to estimate performance is the SFA. Like the DEA, the SFA may be defined as the relative distance of a firm from some best practice frontier applied/measured for a class of firms. However, one has to include factors other than inputs and outputs in an econometrics model to explain the technical efficiency portion of the efficiency measure (see Meeusen and van den Broeck 1977). While DEA examines total efficiency, SFA examines only the technical change aspects. This approach helps to overcome a primary shortcoming of the DEA of not accommodating measurement errors, which could have an influence on the shape and position of the estimated frontier according to Seiford and Thrall (1990), Bauer (1990) and Greene (1993). Besdies, SFA lends explanations as to what factors are driving the efficiency. Hence, unlike prior studies, this study purports to measure *and* find correlated factors driving efficiency.

In a seminal paper using the DEA and SFA, Berger and Humprey (1997) provide a survey of 130 studies covering 21 countries. They conclude that (i) non-parametric measures of efficiency such as DEA yield a mean efficiency statistic *slightly lower with a large dispersion* while (ii) the parametric measures such as SFA provide a *slightly higher efficiency statistics* *with lower dispersion*. For financial firms, the means in that study are respectively 0.72 and 0.84. For a reference to different concepts of efficiency, see Berger and Mester (1997). They concluded that, although different measures add some valuable information, profit efficiency measures are not positively correlated with cost efficiency measures and so suggested support as a reason that this may be due to different type of optimization measures.

Recent development in the application of frontier methodology shows that the frontier analysis not only can be applied to determine efficiency scores of a banking firm over a certain periods, but also it can be used to investigate the influence of contextual or environmental facors on the scores themselves. Liadaki and Gaganis (2010) applied the SFA analysis to examine the relationship between profit efficiency and stock prices of 171 banks in 15 countries, while Fried *et al*. (1993) evaluated the efficiency performance of the US credit unions. Maudos *et al.* (2002) examined several possible sources for the cost and efficiency differences among European banks by including factors such as size, market characteristics and specialization.

Thus, this quick review suggests that the Indonesian banks should be studied using both parametric and non-parametric methods since the validity of the findings is limited if only one method is applied to a period data. Further, it is important to also investigate for the first time the determinants or the sources of bank efficiency performance in a country study, such as this on Indonesia.

3. Data and Methodology

3.1 Data

The data used in this study relate to all public listed banks in the Indonesian Stock Exchange (BEI) as included in the BEI database. Annual financial statements were obtained from the BEI database. The data are deflated with relevant consumer price index (CPI): this is commonly done in frontier studies to ensure that performance is not due to inflationary effect on variables. The data relate to 18 commercial banks over 2004 and 2008. Table 1 presents a summary of descriptive statistics namely means and standard deviations of the input/output variables used. The crucial issue in this research is to choose the appropriate inputs and outputs variables to develop the efficiency models. There is still no universal agreement as to the explicit definitions and measurement of a bank's inputs and outputs. In general, the definitions of input and output depend on a particular set of banking concepts. This study follows the commonly adopted *intermediation* approach (Sealey and Lindley 1977) for identifying and applying the models to banks.

Table 1: Variables and selected descriptive statistics, Indonesia

Variable	Description	Mean	Standard Deviation
Dependent variables:			
Y1	Total costs	3,613,114	12,999,207
Y2	Pre-tax profits	8,085,847	2,783,274
Outputs:			
LOAN	Loans	3,607,999	3,825,999
OEA	Other earning assets	2,431,464	3,825,999
NOII	Non-interest income	99,020	142,821
Inputs:			
INTEXP	Interest expenses	2,039,512	8,603,939
DEP	Deposits	6,303,793	8,797,956
NOIE	Non-interest expenses	433,271	3,253,223
Input prices:			
Price of borrowed funds	Interest expenses/total deposits	2.403	12.085
Price of physical capital	Non-interest expense/fixed assets	1.162	4.514
Price of labour	Personnel expense/total assets	0.02	0.022
Explanatory variables			
SIZE	Market capitalization	2,508,249	5,753,055
RISK	Non-Performing Loans	3.97%	0.028

As is the most common use in other studies, we choose outputs to mean loans, other earning assets, and non-interest income: and inputs are interest expense for capital, deposits and non-interest expenses. The figures are in million of local currency, IDR. For example, the banks had output factor *loan* of IDR 3,607,999 million. The dispersion of this factor across the banks is 3,825,999 million. The variables are converted to index, so the magnitude does not matter in our tests.

3.2 Test Models

3.2.1 Data Envelopment Analysis

This study employs two types of the DEA approaches. First, it applies the standard DEA approach to measure allocative and technical efficiency. Second, the Malmquist factor productivity measure identifies efficiency gain/loss. The model utilizes data as inputs and output quantities of a group of banks, the decision making units (DMUs), to construct a piece-wise frontier over the data points. This frontier is constructed by the solutions from a sequence of linear programming problems, one for each bank over the time periods. Efficiency scores or measures are then estimated relative to this frontier, which corresponds to an efficient technology used by the firm. In addition, it allows efficiency to be estimated without having to stipulate either the structure of production function or the weights for the inputs and outputs used. Charnes *et al.* (1978) introduced the DEA constant return to scale (CRS) method.

CRS takes into account multiple inputs that are used in the production process to generate outputs and yields our measures of total factor productivity (TFP) a score including all factors of productions. The DEA input approach defines the frontier by seeking for the maximum possible reduction in input usage, with output held constant, *vice versa*. DEA can be estimated either as input-oriented or output-oriented index. The two results of both measures give the same technical efficiency scores when constant returns to scale is assumed. In this paper, an input-oriented measure using CRS is assumed because the DMUs want to minimize their inputs to achieve given outputs using production function. DEA measures are obtained by introducing a ratio of *M* outputs over *N* inputs, as follows:

$$\begin{aligned} &\text{Max}_{x,y} && \left(\mathbf{y}'\mathbf{q}_i / \mathbf{x}'\mathbf{p}_i\right) \\ &\text{Subject to} && \mathbf{y}'\mathbf{q}_j / \mathbf{x}'\mathbf{p}_j \le 1, \quad j = 1, 2, ..., I, \\ & && \mathbf{y}, \mathbf{x} \ge 0 \end{aligned} \tag{1}$$

where **y** represents an $M\times1$ vector of output weights and **x** represents an $N\times1$ vector of inputs weights. The $N\times1$ input matrix, **P,** *and* the $M\times1$ output matrix, **Q**, represent the data for all *I* DMUs.

Malmquist total factor productivity index

Total factor productivity (TFP) index is the ratio of the weighted aggregate output to a weighted aggregate input quantity index. TFP growth is the geometric mean of Malmquist TFP indices that can be decomposed in to two output-based measures: one index uses period *t* technology and the other period *t+1* technology (Coelli 2005). The Malmquist indices are defined using distance functions. This approach is arguably superior in identifying the net gain in efficiency after input adjustments by the DMU. TFP is measured in two stages. The Malmquist index of total factor productivity change (TFPCH) over period t and t+1 is the product of technical efficiency change (EFFCH) and technological change (TECHCH) as follows:

$$\text{TFPCH} = \text{EFFCH} \times \text{TECHCH} \quad (2)$$

Following Fare *et al*. (1994), the Malmquist productivity change index, therefore, can be written as involving the two indices:

$$m_0(y_t, x_t, y_{t+1}, x_{t+1}) = \frac{d_0^{t+1}(y_{t+1}, x_{t+1})}{d_0^t(y_t, x_t)} \left[\frac{d_0^t(y_{t+1}, x_{t+1})}{d_0^{t+1}(y_{t+1}, x_{t+1})} \times \frac{d_0^t(y_t, x_t)}{d_0^t(y_t, x_t)} \right]^{1/2} \quad (3)$$

where, *y* and *x* are outputs and inputs across time *t* to *t+1*. The Malmquist indices are computed in this study relative to previous periods over the test window. The technical efficiency change measures the change in efficiency between period *t* and *t+1*, while the technical change captures the shifts in the technology applied over time by a DMU. A value greater than one (less than one) in both cases indicates growth (or decline) in productivity: that is positive (or negative) factor performance.

3.2.2 Stochastic Frontier Analysis

After estimating the cost and profit efficiency of the banks, we also examine possible factors that influence both estimates. This has *not yet* been done for Indonesian banks. Some studies have used size as a factor that influences efficiency scores. For example, Pitt and Lee (1981), Megistae (1996), and Brada, King and Ying Ma (1997) found that firm size has a positive relationship with technical efficiency. On the other hand, studies by Chen and Tang (1987), Hill and Kalirajan (1993) found no relationship between size and technical efficiency. In addition, a study by Moudos *et al.* (2002) indicate that bank size influences cost and profit efficiency. In addition to DEA, this study thus able to use the SFA methodology to estimate cost and profit efficiency of the banks.

3.2.2.1 Cost efficiency

The cost efficiency model employed in this study is the one by Battese and Coelli (1985) which permits estimation of efficiency in a single stage. For more details on the SFA methodology, see for example: Battese and Corra 1977, Battese and Coelli 1993, and Coelli *et al*., 1998).

The general form of cost efficiency can be written as:

$$C_{it} = (q_{it}, p_{it}, \beta) + (U_{it} + V_{it}) \quad \text{i = 1,2,...,N; t=1,2,...,T} \qquad (4)$$

C_{it} represents the costs (expenses) of the i-th firm in the t-th period, q_{it} is vector prices of variable inputs, p_{it} is vector of quantity of variable outputs, V_{it} is random error, while U_{it} is inefficiency.

Following Liadaki and Gaganis (2009), the specific form of cost function use in this study is written as follows:

$$Ln\frac{TC}{P_3} = \beta_0 + \beta_1 \ln(Q_1) + \beta_2 \ln(Q_2) + \beta_3 \ln(Q_3) + \beta_4 \ln(\frac{P_1}{P_3}) + \beta_5 \ln(\frac{P_2}{P_3}) + \beta_6 \frac{1}{2}\left[\ln(Q_1)\right]^2 + \beta_7 \ln(Q_1)\ln(Q_2) + \beta_8 \ln(Q_1)\ln(Q_3)$$
$$+ \beta_9 \frac{1}{2}\left[\ln(Q_2)\right]^2 + \beta_{10} \ln(Q_2)\ln(Q_3) + \beta_{11} \frac{1}{2}\left[\ln(Q_3)\right]^2 + \beta_{12} \frac{1}{2}\left[\ln(\frac{P_1}{P_3})\right]^2 + \beta_{13} \ln(\frac{P_1}{P_3})\ln(\frac{P_2}{P_3}) + \beta_{14} \frac{1}{2}\left[\ln(\frac{P_2}{P_3})\right]^2 + \beta_{15} \ln(Q_1)\ln(\frac{P_1}{P_3})$$
$$+ \beta_{16} \ln(Q_1)\ln(\frac{P_2}{P_3}) + \beta_{17} \ln(Q_2)\ln(\frac{P_1}{P_3}) + \beta_{18} \ln(Q_2)\ln(\frac{P_2}{P_3}) + \beta_{19} \ln(Q_3)\ln(\frac{P_1}{P_3}) + \beta_{20} \ln(Q_3)\ln(\frac{P_2}{P_3}) + \beta_{21} D_1 + \beta_{22} D_2 + (V_{it} + U_{it})$$

(5)

where TC is defined as the total costs; P_i is the vector of input prices; Q_i is a vector of variable outputs; and D_i is a vector of fixed netputs. This model is estimated using maximum likelihood estimation.

This study also follows the Battese and Coelli’s (1995) representation for technical inefficiency effects in the stochastic frontier production function using panel data. Therefore, the model for the technical inefficiency effects for this study is written as:

$$u_{it} = \delta_0 + \delta_1 Size_{it} + \delta_2 CreditRisk_{it} + W_{it} \qquad (6)$$

where : $Size_{it}$ represents the market capitalization the bank $i-th$ at the $t-th$ year of observation.

$Risk_{it}$ represents the non-performing loan of the bank $i-th$ in the $t-th$ year of observation

3.2.2.2 Profit efficiency

Following Humprey and Pulley (1997), profit efficiency is defined as how close a firm is to generating maximum possible outputs given a particular level of input and output prices. It is the ratio of predicted maximum profit which could be earned if a firm was as efficient as the best practice firm after adjusting for random error. The value is bounded between 0 and 1. The higher the profit efficiency score is, the more profit efficient the firm will be. If the score is 1, it means the most profit efficient firm. The general form of profit function can be written as:

$$P_{it} = f(q_{it}, p_{it}; \beta) + (V_{it} - U_{it}) \qquad (7)$$
$$i = 1,2,..., N; t = 1,2,..., T$$

P_{it} is the profit before tax of the i-th firm in the t-th period, q_{it} represents the vector of output quantities of the i-th firm in the t-th period; p_{it} is vector of quantity of variable outputs of the i-th firm in the t-th period. To develop a profit efficiency mode for this study we replaced total cost (TC) in the cost efficiency model with pre-tax profit, while the inputs prices and outputs remain the same.

4. Findings

4.1 Efficiency Estimates

In this section, we present our findings, and provide a discussion of banking performance over the test period. We calculated efficiency values with the objective of estimating input usage efficiency (input orientation) and returns to scale (increasing or decreasing returns to scale). Malmquist indices provide the components of total factor productivity as being made up of technical efficiency and efficiency change. A mean value more than one indicates improvement in performance, while a value less than one indicates a inefficiency. The indices can be decomposed into technological change, interpreted as efficiency due from banks adopting newer ways of doing things thus causing a frontier shift; and efficiency change, which is due to management's effort to secure higher efficiency (catch-up). The efficiency change or catching-up effect is further decomposed into pure and scale efficiency changes to identify the main sources of improvements/deteriorations in management performance of banks. Table 2 presents the efficiency estimates from DEA efficiency measures and

Malmquist productivity indices. By decomposing the results (TFP) into its components, we are able to make further conclusions about the efficiency performance.

Table 2: Results of the data envelopment analysis using Malmquist productivity indices

Year	efficiency change (catch-up)	technological change (frontier shift)	Malmquist index of total factor productivity change
2004 - 2005	1.054	1.039	1.095
2005 - 2006	0.976	0.893	0.872
2006 - 2007	0.964	0.985	0.950
2007 - 2008	1.040	0.970	1.008
mean	**1.008**	**0.970**	**0.978**

The average score of 0.978 is almost close to 1.00 which means that, compared to significant declines therefore inefficiency during periods of economic crisis (Can and Ariff, 2009), there is improvement, though not yet as positive TFP gains by banks operating in the region of increasing returns to scale. However, in this period, the average score still falls short of any TFP gains expected. These statistics indicate that all banks in the sample experienced productivity decline of 2.2 percent. The scores in periods 2004-05 and 2007-08 suggests that there are gains in efficiency whereas the inefficiency in the other two periods has led to an overall 2.2 percent loss of efficiency.

As to the source for this, we find the result is driven by negative shift of the frontier in two periods and the most recent period prior perhaps due to the onset of the World Financial Crisis in 2008-09. It indicates that the TFP decline as being entirely due to negative technical change although there is a small improvement in catching-up to the average frontier or management efficiency. This means that the decline may be due to lack of investment in newer technology over this specific period. The test period is a period of adjustment by banks to the very high interest rate because of high inflation and exchange rate volatility: interest rates have declined in 2008-10 so capital is available at cheaper cost since 2007 with inflation having fallen. Further, the post 1999-2001 impact of world slowdown and political unrest in Indonesia did not provide any attraction for further investments in the banking sector, which placed a drain of capital sources.

Table 3 is a summary of results on different components of efficiency measures. The reader will note performance statistics on: technical efficiency (TE); allocative efficiency (AE); and overall efficiency (OE). The mean score of overall efficiency, technical efficiency and allocative efficiency are 0.918, 0.979, and 0.939 respectively. These figures indicate the mean value of allocative efficiency is lower than that of technical efficiency (TE).

Table 3: Overall efficiency, technical efficiency and allocative efficiency

Bank	OE	TE	AE
1	0.931	0.940	0.990
2	1.000	1.000	1.000
3	0.717	1.000	0.717
4	1.000	1.000	1.000
5	0.820	1.000	0.820
6	1.000	1.000	1.000
7	0.865	0.867	0.997
8	0.601	1.000	0.601
9	1.000	1.000	1.000
10	0.818	1.000	0.818
11	0.900	0.903	0.997
12	1.000	1.000	1.000
13	1.000	1.000	1.000
14	1.000	1.000	1.000
15	1.000	1.000	1.000
16	1.000	1.000	1.000
17	0.879	0.909	0.967
18	1.000	1.000	1.000
Mean	**0.918**	**0.979**	**0.939**
Std Deviation	**0.117**	**0.043**	**0.119**

That is usually interpreted as meaning the banks experienced *decreasing returns to scale*, which is a decline in productivity. This also means that the banks are using more input resources than is needed to produce the current output levels efficiently. That is, bank management needs to decrease input usage and change the scale of production to be able to improve their overall efficiency performances. (Cost efficiency to be reported later also examines this aspect.)

The overall efficiency in the technological aspect of efficiency is down over the period by 8.12 percent (1-0.918), a result consistent with what is reported in Table 2. The technical efficiency is down by 2.1 percent (1-0.979) due also to the lack of top management using more resources for the level of production or due to lack of sufficient investment to adopt newer technology or both.

4.2 Cost and Profit Efficiency

The mean cost and profit efficiency measures are reported in Table 4. The overall mean cost efficiency is 1.784, while that of profit efficiency is 0.753. This means that the average banks could reduce its costs by 78.4 percent to improve its profits by 24.7 percent to match its performance to the level of the most efficient bank in the test: of course such an achievement for all banks may not be feasible, but it is an average figure. This finding confirms the earlier findings of previous studies of Bos and Kool (2005) for Netherlands. They also found that, in general, banks experienced higher profit efficiency than cost efficiency. Based on the study of small cooperative Dutch banks, they found that the banks needed to improve cost efficiency by 39.3 percent, compared to 8.7 percent room for improving their profit efficiency. Hence, compared to the scores in a developed banking system, the Indonesian banking efficiency is lot worse, in fact about twice as bad as in that case.

In contrast, most previous studies found that average profit estimates are lower than those of cost efficiency. See for example, Berger and Mester (1997), Moudos *et al*. (2002), and Yildirim and Philippatos (2007). These studies found 0.860 and 0.539; 0.865 and 0.545; 0.770 and 0.626 of cost and profit efficiency respectively across many countries/regions. Reading the results of tables 2 and 3, our new finding is point to poor control of bank management on costs relative to the search for profits.

4.3 Determinants of Cost and Profit Efficiency

The productivity index values are used to examine the sources of the cost and profit inefficiency performance of banks. This section reports *new* findings using the scores on technical efficiency and their relationship to specific banking variables. The maximum likelihood estimation of the parameters in the Cobb-Douglas equation and the translog stochastic frontier production function are used to obtain the results using the software package FRONTIER Version 4.1c (Coelli 1996).

The maximum likelihood method is applied to estimate the parameters of the model and the prediction of the technical efficiencies of the banks. The inefficiency effects in the input use are modelled in terms of three output variables: loans (output 1), other earning assets (2), and interest income (3) in a given year. The three production inputs are: deposits (input 1), interest expenses (2) and non-interest expenses (3). The factors specified as potential sources of performance are: size (proxy for the value of market capitalization), and banking risk (non-performing loans). The likelihood ratio (LR) test is used to test the null hypotheses that the cost inefficiency effects do not exist in the model and that cost inefficiency does not depend on the bank-specific variables.

The first test result reported in Table 4 is on the null hypothesis that inefficiency effects are not stochastic. The LR test for the first null is accepted for cost efficiency, and is rejected for profit efficiency estimate. It means that the Cobb-Douglas functional form is preferred to the translog form for estimating cost efficiency. The second null hypothesis specifies that the inefficiency effect is absent. This null hypothesis is strongly rejected at 0.05 probability level of significance for both cost and profit efficiency. This suggests that there is technical inefficiency.

Table 4: Generalized Likelihood-Ratio tests of null hypothesis for parameters in the Translog Stochastic Frontier for cost and profit efficiency

Null Hypotheses, Ho	Cost Efficiency	Profit Efficiency	Critical Value*
$H_0 : \gamma = 0$	0.48	24.57*	14.07
$H_0 : \gamma = \delta_0 = \delta_1 = \delta_2 = 0$	23.32*	286.7*	8.76
Variance Parameters			
$\hat{\gamma}$	0.999	0.969	

*Critical values are obtained from the appropriate chi-square distribution, except for the test of hypotheses involving $\gamma = 0$. (*Kodde and Palm, (1986).*

The estimate for the variance parameter γ is close to one, which indicates that the inefficiency effects are likely to be highly significant in the analysis of cost and profit efficiency of Indonesian banks.

Table 5 reports the estimation results of the cost and profit efficiency estimation and the influence of banks' size and risk on both cost and profit inefficiency. These statistics show that both size and risk affect a bank's cost and profit efficiency negatively. However, the influence is not statistically significant. So, the results indicate that that both size and risk of the banks have no significant influence on cost inefficiency estimates although the results are as per those observed in other countries in direction.

Table 5: The determinants of cost and profit efficiency

Variable	Cost Efficiency	Profit Efficiency
Mean	**1.784**	**0.753**
Constant	-0.149	-0.887
	(-0.152)	(-0.589)
Size	-0.001	-0.157
	(-1.442)	(-12.353)***
Risk	0.034	-2.473
	(0.191)	(-5.045)***

Note: Note 1: Estimated t-values are given in parentheses to three significant digits. Values that exceed the critical value in the table are significant at .01(***) probability levels.

In contrast, both factors have a statistically significant and negative influence on profit inefficiency. This implies that increasing market capitalization and non-performing loans will decrease profit efficiency.

5. Conclusion

This study started with the aim of estimating a set of comprehensive efficiency performance scores and to identify factors correlated with cost and profit efficiency of Indonesian listed banks over a recent yet studied period. The recent period has seen some uncertainties and pointed reforms in banking sector, which should help garner gains by changing its historically poor efficiency performance. We use all the listed banks in the Indonesian stock exchange: the assets controlled by these banks account for 80 per cent of banking assets. We modelled bank efficiency using both non-parametric *and* parametric approaches, in addition to using a model to identify two determinants of performance so far unknown about this banking market.

Our findings suggest that the banks experienced productivity growth in two contiguous periods and declines in two other contiguous periods, one of which coincided with the global financial crisis. For example in 2007-08, there was a total productivity growth of +0.8 percent after two years of declines. The average decline is -2.2 percent during the test period. However, compared to scores reported for crisis periods in several countries including this country in prior studies for periods before 2002, this period registered productivity change very close to the borderline of efficiency at 1.00. The actual number is 0.978, which suggests the period average decline of -2.2 percent. This decline is mainly driven by negative shifts of the technical frontier in two periods, although there is a slight improvement in managerial efficiency over the entire period by 0.8 per cent. We explain that this is due to the lack of capital to obtain newer technology because, during this period up about 2006, inflation was high so interest cost was higher and foreign investments declined.

Our results suggest a new finding on bank's overall, technical and allocative efficiency. It indicates that the mean score of overall efficiency, technical efficiency and allocative efficiency are 0.918, 0.979, and 0.939 respectively: these numbers have not been reported before for Indonesia so no comparison can be made. These numbers appear to be in line with numbers reported for other countries. It implies that the banking sector has yet crossed the barrier from inefficiency to efficiency. The mean cost efficiency is 1.78 while that of profit efficiency is 0.75. This means that the average banks could reduce it costs by 78 per cent and improve it profits by 25 per cent to match performance with one of the most efficient bank. It is an indicative number, although such a feat is not possible for all banks to catch up with the best practice. Other statistics from other countries suggest that cost control by management is critical because this is about twice as low as in other economies.

An interesting new result relate to factors influencing cost and profit efficiencies. Both bank size and bank credit risk (non-performing loans) negatively affect cost and profit efficiencies. It is a long-running explanation that Indonesian banking practices appear to have poor credit risk assessment mainly because of the capture of banks by real sector conglomerates However, the influence is not statistically significant in the case of cost inefficiency. But, both factors have statistically significant and negative influence on profit inefficiency. This study does not include banks not listed on the share market, so the findings are not generalisable to all banks. However, banks included in this study account for 80 percent of the total assets of all the banks, hence, the findings has validity for the sector.

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