Regulatory Reforms and Bank Efficiency in Indonesia: A Two-Stage Analysis

by

Felisitas Defung,

Abstract

More than a decade, after severe economic crisis 1997, Indonesia has undergone major regulatory changes in the banking industry. The restructuring program is continuing up to present to strengthen and improve the performance of the banking system. This paper examines the impact of regulatory changes to the relative technical efficiency (TE) of the Indonesian banking industry employing the data envelopment analysis (DEA) in the first stage and censored Tobit regression model in the second stage. To overcome the limitation regarding the lack of statistical inference in DEA, this paper employs the bootstrapping approach developed by Simar and Wilson (1998). This approach provides the bias corrected estimate and confidence intervals of DEA-efficiency score. The analysis covers 101 Indonesian commercial banks using 19 years of data (1993 – 2011). The finding shows that although the average industry technical efficiency is inefficient over the period of analysis, but it shows an improvement. State and foreign bank are found to be more efficient that other group of bank. On the second stage the impact of regulatory reforms is positive and significant at the industry level.

Keyword: Efficiency; bootstrap, data envelopment analysis; banking.

1. Introduction

After the Asian financial crisis (AFC) in 1997, the Indonesian banking sector has undergone tremendous changes following changes in government regulations. Currency, banking and debt crises were the additional features of the crisis faced by the Indonesian economy. Most of the actions taken by regulators following financial crises are aimed at bank restructuring to rebuild the industry toward a stronger and more resilient system. In the case of Indonesia, the restructuring program was not only because it was needed but also it was required by the terms of the IMF assistance it received (Sato 2005).

During the 2000s, a series of regulations reforms launched, including the revision of two main regulations in Indonesian banking sector; the Banking Act (*UU Perbankan No. 10/1998*) and the Central Bank Act (*UU Bank Indonesia No. 23/1999*). Subsequently, the reforms resulted in number policies including restructuring, privatisation, and establishment several financial-related instructions. These include the enactment the of Islamic Bank Act in 2008; the establishment of The Indonesian Deposit Insurance Corporation (IDIC) in 2004; and lately, the establishment of the Financial Service Authority (FSA) in 2011. The essence of these events is to convey the industry toward international practice standards such as: the independence of the central bank; a proper deposit guarantee scheme; and an integrated supervision system.

The IDIC introduced in September 2004 to replace the blanket guarantee system adopted since the AFC. Unlike the BG system, which insured the full amount of deposits – but did

this for domestic banks only – the IDIC system insures all banks, including joint venture banks and the branches of foreign banks. However, this new insurance system is for limited amounts[1]. Under this new arrangement, banks may have to adjust their operations because they are forced to perform efficiently and soundly in order to gain or retain the confidence of their larger depositors.

Despite extensive and growing number of research regarding bank efficiency in developing countries, studies on Indonesian case have been few. Studies on Indonesian banks that have been published scholarly include Margono, Sharma, and Melvin (2010) Hadad et al. (2010), Hadad et al. (2012), and Zhang and Matthews (2012). These studies examine bank efficiency and productivity growth of the Indonesian bank sector using various frontier approaches. By far, studies on Indonesian banks have never been comprehensively examining the whole industry with a longer period of data. The most recent study in Indonesian case covers the data up to 2007. In addition, there is a lack of recent empirical studies that analyse the efficiency of Indonesian banking sector after the recent regulatory change.

This paper tries to examine the technical efficiency of Indonesian banks during the period before crisis until 2011. The non-parametric DEA method is utilised in this study along with the application of bootstrapping procedure developed by Simar and Wilson (1998). With the bootstrap method, bias-corrected estimates and confidence intervals of the original DEA efficiency score can be obtained. Furthermore, this study employs the second stage analysis to investigate what determines the variation in Indonesian banks' efficiency

The reminder of this paper is restructured as follows: Section 2 provides a brief history and background of the Indonesian banking sector. Section 3 includes the review of related studies followed by Section 4 presents the methodology, data and variables. Section 5 discusses the empirical result and Section 6 concludes the paper.

2. The Indonesian Banking Industry

The financial sector in Indonesia, like most emerging economies, is dominated by the banking industry. However, the share of the financial sector assets to the GDP is relatively small (below 60%) compared to China, Korea, Malaysia and Thailand (IMF, 2010). The commercial bank is the engine of the industry, as it is historically in the lead far above rural banks. The share of commercial banks to the total assets in the industry is above 90% on average during the last decade[2]. The commercial banks are officially divided into six groups, namely (including their assets share in 2011): state owned banks (36%); foreign exchange commercial banks (40.1%); non-foreign exchange commercial banks (2.9%); regional development banks (8.3%); joint venture banks (5%); and foreign owned banks (7.3%).

Table 1 reveals the structure of Indonesian commercial banks during the last twelve years. It is obvious that the restructuring programs have resulted in the constant decrease in the number of banks from 239 in 1996 to 151 in 2000 then decreasing to 120 banks in 2011. These numbers include two Islamic commercial banks in 2000 and 11 in 2011. The reduction is mainly due to post-crisis liquidations and mergers which commenced in 1999. Even though the development of Islamic commercial banks is noticeable following the release of Act No 21 of 2008, the conventional commercial banks still dominate the industry with more than 95% of total assets on average during the last decade. Furthermore, the structure of the

[1] Initially, the IDIC only insured deposit up to IDR 100 million, but since October 2008 the coverage increases to IDR 2 billion up to present.

[2] Calculated from Indonesian Banking Statistic, Bank Indonesia (2000–2011)

banking system is also changed due to an increasing foreign presence in the banking industry from 4.5% in 2000 to 45.8% in 2009. The sale of government shares to both domestic and foreign investor during a re-privatisation program from 2000 to 2007 a major cause (Zhang and Matthews 2011).

Table 1 Summary of Indonesian Banking Industry Profile

Descriptions	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mergers*	7 (1)	9 (4)	5 (1)	2 (1)	3 (1)	2 (1)	2 (1)	4 (2)	7 (3)	2 (1)	2 (1)	2 (1)
Number of Banks	151	145	141	138	133	131	130	130	124	121	122	120
Total Assets (IDR tn)	1,039.9	1,099.7	1,112.2	1,213.5	1,272.1	1,469.8	1,693.9	1,986.5	2,310.6	2,534.1	3,008.9	3,652.8
Foreign ownership**	4.5 %	NA	NA	31.0%	NA	39.7%	41.9%	42.1%	48.0%	45.8%	NA	NA

Note: * Number outside the parentheses is total banks closed through merger; number in parentheses is the number of merged banks
** Including foreign bank branches, joint-venture and foreign acquisition banks. The rest of the percentage is domestic ownership which consist of state and privately owned banks
Source: Indonesian Bank Directory, Bank Indonesia various issues,
Indonesia Bank Statistic, Bank Indonesia various issues,
IMF Country Report (2004) and Bank Supervision repost, Bank Indonesia various issue

The better shape of the industry can be noticed from the increase in total assets which is reversing the trend of the number of banks. However, the increase is not a constant growth as the global economic turbulence in 2009 lowered the growth rate to only 9.7% in 2009 while in 2008 the growth was 16.3%.

3. Related Studies

Efficiency and productivity studies in the literature have grown rapidly during the last decade, including applications in banking sector. After being predominantly conducted in developed economies, recently, the studies have been expanded to consider emerging economies including Asian countries (Kourouche 2008). Some of the studies in emerging economies include Taiwan (Chiu, Chen, and Bai 2011), Hong Kong (Drake, Hall, and Simper 2006a)India (Kumar, Malathy, and Ganesh 2010), Singapore (Lee, Worthington, and Leong 2010), the Philippines (Manlagñit 2011), Malaysia (Sufian 2009) and Brazil (Tecles and Tabak 2010). However, in the case of Indonesian banks only a few studies appear in the literature. These include studies by Harada and Ito (2005), Hadad et al. (2008), Hadad et al. (2010), Sufian (2010), and Zhang and Matthews (2011) who use non-parametric data envelopment analysis (DEA) to examine Indonesian bank efficiency.

Harada and Ito (2005) find the efficiency of Indonesian bank range from 80% to 94%, whereas Omar, Majid, and Rulindo (2007) report a lower result (86.2% to 91.2%). However, both of the studies cover a relatively small samples banks and a short period of data. While Margono, Sharma, and Melvin (2010) employing parametric stochastic frontier analysis (SFA) find that cost efficiency of Indonesian banks increased from 65% to 91% in the pre-crisis period then later decreased to 53%.

There are two basic approaches that are used to estimate the productivity change: the parametric approach which is the econometric estimation of production; and non-parametric which is the done through the construction of an index number. This study adopts the latter because it does not require setting a functional form in the structure of production technology.

Studies examine the impact of deregulations and financial reforms provide mixed evidence. Some studies report financial reforms improve bank efficiency, such as in Portugal (Canhoto and Dermine 2003), Korea (Gilbert and Wilson 1998), Turkey (Isik and Kabir Hassan 2003a), Thailand (Leightner and Lovell 1998) and India (Bhattacharyya, Lovell, and Sahay 1997). Other studies find a possible adverse effect of deregulation on bank efficiency (Humphrey and Pulley 1997, Grabowski, Rangan, and Rezvanian 1994, Grifell-Tatjé and Lovell 1996). The third kind of study identifies no change in banking efficiency after deregulation, or only show a limited impact, as reported by (Elyasiani and Mehdian 1995), (Hao, Hunter, and Yang 2001) and (Havrylchyk 2006). Despite the difference in research design, data used, and other factors, the effect of deregulation on bank efficiency remains empirical question.

4. Methodology

4.2 Data and Variables

The data are taken from the individual bank's financial statement published by the Indonesian Central Bank (*Bank Indonesia*) over the period 1993 to 2011. The data set is comprised of annual observations for 101 commercial banks. The representation of banks in each group is is detailed in Table 2The banks that are included in the data set are those that existed from 1993 until 2011. Based on the number of existing banks in 2011, 19 banks have to be excluded. The banks that are excluded from the data set include banks that liquidated or closed during the period of study, have extensive missing data, were just established within the covered period (11 banks). Yet, the average representation of data in terms of total commercial bank assets is 96% over the period of analysis.

Table 2. Bank Groups (2011)

No	Groups	Number of Banks	Percentage of total assets (%)
1	State owned bank	4 (4)	100
2	Private national bank*)	53 (66)	94
3	Regional development bank	25 (26)	98
4	Joint venture bank	11 (14)	95
5	Foreign bank	8 (10)	77
	Total	101 (120)	96

Notes: The number outside of the brackets is the number of banks in the sample; the current number of banks (2011) is present inside of the brackets.

* Private national banks include forex commercial banks and non-forex commercial banks

The measure of efficiency and productivity might be meaningless if input and output measures used are not specified carefully. Das and Ghosh (2006) and Sathye (2001) emphasise the input and output specification in banking efficiency and productivity studies has a crucial effect on the outcome. The literature shows intermediation and production approaches are the most popular method in specifying input and output in efficiency and productivity studies (Berger and Humphrey 1997). However, up to the present time there is no consensus which approach work best. The production approach regards banks as production centres for depositors and borrowers (Denizer 1999) in which deposits are placed as one of the outputs. While the intermediation approach, introduced by Sealey Jr and Lindley (1977), focuses on the function of banks in intermediating funds from depositors to the borrowers, where deposits are treated as inputs together with other input variables.

Given that there is no consensus as to which approach works best, the present study specifies two models that can be used to specify input and output variables. The first model follows the intermediation approach (hereafter referred to as Model A), which focuses on the role of banks' in intermediating funds from surplus to deficit units. The second model is based on the revenue or operating approach (hereafter referred to as model B) of Drake, Hall, and Simper (2006b). This model is used captures banks' activities in maximising both interest and non-interest revenues. According to Avkiran (1999) the latter model measures the efficiency that is directly attributable to management in controlling costs and generating revenue, whereas the former model provides a less direct measure of efficiency. Similarly, two separate model analyses have been used in many studies, such as (Avkiran 1999) for Australian banks, Sathye (2003) for Indian banks and Sufian (2010) for Indonesian banks. Details regarding the input and output variables included in both models are presented in Table 3.

Table 3. Variables for DEA

Model	Outputs	Inputs
Model A	Total Loan (y_1)	Total Deposits (x_1)
	Other Earning Assets (y_2)	Fixed Assets (x_2)
Model B	Interest Income (y_1)	Interest Expenses (x_1)
	Non-Interest Income (y_2)	Non-Interest Expenses (x_2)

A set of explanatory variables are selected to explain the sources of efficiency the Indonesian banking industry in the second stage. Table 4 lists the explanatory variables included in this study. Following previous studies, this study includes variables that measure economic conditions, bank characteristics, market concentration, restructuring policies, bank status, regulatory changes, bank group and ownership status.

Table 4. Second Stage Variables and Definitions

Variable		Symbol	Exp. sign	Description
Dependent variable	Bank efficiency	TE (A) TE (B)		Technical efficiency of the bank for both Models A and B
Macroeconomic condition	Economic growth	GDP	+	Annual GDP growth
	Inflation	Infl	-	Inflation, consumer price (annual %)
	Broad money	Bmoney	+/-	Broad money is the sum of the currency outside the bank measured by the percentage of GDP
Market concentration	Concentration ratio	HHI	-	Herfindal index (HHI) measured by sum of squared shares of bank loans to total loans.
Bank characteristic factor	Size	Size	+	Bank size measured by the natural log of total assets
	Risk management	NPL	-	Non-performing loan ratio (NPL) measured by the ratio of non-performing loan to the total loans
	Profitability	ROA	+	Return on assets ratio (ROA) measured by the ratio of annual profit before taxes to average assets
	Capital strength	CAR	+/-	Capital adequacy ratio (CAR) measured by the ratio of capital to the risk-weighted assets.
Restructuring	Bank restructuring	Dmerger	+	Represented by a dummy variable that takes a value of 1 for a merged bank and 0 for a bank that did not merge
Regulatory change	Regulation change	dregch	+	Dummy variable that takes a value of 1 for all observations during the period from 2005 -2011 and 0 for the prior period
Bank status	Listing bank	dlisting	+	Dummy variable that takes a value of 1 for a listing bank and 0 for non-listing
	Foreign exchange operation	dforex	+	Dummy variable that takes a value of 1 for a foreign exchange bank and 0 otherwise
Ownership structure / group	State bank	d_state	+/-	Dummy variable equal to 1 for state bank and 0 otherwise
	Private bank	d_private	+/-	Dummy variable equal to 1 for domestic private bank and 0 otherwise
	Regional development	d_rdb	+/-	Dummy variable equal to 1 for regional development

bank			bank and 0 otherwise
Joint venture bank	d_jvb	+/-	Dummy variable equal to 1 for foreign joint venture bank and 0 otherwise
Foreign bank	d_purefb	+/-	Dummy variable equal to 1 for foreign bank and 0 otherwise

It would be ideal if all of the variables could be regressed covering full period for which the efficiency measures are calculated in the first stage (from 1993 to 2011). However, due to the unavailability of bank-specific variables from before 2000, the estimation is separated into two different periods. The period covering 1993 – 2011 is run without *CAR*, *NPL* and *ROA*, and the period from 2000 – 2011 includes all of the variables. Table 5 provides a summary of the inputs and outputs used over the study period. The table reveals that total deposit is the dominant input while total loans is the biggest part of the output on average.

Table 5. Descriptive Statistics of the Outputs and Inputs for Indonesia Banks, 1993-2011 (IDR millions at 2000 prices)

	Total Loans	Other Earning Assets	Interest Income	Non-Interest Income	Total Deposits	Fixed Assets	Interest Expenses	Non-Interest Expenses
Mean	47,898.83	27,410.02	10,115.41	1,434.00	74,765.25	2,179.09	7,994.35	4,894.40
Max	973,979.27	625,001.56	273,344.02	72,447.24	2,461,022.61	54,090.65	1,361,209.05	556,933.81
Min	4.78	39.29	10.27	0.1	14.51	3.64	0.96	9.5
SD	126,638.28	72,941.01	28,332.74	4,411.30	218,286.08	6,111.27	49,257.12	24,124.68

Source: The data were collected from individual bank financial reports published by Bank Indonesia

4.1 Data Envelopment Analysis (DEA)

This study employs non-parametric DEA approach with variables return to scale (VRS) assumption to examine input-oriented technical efficiency of Indonesian banks. Following Banker, Charnes, and Cooper (1984), the technical efficiency index can be estimated by using following model:

$$
\begin{aligned}
&Min_{\theta,\lambda}\ \theta,\\
&\text{Subject to}\quad -y_i + Y\lambda \geq 0,\\
&\qquad\qquad \theta x_i - X\lambda \geq 0,\\
&\qquad\qquad \mathrm{I1}'\lambda = 1,\\
&\qquad\qquad \lambda \geq 0
\end{aligned}
\qquad (1)
$$

where λ is a $I \times 1$ vector of constants; I1 is an I x1 vector of ones; θ is a scalar value between 0 and 1 and representing the efficiency score for the i^{th} bank; y is the output vector for the i^{th} Decision Making Unit (DMU); Y is the matrix of output of others DMUs which range from $i = 1 \ldots n$; x is a vector of input of the i^{th} DMU; and X is the matrix of input of the others DMUs. The VRS assumption is preferred because, like others DMU, a bank may not operate at optimal scale due to external factors such as imperfect competition and constrains on finance (Coelli et al. 2005).

The limitation of DEA original result is the lack of statistical verification, which leads to there being no measure of the accuracy in the estimated efficiency scores. To address this limitation, this study employs the DEA bootstrapping procedure developed Simar and Wilson (1998). The process can be summarised in the following steps:

1. Calculate the DEA efficiency score θ_i for each bank $i = 1, \dots, n$, by solving the linear programming models previously.
2. Using kernel density estimation, generate a random sample of size *n* from $\widehat{\theta_i}$ $i = 1, \dots, n$, given $\theta^*_{1b}, \dots, \theta^*_{Lb}$.
3. Calculate a pseudo-data set $(x^*_{ib}, y_i), i = 1, \dots n$ to construct the reference bootstrap technology.
4. For the pseudo-data, calculate the bootstrap estimate of efficiency $\hat{\theta}^*_{ib}$ of $\hat{\theta}_i$ for each $i = 1, \dots,$ by solving the bootstrapped input as explained in the previous chapter.
5. Repeat all of the steps *B* times (in this study, B = 1,000) to generate a set of estimates$\{\hat{\theta}^*_{ib}, b = 1, \dots, B\}$.

To construct a confidence interval, Simar and Wilson (2000) propose an improved procedure that automatically corrects for bias without the explicit use of a noisy bias estimate. If the distribution of $(\hat{\theta}^*_{ib} - \hat{\theta}_i)$ is known, then it would be possible to approximate a_α and b_α such that $Pr(-b_\alpha \leq \hat{\theta}_i - \theta \leq -a_\alpha) = 1 - \alpha$. This term can thus be approximated by estimating the values a^*_α and b^*_α given by $r\,(-b^*_\alpha \leq \theta^*_{ib} - \theta_i \leq -a^*_\alpha) = 1 - \alpha$. Sort the values $\hat{\theta}^*_{ib} - \hat{\theta}_i$ for $b = 1, \dots, B$ in increasing order, and delete $(\alpha/2 \; x \; 100)$% of the rows at either end of the sorted list. After setting $-\hat{b}^*_\alpha$, $-\hat{a}^*_\alpha$ to the endpoint of the sorted array, the estimated $(1 - \alpha)$ percentage confidence interval is $\hat{\theta}_i + \hat{a}^*_\alpha \leq \theta \leq \hat{\theta} + \hat{b}^*_\alpha$.

This procedure can be performed using Performance Improvement Management software (PIM-DEAsoft) version 3.1.

Some external factors could not be accommodated directly in DEA, hence, following as Coelli at al. an also previous empirical studies such as Tecles and Tabak (2010), Sufian (2009) and Barth et al. (2013), this paper adopt the two-stage method to analyse the relationship between bank efficiency measures and some explanatory variables. DEA efficiency score obtained in the first step are run as dependent variable. Since the efficiency score are bounded between 0 and 1, the nature of the dependent variable (DEA score) makes the use of the common least square regression technique unsuitable. Therefore, this study employs the Tobit regression method that allows for limited-range dependent variables. The standard Tobit model can be defined as follows:

$$y^*_i = \beta' z_i + \varepsilon_i; \; y_i = y^*_i, \text{ if } y^*_i \geq 0, \text{ and } y_i = 0, \text{ otherwise} \qquad (2)$$

where $\varepsilon_i \approx N(0, \sigma^2)$, z_i and β are the vectors of explanatory variable and its coefficients, respectively, whereas y_i and y^*_i are the observed DEA efficiency score and the vector a latent variable. To examine the above explanatory factors on Indonesian bank efficiency, Equation (2) can be extended as follows:

$$TE_{it} = \alpha + \beta_1 size_{it} + \beta_2 CAR_{it} + \beta_3 NPL_{it} + \beta_4 ROA_{it} + \beta_5 HHI_t + \beta_6 GDP_t + \beta_7 inlf_t + \beta_8 BMoney_t + \beta_9 Dforex_{it} + \beta_{10} Dlisting_{it} + \beta_{11} Dmerger_{it} + \beta_{12} DregCh_t + \beta_{13} D\_state_i + \beta_{14} D\_PureFB_i + \beta_{15} D\_private_i + \beta_{16} D\_JVB_i + \beta_{17} D\_RDB_i + \varepsilon_{it} \qquad (3)$$

where for bank *i* at time *t* representing annual observation, TE_{it} is the DEA technical efficiency obtained either using intermediation approach (Model A) or revenue approach (Model B). All of the estimations, including the maximum-likelihood estimates of the parameters, are obtained using the commercial statistical software, STATA 12.

5. Empirical results

5.1 Efficiency of Indonesian Banking Sector

Table 6 summarises the annual means of DEA technical efficiency scores for the entire banking industry during the 1993-2011 period. Each measure presents the results for both approaches, Model A and Model B, beginning with the estimated efficiency (the original DEA efficiency) in columns 2 and 3, followed by bias-corrected estimates in columns 4 and 5 and estimates of bias in columns 6 and 7. The remaining four columns provide the lower and upper bounds of the efficiency estimates for the 95% confidence interval.

Table 6. Annual Mean Efficiency Estimates for the Indonesian Banking Industry

Year	Estimated Efficiency		Bias-corrected Mean		Bias		Lower Bound		Upper Bound	
	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B
1993	0.4759	0.8117	0.4189	0.7861	0.0569	0.0255	0.3349	0.7433	0.4801	0.8127
1994	0.4827	0.8198	0.3947	0.7925	0.0880	0.0273	0.2906	0.7491	0.4880	0.8207
1995	0.5611	0.7990	0.4902	0.7747	0.0709	0.0244	0.3979	0.7323	0.5648	0.8002
1996	0.5369	0.8250	0.4911	0.8045	0.0457	0.0205	0.4302	0.7678	0.5404	0.8257
1997	0.4880	0.7864	0.4181	0.7604	0.0699	0.0260	0.3331	0.7215	0.4916	0.7878
1998	0.7136	0.6643	0.6847	0.6180	0.0289	0.0463	0.6381	0.5447	0.7157	0.6678
1999	0.6393	0.5317	0.6048	0.4471	0.0345	0.0846	0.5485	0.3433	0.6418	0.5380
2000	0.5858	0.7003	0.5420	0.6610	0.0437	0.0393	0.4547	0.5908	0.5876	0.7020
2001	0.5583	0.7131	0.4958	0.6725	0.0625	0.0407	0.3903	0.6045	0.5618	0.7147
2002	0.6075	0.6857	0.5597	0.6525	0.0478	0.0332	0.4716	0.5949	0.6093	0.6878
2003	0.6133	0.4243	0.5646	0.3514	0.0487	0.0729	0.4798	0.2446	0.6154	0.4287
2004	0.6668	0.3650	0.6218	0.2849	0.0450	0.0801	0.5441	0.1723	0.6688	0.3719
2005	0.6822	0.6700	0.6389	0.6239	0.0433	0.0461	0.5645	0.5483	0.6839	0.6718
2006	0.6934	0.7155	0.6516	0.6834	0.0419	0.0320	0.5780	0.6256	0.6949	0.7169
2007	0.6981	0.7184	0.6597	0.6868	0.0384	0.0316	0.5929	0.6285	0.6994	0.7197
2008	0.5785	0.7198	0.5202	0.6828	0.0583	0.0370	0.4327	0.6229	0.5814	0.7218
2009	0.5268	0.6975	0.4705	0.6628	0.0563	0.0347	0.3795	0.6049	0.5299	0.6996
2010	0.5851	0.7048	0.5327	0.6632	0.0523	0.0416	0.4509	0.6028	0.5878	0.7071
2011	0.5956	0.8022	0.5471	0.7795	0.0486	0.0227	0.4676	0.7412	0.5980	0.8033
Mean	0.5942	0.6923	0.5425	0.6520	0.0517	0.0403	0.4621	0.5886	0.5969	0.6946

Source: Author's calculations.

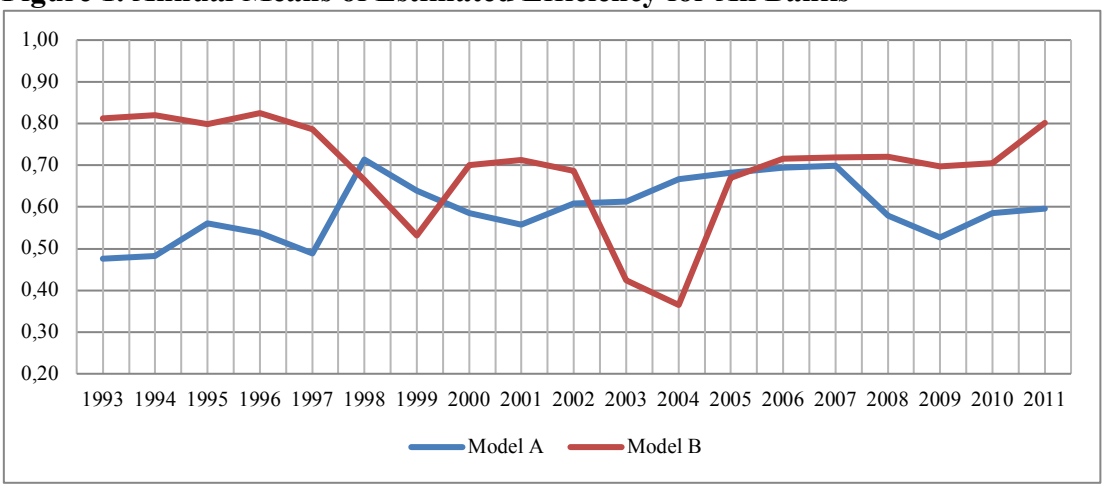
As a whole, the Indonesian banking industry is technically inefficient during the period of analysis. Although inefficiency is evident under both approaches, the two approaches show different patterns throughout the period. As shown in the table, the average efficiency estimate for Model A is 59.42% for the entire period, with annual average scores ranging from 48% to 71%. These scores are lower than those found for model B, for which the average efficiency estimate is 69.23%, with annual average scores ranging from 36% to 82%. These results suggest that the industry is more efficient under model B, indicating that there is a scope for the Indonesian banking industry to reduce its use of inputs by 30.77% on average, given current levels of output. By contrast, the average score for model A suggests that reductions in inputs can be as high as 40.58%, without a reduction in the amount of output produced. These empirical results imply substantial asymmetry between institutions in terms of their technical efficiency. In particular, different approaches to the determination of input and output variables appear to generate different efficiency estimates. Also it signifies

the flexibility of the DEA method in producing efficiency scores when alternative sets of input and output variables are considered. It is important to note that the pre-crisis improvements in efficiency coincide with the implementation of deregulation in the 1990s by the Indonesian government. It can be inferred that deregulation increased competition among banks, which led to improved performance in the banking sector.

Models A and B exhibit interesting opposing patterns during the period of analysis. Figure 1**Error! Reference source not found.** clearly displays the trend of estimated efficiency over the study period, vividly showing that the models tend to move in different directions from the beginning of the sample period until 2008 but subsequently move in the same direction from 2009 onward. Although both approaches indicate inefficiency throughout the period, the intermediation approach shows efficiency improvement, whereas the revenue approach shows efficiency deterioration towards the end of period. In addition, this pattern highlights the sensitivity of the outcome to the choice of inputs and outputs and suggests that the liberalisation policies adopted by the government did not appear to maximise the efficiency of the intermediation function of banks but instead created an opportunity for banks to exploit the business side to maximise revenue.

During the initial period, efficiency as measured by Model A begins at the lowest level of average efficiency (47.59%) but overall increases slightly throughout the period, although notable ups and downs occurred. Given the low score, financial liberalisation in the late 1980s does not seem appear to have had a substantial effect on bank efficiency at the beginning of the 1990s. By contrast, Model B begins with an average efficiency level that is 1.7 times higher than that of Model A in 1993 (81.17%) and reached its highest level at 82.50% in 1996. This early period witnessed a significant efficiency gain for this model before efficiency decreased considerably, declining to its low point at 36.50% in 2004. Furthermore, Model B also generally exhibits a higher level of efficiency, except in the 1998-1999 and 2003-2005 periods. The pattern of these initial results is similar to the pattern identified by Zhang and Matthews (2012) who also find that cost efficiency in the Indonesian banking industry is low in the initial period (1992-1993) in their asset creation model (which is similar to Model A in this study) but is relatively high in their income flow model.

Figure 1. Annual Means of Estimated Efficiency for All Banks



Source: Author's DEA results (table 6)

Following that initial divergence, Figure 1 also shows fluctuations during three periods of the time frame under investigation: 1997-1999, 2003-2004 and 2008-2009. These three main periods of fluctuation can be attributed to the three major events during the sample period

that caused a decline in the average efficiency: the AFC in 1997, the re-privatisation process following the AFC and the global financial crisis. The first period of fluctuations, 1997 to 1999, is notable as the period of the AFC. In the early part of the sample period, both approaches show decreasing efficiency until 1997, when the intermediation approach surprisingly begins to show sharply increased efficiency through 1998, while the revenue approach (Model B) shows deterioration until 1999. This finding could be explained by a loss of depositor confidence, given the absence of a proper deposit guarantee scheme. The volume of deposits would then decline significantly as a result of massive withdrawals from banks. By contrast, on the output side, loans remained on the balance sheets of banks, with the amount of outstanding loans mounting because of the accumulation of unpaid loans. On the revenue approach side, as banks carried more non-performing loans during the crisis period, interest income declined, hence lowering the average efficiency measured by Model B.

The second period (2003-2004) is the period of re-privatisation, which shows a pattern that is somewhat similar to that of previous events. Under re-privatisation, the government sells most of the ownership of a nationalised bank to private domestic or foreign investors. The final period of fluctuations (2008-2009) is the period of the global financial crisis, which spread to the Indonesian banking industry. It is worth noting that the two models show dramatically different perspectives for these two events. During the 2003-2004 period, Model B shows a substantial decrease in efficiency to its lowest level (36.5%), whereas Model A shows an improvement in efficiency. In the 2008-2009 period, although both models show declining efficiency, the decline indicated by Model B is much larger than that of Model A. Hence, the results prompt a question regarding the sources of these differences.

The sensitivity of the efficiency estimates with respect to sampling variation is revealed that, although, the original efficiency estimates lie within the confidence interval, they are upwardly biased compared with bias-corrected efficiency scores. This result is similar to those reported by Simar and Wilson (1998) but contrast with those obtained by Tortosa-Ausina et al. (2008). The results of the bias-corrected estimates, as presented in columns 4 and 5, are shown to differ from the original efficiency estimates, as presented in columns 2 and 3. The biases vary not only across the period but across the models. As presented in columns 6 and 7, the bias in model A is less than 0.05 in 1996, 1998-2000, 2002-2007 and 2011, whereas in the remaining years, the bias is above 0.05, with 1994 showing the largest bias.

Turning to the results for groups of banks, Table 7 and Table 8 present the annual means of the bootstrapped efficiency scores for each group of banks under Models A and B. Each table includes five groups of banks,: state-owned banks, private national banks, regional development banks, joint venture banks and foreign banks. The measurement results are presented horizontally for each bank group, moving consecutively from the original measures of efficiency, the bootstrapped bias-corrected scores, and the bias estimates, as well as the lower and upper bounds of the 95% confidence interval. To support the broad results presented in these two tables and to facilitate identification of the sources of efficiency, Table 9 presents the number of efficient banks for each group under both models.

A comparison of Table 7 and 8 provides two different pictures or patterns of efficiency among the bank groups for Model A and Model B, respectively. This difference again highlights the sensitivity of the results to the choice of input and output variables. Model A, which is displayed inFigure 2 and 3, reveals disparities between the efficiency levels of bank groups, although fluctuations still occur. The group of state-owned banks is found to be the best performing group throughout the period, average efficiency scores ranging from 81% to

100%, which is far above the industry average (47.6% to 71.4%). by the percentage of efficient banks in this group, with a minimum of 25% of banks on the efficient frontier. Following state-owned bank group are the foreign and joint venture bank groups as the second and third most efficient groups, respectively. The mean efficiency of the foreign banks ranges from 51% to 97%, while and that of the joint venture banks ranges from 66% to 90%, exceeding the average industry efficiency by 18% and 22%, respectively.

Meanwhile, the group of private national banks is ranked only slightly above regional development banks, which are found to constitute the least efficient group in the industry. Both of these groups fall below the industry level, with efficiency scores ranging from 33% to 71%. Our findings are similar to those of Hadad et al. (2008) and Hadad et al. (2012) with respect to the ranking of groups from the most efficient to the least efficient, although the efficiency scores of the groups differ between these studies. It also confirms the result of Salim, Hoquea, and Suyanto (2010) for Australian banks in regard that major banks are relatively efficient compared to regional banks.

The group of bank in Table 7 and 8 are based on annual means of efficiency, which provides only a partial view of the performance of the groups as a whole. Table 9 provides the number of efficienct bank in each group which is supports the annual mean result. Based on the number of efficient banks, the state-owned bank group has the highest number of efficient bank (at least one out of four) and ranks as the top among bank groups. By contrast, the group of regional development banks has the highest proportion only once, in 1996, with four of 25 banks (or 16%) found to be efficient, and in some years, 1993, 2001, 2003, 2004 and 2009 to 2011, this group of banks do not have any efficient banks at all.

The difference in efficiency between state-owned and regional banks is interesting. Banks in both of these groups are government-owned, but they are unequal in terms of business size. State-owned banks are owned by the state government, whereas regional development banks are owned by local governments. However, the status of regional development banks as the least efficient among different types of banks has become a serious concern, as this group ranks third in customer deposits.

The results under the revenue approach (Model B) reveal interesting findings and show important differences in the efficiency levels of these groups, as presented in Table 8 and displayed in Figure 3**Error! Reference source not found.** The point of commonality between this model and Model A is that state banks are ranked at the top, with an average efficiency ranging from 55% to unity, whereas the other groups and the industry as a whole have much lower efficiency levels. The figure also shows that the average scores of the other groups appear to be only slightly different from each other.

In brief, the technical efficiency of all groups reveals a high fluctuation during the study period except for state-owned banks. This finding suggests that the deregulation and liberalisation of the banking sector in Indonesia has had a different effect for each group. The nature of the bank group's business operation appears to influence their performance in response to the liberalisation.

Table 7. Model A – Annual Means of Efficiency Estimates per Group, 1993-2011

Groups		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean
State-owned banks	Eff Estimate	0.9883	0.9650	1.0000	1.0000	0.9473	0.8107	0.9047	0.8478	0.8816	0.9277	0.9152	0.9369	0.9122	0.9529	0.9607	0.9209	0.8991	0.9975	0.9497	0.9325
	Bias-corrected	0.9775	0.9326	1.0000	1.0000	0.9036	0.7643	0.8718	0.8141	0.8464	0.9006	0.8832	0.9134	0.8831	0.9318	0.9358	0.8616	0.8216	0.9950	0.9260	0.9033
	Bias	0.0108	0.0325	0.0000	0.0000	0.0438	0.0465	0.0329	0.0337	0.0352	0.0271	0.0320	0.0235	0.0290	0.0212	0.0249	0.0593	0.0775	0.0025	0.0238	0.0293
	LB	0.9766	0.9301	1.0000	1.0000	0.8946	0.6848	0.8094	0.7432	0.7687	0.8553	0.8304	0.8739	0.8243	0.9059	0.9214	0.8418	0.7982	0.9950	0.8994	0.8712
	UB	0.9899	0.9692	1.0000	1.0000	0.9530	0.8122	0.9061	0.8484	0.8830	0.9285	0.9160	0.9392	0.9125	0.9535	0.9621	0.9252	0.9066	0.9993	0.9512	0.9345
Private national banks	Eff Estimate	0.4190	0.4698	0.5271	0.4708	0.4149	0.7062	0.6091	0.5310	0.4890	0.5482	0.5415	0.5891	0.6258	0.6083	0.6197	0.4858	0.4594	0.5114	0.5394	0.5350
	Bias-corrected	0.3656	0.3937	0.4650	0.4279	0.3464	0.6761	0.5736	0.4783	0.4202	0.5003	0.4907	0.5383	0.5794	0.5612	0.5765	0.4243	0.4018	0.4555	0.4797	0.4818
	Bias	0.0535	0.0761	0.0621	0.0429	0.0685	0.0300	0.0356	0.0527	0.0688	0.0479	0.0508	0.0508	0.0464	0.0470	0.0432	0.0615	0.0576	0.0559	0.0597	0.0532
	LB	0.2842	0.3037	0.3749	0.3657	0.2521	0.6251	0.5103	0.3700	0.2926	0.4084	0.3981	0.4470	0.4959	0.4756	0.4967	0.3211	0.2998	0.3638	0.3842	0.3931
	UB	0.4230	0.4754	0.5307	0.4743	0.4184	0.7086	0.6116	0.5330	0.4926	0.5501	0.5436	0.5913	0.6276	0.6097	0.6210	0.4886	0.4624	0.5141	0.5421	0.5378
Regional development banks	Eff Estimate	0.3385	0.3502	0.4668	0.4758	0.3848	0.6091	0.4962	0.4522	0.4916	0.5200	0.5624	0.6190	0.6378	0.7096	0.6630	0.5382	0.4010	0.4996	0.4775	0.5102
	Bias-corrected	0.2854	0.2792	0.3935	0.4402	0.3366	0.5855	0.4671	0.4147	0.4353	0.4677	0.5155	0.5751	0.5983	0.6751	0.6269	0.4802	0.3384	0.4471	0.4311	0.4628
	Bias	0.0531	0.0710	0.0733	0.0357	0.0482	0.0236	0.0291	0.0375	0.0564	0.0523	0.0470	0.0438	0.0395	0.0345	0.0360	0.0580	0.0626	0.0525	0.0464	0.0474
	LB	0.1954	0.1621	0.2886	0.3944	0.2663	0.5508	0.4198	0.3415	0.3435	0.3776	0.4436	0.4968	0.5189	0.6060	0.5538	0.3910	0.2318	0.3561	0.3463	0.3834
	UB	0.3421	0.3537	0.4706	0.4791	0.3879	0.6113	0.4987	0.4543	0.4953	0.5221	0.5648	0.6211	0.6396	0.7114	0.6645	0.5409	0.4042	0.5024	0.4803	0.5129
Joint venture banks	Eff Estimate	0.7758	0.6641	0.7389	0.7409	0.8556	0.8346	0.8526	0.8528	0.7045	0.7874	0.7471	0.9001	0.8273	0.8064	0.8859	0.7193	0.6718	0.7347	0.7070	0.7793
	Bias-corrected	0.7181	0.5271	0.6192	0.6853	0.7726	0.8077	0.8217	0.8248	0.6339	0.7373	0.6796	0.8763	0.7903	0.7629	0.8569	0.6622	0.6245	0.6870	0.6741	0.7243
	Bias	0.0577	0.1369	0.1197	0.0556	0.0830	0.0269	0.0309	0.0281	0.0706	0.0501	0.0675	0.0238	0.0370	0.0435	0.0290	0.0570	0.0473	0.0477	0.0330	0.0550
	LB	0.6628	0.3966	0.5416	0.6255	0.7112	0.7651	0.7739	0.7715	0.5401	0.6390	0.5683	0.8437	0.7437	0.6926	0.8189	0.5780	0.5416	0.6048	0.6092	0.6541
	UB	0.7831	0.6698	0.7443	0.7450	0.8605	0.8356	0.8540	0.8539	0.7074	0.7887	0.7489	0.9010	0.8292	0.8081	0.8872	0.7227	0.6743	0.7378	0.7093	0.7821
Foreign banks	Eff Estimate	0.6310	0.5101	0.6306	0.6626	0.5926	0.8705	0.8599	0.8661	0.8458	0.8582	0.8946	0.8780	0.8747	0.9091	0.9324	0.9277	0.9461	0.9071	0.9733	0.8195
	Bias-corrected	0.5236	0.3346	0.5378	0.5626	0.4566	0.8387	0.8118	0.8358	0.8005	0.8170	0.8666	0.8306	0.8252	0.8699	0.8986	0.8864	0.9142	0.8488	0.9560	0.7587
	Bias	0.1075	0.1755	0.0928	0.1000	0.1359	0.0318	0.0481	0.0303	0.0453	0.0411	0.0280	0.0474	0.0494	0.0391	0.0338	0.0413	0.0319	0.0584	0.0174	0.0608
	LB	0.3718	0.1688	0.4097	0.4388	0.3267	0.7952	0.7645	0.7882	0.7609	0.7481	0.8080	0.7673	0.7807	0.8306	0.8703	0.8625	0.8922	0.8143	0.9467	0.6918
	UB	0.6368	0.5191	0.6342	0.6684	0.5959	0.8721	0.8636	0.8681	0.8492	0.8592	0.8960	0.8794	0.8760	0.9103	0.9330	0.9306	0.9479	0.9098	0.9738	0.8223

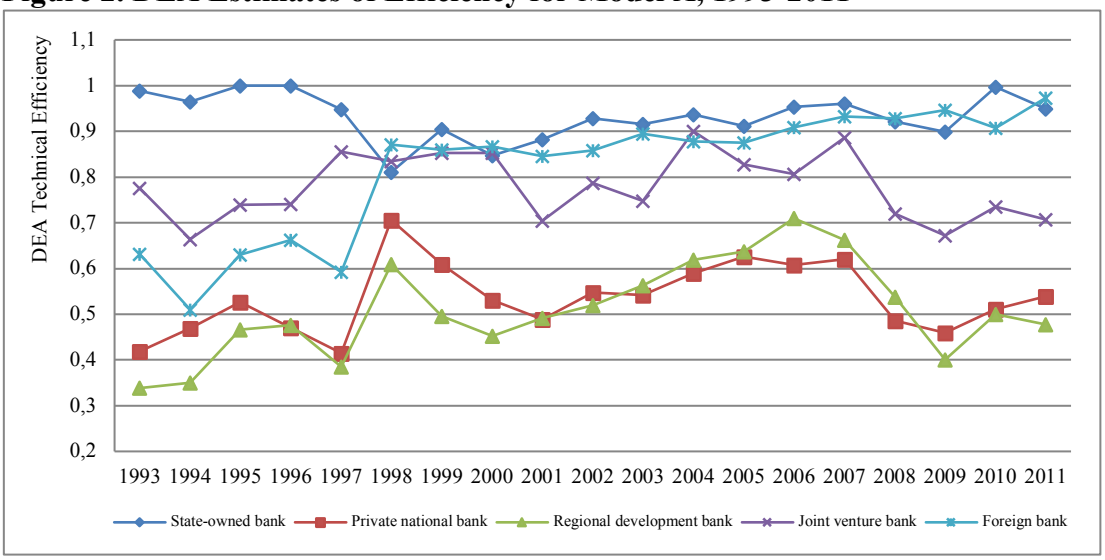
Source: Author's calculations. Note: LB denotes lower bound; UB denotes upper bound.

Table 8. Model B – Annual Means of Efficiency Estimates per Group, 1993-2011

Groups		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean
State-owned banks	Eff Estimate	1.0000	0.9957	1.0000	1.0000	0.9914	0.8624	0.5475	1.0000	0.9556	0.9625	0.9919	0.9802	0.9394	0.9766	1.0000	0.9485	0.9646	0.9190	0.9179	0.9449
	Bias-corrected	1.0000	0.9919	1.0000	1.0000	0.9841	0.8338	0.4319	1.0000	0.9281	0.9363	0.9840	0.9610	0.8944	0.9606	1.0000	0.9145	0.9384	0.8746	0.8888	0.9222
	Bias	1.0000	0.9914	1.0000	1.0000	0.9828	0.8393	0.4418	1.0000	0.9198	0.9317	0.9838	0.9605	0.8788	0.9533	1.0000	0.9074	0.9340	0.8698	0.8971	0.9206
	LB	1.0000	0.9914	1.0000	1.0000	0.9828	0.7738	0.2930	1.0000	0.9112	0.9250	0.9838	0.9605	0.8788	0.9533	1.0000	0.8969	0.9292	0.8381	0.8358	0.9028
	UB	1.0000	0.9961	1.0000	1.0000	0.9921	0.8631	0.5522	1.0000	0.9562	0.9646	0.9946	0.9907	0.9408	0.9774	1.0000	0.9500	0.9664	0.9207	0.9186	0.9465
Private national banks	Eff Estimate	0.8199	0.8192	0.8137	0.8200	0.7489	0.6525	0.5282	0.7067	0.7083	0.6349	0.4274	0.3595	0.6948	0.7569	0.7481	0.7723	0.7874	0.8108	0.8524	0.7085
	Bias-corrected	0.7919	0.7905	0.7892	0.7973	0.7170	0.6002	0.4508	0.6621	0.6621	0.5973	0.3425	0.2677	0.6420	0.7223	0.7118	0.7344	0.7517	0.7687	0.8325	0.6649
	Bias	0.7947	0.7927	0.7925	0.8000	0.7189	0.6051	0.4535	0.6693	0.6669	0.6023	0.3451	0.2751	0.6468	0.7260	0.7163	0.7387	0.7552	0.7712	0.8342	0.6687
	LB	0.7478	0.7464	0.7453	0.7574	0.6695	0.5207	0.3563	0.5818	0.5853	0.5313	0.2321	0.1399	0.5605	0.6641	0.6492	0.6758	0.6983	0.7124	0.8015	0.5987
	UB	0.8209	0.8201	0.8149	0.8208	0.7504	0.6560	0.5341	0.7084	0.7099	0.6369	0.4323	0.3668	0.6968	0.7584	0.7494	0.7743	0.7897	0.8133	0.8535	0.7109
Regional development banks	Eff Estimate	0.7413	0.7981	0.7521	0.8233	0.8102	0.6537	0.5231	0.6624	0.6901	0.7129	0.3246	0.2687	0.6171	0.6588	0.6639	0.6532	0.6072	0.6199	0.7452	0.6487
	Bias-corrected	0.7169	0.7738	0.7282	0.8052	0.7884	0.6128	0.4508	0.6272	0.6529	0.6816	0.2551	0.1981	0.5759	0.6236	0.6322	0.6131	0.5708	0.5766	0.7204	0.6107
	Bias	0.7218	0.7767	0.7301	0.8071	0.7917	0.6198	0.4570	0.6330	0.6586	0.6852	0.2643	0.2092	0.5843	0.6281	0.6409	0.6176	0.5756	0.5801	0.7238	0.6161
	LB	0.6652	0.7295	0.6891	0.7757	0.7536	0.5407	0.3483	0.5668	0.5909	0.6303	0.1387	0.0818	0.4917	0.5564	0.5642	0.5464	0.5069	0.5141	0.6757	0.5456
	UB	0.7425	0.7989	0.7533	0.8240	0.8117	0.6571	0.5288	0.6643	0.6918	0.7151	0.3286	0.2742	0.6189	0.6603	0.6652	0.6553	0.6093	0.6223	0.7464	0.6509
Joint venture banks	Eff Estimate	0.7802	0.7989	0.7581	0.7818	0.8226	0.6528	0.5538	0.6565	0.6848	0.7123	0.4400	0.4255	0.6228	0.6472	0.6744	0.6482	0.5335	0.5321	0.7855	0.6585
	Bias-corrected	0.7517	0.7694	0.7307	0.7617	0.8028	0.6153	0.4523	0.6089	0.6477	0.6850	0.3599	0.3351	0.5803	0.6213	0.6495	0.6184	0.4969	0.4936	0.7594	0.6179
	Bias	0.7538	0.7736	0.7327	0.7687	0.8043	0.6202	0.4488	0.6086	0.6513	0.6923	0.3679	0.3300	0.5846	0.6300	0.6556	0.6263	0.5069	0.5040	0.7618	0.6222
	LB	0.7059	0.7205	0.6919	0.7144	0.7735	0.5559	0.3358	0.5337	0.5797	0.6251	0.2396	0.2407	0.5151	0.5556	0.5990	0.5487	0.4093	0.4082	0.7151	0.5509
	UB	0.7812	0.7998	0.7593	0.7825	0.8242	0.6571	0.5609	0.6584	0.6862	0.7143	0.4443	0.4328	0.6246	0.6484	0.6757	0.6499	0.5351	0.5336	0.7866	0.6608
Foreign banks	Eff Estimate	0.9102	0.8288	0.7994	0.8292	0.8097	0.6884	0.5449	0.7471	0.7297	0.7572	0.4135	0.3238	0.6033	0.5886	0.6189	0.5738	0.4821	0.4135	0.6324	0.6471
	Bias-corrected	0.8876	0.7932	0.7668	0.8057	0.7913	0.6447	0.4160	0.7248	0.7018	0.7346	0.3807	0.2703	0.5792	0.5663	0.5932	0.5411	0.4561	0.3768	0.6055	0.6124
	Bias	0.8866	0.7943	0.7712	0.8105	0.7942	0.6467	0.4188	0.7300	0.7070	0.7401	0.3907	0.2767	0.5852	0.5705	0.5920	0.5456	0.4619	0.3803	0.6087	0.6164
	LB	0.8615	0.7433	0.7024	0.7630	0.7650	0.5826	0.2831	0.6743	0.6470	0.6906	0.2891	0.1883	0.5237	0.5236	0.5527	0.4843	0.3999	0.3147	0.5551	0.5550
	UB	0.9111	0.8298	0.8004	0.8299	0.8110	0.6927	0.5547	0.7485	0.7312	0.7594	0.4171	0.3302	0.6048	0.5897	0.6202	0.5757	0.4837	0.4153	0.6336	0.6494

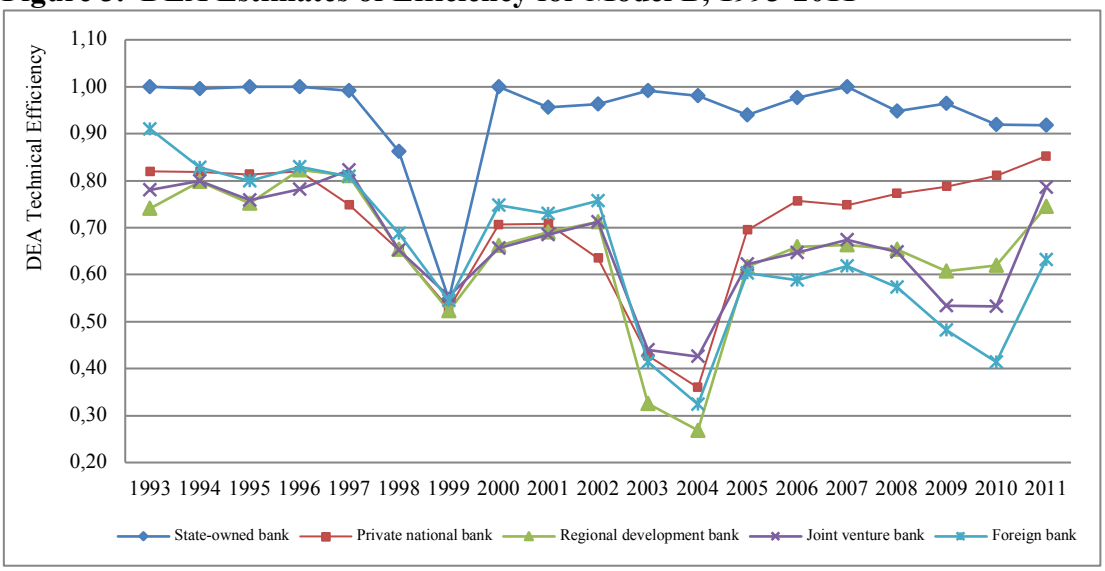
Source: Author's calculations. Note: LB denotes lower bound; UB denotes upper bound.

Figure 2. DEA Estimates of Efficiency for Model A, 1993-2011



Source: Author's DEA results

Figure 3. DEA Estimates of Efficiency for Model B, 1993-2011



Source: Author's DEA results

Table 9. The Number of Efficient Banks by Group

Groups	State-owned bank (4 banks)		Private national bank (53 banks)		Regional development bank (25 banks)		Joint venture bank (10 banks)		Foreign bank (9 banks)		Total (101 banks)	
	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B
1993	3	4	3	9	2	0	3	1	2	3	27	36
1994	3	3	1	8	2	4	2	2	0	1	25	30
1995	4	4	4	12	1	2	1	1	2	1	31	36
1996	4	4	5	10	4	3	4	1	1	2	36	44
1997	2	3	3	6	2	4	3	1	2	2	26	34
1998	2	3	10	9	2	4	6	1	5	1	42	55
1999	3	1	8	8	1	2	6	1	3	0	33	43
2000	3	2	7	9	1	3	7	1	5	3	38	54
2001	3	3	3	8	0	2	4	1	5	2	29	41
2002	3	2	6	7	1	3	5	2	5	2	34	48
2003	3	3	5	5	1	0	4	1	5	0	27	37
2004	2	3	4	4	3	0	7	1	5	0	29	42
2005	3	2	3	8	1	2	3	1	4	1	27	36
2006	3	3	5	10	3	2	3	1	5	1	35	45
2007	2	4	5	10	3	2	4	1	6	0	37	48
2008	2	2	2	11	3	1	2	1	5	0	29	37
2009	1	2	4	12	0	2	3	1	7	0	32	43
2010	3	2	4	12	0	1	2	1	5	0	30	38
2011	3	2	4	14	0	3	3	2	8	0	39	52

Source: Author's calculation.

5.2 The Determinants of Indonesian Banks' Efficiency

The estimation results are presented in Table 10 for two models, Model A (the intermediation approach) and Model B (the revenue approach), and for each model there are two periods of estimation results, the period from 1993 – 2011, which is without the three internal bank characteristic variables, and the period from 2000 – 2011, which includes the three variables.

The estimations cover the entire Indonesian banking industry and include all of the dummy groups of banks (five groups), although the results for the regional development banks are omitted as they are the base case. All of the models and versions have good explanatory power, and the Wald chi^2 are all statistically significant at 1%. This result means that the regression model explains at least some sources of efficiency.

Some explanatory variables demonstrate their significant roles, in explaining their effect on efficiency, although inconsistent signs of influence exist in some cases. For example, the variables for listing and merger are negative and significant in the 1993–2011 Model B and the 2000–2011 Model A, while in the other period and model, these variables are not significant. This result demonstrates the various effects of the variables in the model. Apart from that, there are some variables exhibit consistent results across the models and periods: size, broad money, foreign bank, state bank and JVB are positive and significant, and *CAR* is positive but insignificant. While other variables such as *NPL* and foreign exchange are insignificant but have a mixed sign, inflation, regulatory change and *ROA* are positive but show mixed significance. The remainder of the variables have mixed results.

Table 10. Determinants of Efficiency (TE) – Tobit Regression Model

Variable	Model A				Model B			
	1993–2011		2000–2011		1993–2011		2000–2011	
	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Size	0.039***	0.007	0.050***	0.008	0.039***	0.006	0.041***	0.008
CAR	-		0.004	0.004	-		0.004	0.005
NPL	-		-0.003	0.059	-		0.039	0.067
ROA	-		0.130	0.080	-		0.514***	0.093
HHI	-0.273***	0.043	0.567**	0.243	0.197***	0.045	-1.313***	0.283
GDP	0.005*	0.003	0.061***	0.008	0.041***	0.003	-0.029***	0.009
Infl	0.006***	0.001	0.009***	0.001	0.012***	0.001	0.000	0.002
BMoney	0.003**	0.001	0.007***	0.002	0.009***	0.001	0.019***	0.002
Dforex	0.004	0.020	-0.038	0.024	-0.022	0.019	0.013	0.025
Dlisting	0.017	0.019	-0.010	0.021	-0.051***	0.019	-0.035	0.023
Dmerger	-0.030	0.027	-0.068**	0.029	0.010	0.027	0.001	0.031
DRegCh	0.017	0.017	0.040	0.032	0.153***	0.018	0.230***	0.037
D_state	0.255***	0.075	0.239***	0.083	0.149**	0.059	0.170**	0.069
D_PureFB	0.249***	0.053	0.323***	0.059	0.148***	0.041	0.144***	0.049
D_Private	0.022	0.033	0.033	0.037	0.046*	0.025	0.030	0.031
D_JVB	0.291***	0.045	0.299***	0.050	0.087**	0.036	0.100**	0.044
Intercept	0.125	0.100	-1.036***	0.253	-0.662***	0.099	0.248	0.288
/sigma_u	0.126***	0.010	0.139***	0.011	0.092***	0.008	0.109***	0.009
/sigma_e	0.174***	0.003	0.138***	0.003	0.183***	0.003	0.162***	0.003
rho	0.343	0.036	0.502	0.041	0.201	0.028	0.313	0.038
Log likelihood	515.52		546.00		451.62		395.79	
Wald chi^2	349.06***		244.99***		402.67***		529.54***	
Observation	1919		1212		1919		1212	

Sources: Author's calculation

Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. SE is standard error.

Among the bank-specific variables, the size variable consistently shows a positive influence on the efficiency of the banking industry under both models and in different estimation periods. This supports the idea that larger banks are likely to be more efficient than smaller banks, which confirms similar findings in other Indonesian studies such as Zhang and Matthews (2012), Hadad et al. (2008), Hadad et al. (2010) and Hadad et al. (2012), although those studies' results are not consistently significant. Although it is contrary with those of Ye, Xu, and Fang (2012) and Jha, Hui, and Sun (2013) who find negative relationship. In Indonesia, as noted earlier, large banks possess extensive bank branches, diversified products and better technology, all of which seem to outweigh any negative effects of being "large".

The *HHI* is introduced to the model to assess the effect of market concentration on bank efficiency. Although consistently significant, it exhibits an ambiguous direction of impact over the different models and periods. *HHI* carries a negative coefficient over the longer period (1993–2011) but is positive for the shorter period (2000–2011) of Model A. The results for Model B are vice versa, i.e. a positive coefficient for 1993–2011 and a negative coefficient for 2000–2011. The negative correlation clearly suggests that a highly concentrated market reduces banks' efficiency, which supports the earlier hypothesis. This study in line with those of Ye, Xu, and Fang (2012) and Barth et al. (2013).

Regarding the macroeconomic variables, the annual growth of GDP is statistically significant and positively correlated to bank efficiency (except for 2000–2011 of Model B). The positive and significant correlation result suggests that economic growth is important to maintaining bank efficiency, a claim that is supported by Drake, Hall, and Simper (2006a) and Grigorian and Manole (2006). The volatility of economic growth, especially toward the end of the

1990s, does not seem to have had a negative impact on productivity growth during the period of 1993–2011, except in Model B of TFP regression.

The inflation coefficients are the opposite of that expected. The results show it is positively related to bank efficiency and productivity growth, having a strongly statistically significant relationship to bank efficiency. This finding suggests a higher inflationary environment is favourable to bank efficiency and productivity growth. Although contradictory to the conventional findings of bank efficiency studies (Delis, Molyneux, and Pasiouras 2011, Barth et al. 2013, Castellanos and Garza-García 2013), this result seems to support the argument of Grigorian and Manole (2006). They argue that since inflation could take the form of price and non-price behaviour, high inflation is unnecessarily linked to large inefficiencies. Lastly among the macroeconomic variables, a higher amount of currency outside of the banks, as measured by broad money, is strongly associated with more efficient banks

Looking at bank status, this study does not support the finding of Hadad et al. (2012), that listed banks are more efficient than the industry average. On the contrary, the results confirm the findings of Havrylchyk (2006) in Polish banking. Status as a foreign-exchange bank shows a lack of significance and tends to be negative. This result suggests that the common prejudice of the public regarding the "exclusive" status of foreign exchange banks is not benefited them in their performance. To some extent, this result is surprising because most of the listed and foreign exchange banks in Indonesia are large banks, which are known to be the best performers.

Turning to the restructuring policy (*dmerger*) and regulatory changes, these variables are emphasised as the focus of this study is to analyse the impact of regulatory change to the efficiency. The result under intermediation-based technical efficiency fails to support the positive effect of the restructuring policy on industry efficiency. Moreover, merger even seems to have had an adverse impact in the shorter period (2000–2011). Merger is only positive in Model B for efficiency, but the coefficient is relatively small and insignificant. This result supports earlier studies such as those by Schenk (2006) and Halkos and Tzeremes (2013), which indicate that a merged bank does not always lead to an efficiency gain.

Regulatory changes mostly influence bank efficiency positively, although only with significance at the 1% level under Model B of technical efficiency and 5% in period 2000 – 2011 of TFP. This result indicates that banks responded strongly positive to the implementation of new regulations if measured by revenue approach based. In addition, the intention of the authorities to strengthen and improve bank performance by reforming the regulations had a positive impact. The strong significance of this variable in Model B is perhaps because banks were able to maximise take advantage of the new arrangement of deposit guarantee system under IDIC. The new system guarantees the consumer deposit from a bank failure by setting the deposit interest at a certain rate. This arrangement maybe makes banks able to reduce their interest expenses since they do not need to set higher deposit interest to attract customer, while interest revenue remains the same.

The lack of significance in Model A is, to some extent, consistent with the findings of Barth, Caprio, and Levine (2004). The authors report that the generosity of the deposit insurance scheme has no strong correlation with bank efficiency; instead it has strong negative correlation with bank fragility. These findings highlight that the effect of changes in regulation depend on the various features of banks.

In general, foreign banks appear to be most efficient. This result seems to support the typical findings in developing countries' studies, namely that foreign banks outperform their

domestic counterparts. Nevertheless such comparisons have to be made with caution. In this study 'foreign bank' is defined as the branch of a bank that is 100% foreign-owned, while most other studies examine partially owned foreign banks, which are more comparable to the joint venture banks (JVBs) of this study.

Under Model A, the JVB itself is relatively more efficient than other domestic banks (state, private and RDB). Therefore, as mentioned earlier, these results support the empirical findings in developing countries studies, such as those of Hasan and Marton (2003), Grigorian and Manole (2006), Gardener, Molyneux, and Nguyen-Linh (2011) and Isik and Hassan (2003b). Moreover, this result is also consistent with the study by Zhang and Matthews (2012) in Indonesian case – in particular, their crises and post-crises regressions. However, other researchers report dissimilar findings such as Williams and Nguyen (2005) and Lensink, Meesters, and Naaborg (2008). Compared to other domestic banks (private and RDBs), state banks are found to be relatively more efficient, having positive and statistically significant coefficients. The better performance of state banks over private national banks is consistent with Das and Ghosh (2009) and Bhattacharyya, Lovell, and Sahay (1997) in their Indian bank studies and with other studies (Denizer, Dinc, and Tarimcilar 2000, Altunbas, Evans, and Molyneux 2001, Kraft, Hofler, and Payne 2006). For private banks, the coefficients are consistently positive throughout the regression models, but most of them are statistically insignificant. These results place private banks only slightly above RDBs, the least efficient in the industry. As the largest group, their performance is inordinately reflected in the industry as a whole.

From these findings, it can be seen that the efficiency of Indonesian banks is determined by various factors. Variation in direction, statistical significance and magnitude for some of the variables is apparent in the model, indicating that the role of each variable depends on the period and the model used. The results at the industry level reflect the performance of all banks. Hence, these provide the general picture of the industry.

6. Conclusions

This paper provides an empirical analysis of the technical efficiency of the Indonesian banking sector during the 1993-2011 period. The results are obtained by conducting an input-oriented DEA using the bootstrapped DEA method under an assumption of VRS. Two separate sets of input and output variables under both the intermediation approach (Model A) and the revenue approach (Model B) are employed to measure the efficiency of intermediation activities and revenue-maximising bank business operations. Using the censored Tobit regression model, for each model a set of explanatory variables is regressed on the calculated technical efficiency and total factor productivity change. The estimation is run on two versions of the data set over two periods, from 1993–2011, which excludes three bank characteristic variables, and from 2000–2011, which includes all of the variables.

The empirical results reveal that the banking sector is less than fully efficient under both approaches. In terms of intermediation services, the average technical efficiency over the period of analysis was found to be 59.4%, with values ranging from 47% to 71%. The overall trend indicates improvement, although fluctuations have occurred. The average efficiency of the industry under the revenue approach is found to be 69.2%, with values ranging from 36.5% to 81.9%, which are higher levels of efficiency than is shown under the intermediation approach. These results imply that inputs can be reduced by an average of 40.6% and 30.8% under the intermediation and revenue approaches, respectively, relative to the current best

practices. However, under the revenue approach, unlike the intermediation approach, the trend shows a decline over the sample period. This contrasting movement may be attributed to improvements in bank management in terms of the core function of banking resulting from the presence of proper prudential supervision.

Based on the group results, state-owned banks are revealed to be the best performers under both approaches, with average efficiency scores of 93% and 94% under the intermediation and revenue approaches, respectively. By contrast, the least efficient groups are found to differ under the two approaches, with regional development banks as the least efficient banks (with an efficiency score of 51%) under the intermediation approach and foreign banks as the least efficient banks (with an efficiency score of 64.7%) under the revenue approach.

The regression on the efficiency results are convincing, most of the included variables are significant, although the magnitude does not always support the initial hypothesis. However, the variables show limited explanatory power for productivity growth. External factors, such as bank size, macroeconomic cycle, regulatory changes, and ownership structures, are shown to be the most important factors in Indonesian banking performance.

Several policy implications can be drawn from the findings First, a consistent and simultaneous policy regarding mergers of private banks is needed to promote industry efficiency. Second, there is a need to maintain a stable macroeconomic cycle and speed up reforms to improve bank efficiency and productivity

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