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Bank Ownership and Efficiency in the Aftermath of Financial Crises: Evidence from Indonesia

*Rasyad A. Parinduri and Yohanes E. Riyanto**

Abstract

This paper examines the relationship between types of ownership of banks and their efficiency in the aftermath of a financial crisis using Greene's "true" panel data stochastic frontier model, which takes into account unobserved heterogeneity among banks. The Indonesian banking sector is analyzed using financial data of 144 banks operating in Indonesia over the period of 2000Q4–2005Q2. In the aftermath of the 1997 Asian financial crisis, the cost efficiency of all banks improves over time on average. However, there is some evidence that, as these banks improve their efficiency, state-owned banks are the least efficient banks while joint-venture and foreign-owned banks are the most efficient.

1. Introduction

How do banks perform in the aftermath of a financial crisis? Do state-owned and foreign-owned banks improve their efficiency equally well? What about other types of banks such as private-domestic banks and joint-venture banks?

The literature shows that the ownership structures of banks matter: foreign-owned banks are typically the most efficient banks and state-owned banks are the least efficient ones. Bhattacharya et al. (1997), for example, show that foreign-owned banks in India are more cost efficient than private-domestic banks. Fries and Taci (2005) and Bonin et al. (2005) also find similar results in post-communist European countries. Berger et al. (2009) show foreign ownership of local banks in China helps to improve the banks' cost efficiency; they also find state-owned banks are the least cost efficient.¹

These studies use data envelopment analysis or stochastic frontier analysis (SFA). Most use the latter because it takes into account random shocks to banks' costs or profits and it can handle measurement errors in input prices and outputs. Despite SFA's popularity, however, one estimation issue remains: how to take into account unobserved heterogeneity among banks, which may depend on individual bank's characteristics.

Panel SFA, i.e. fixed effects or random effects models, can address this unobserved heterogeneity if the unobserved characteristics are time-invariant, but the estimations of panel stochastic frontiers introduce another problem. In panel SFA, bank specific effects are considered as inefficiency even though this may not always be the case. These estimators would, therefore, tend to overestimate efficiency variations. Furthermore, random effects models assume no correlation between bank-specific

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effects and explanatory variables, which may lead to biased results if the assumption is violated.

Papers in the literature also classify banks into two broad types of ownership, foreign and domestic ownerships, which fail to capture the complexity of the various types of ownership and its effects on cost efficiency.² For example, a privately owned domestic bank may be formed as a joint venture between a local bank and a foreign bank with the former having a larger ownership stake and hence a dominant control over the entity. A state-owned bank may be owned by a central government or a district government. Moreover, large private-domestic banks are usually allowed to do foreign exchange transactions; the smaller ones are not. These distinct features by type of ownership could then affect the banks' cost efficiency differently.³

Our paper differs from the literature in three ways. One, we use Greene's (2005a,b) "true" panel data stochastic frontier method to address the aforementioned empirical problem in SFA. The "true" panel data method can account for bank-specific effects better than other panel data stochastic frontier models; Greene (2005a,b) does not consider time-invariant unobserved bank-specific effects as a component of inefficiency. Two, we use a more refined classification of bank ownership: we categorize banks into large private-domestic banks, small private-domestic banks, state-owned banks, district-government-owned banks, joint-venture banks and foreign-owned banks. Three, we focus on how the cost efficiency of these different types of banks improves in the aftermath of a financial crisis as the economy recovers.

We use the Indonesian banking industry as a case study. Indonesia is an interesting example of a developing country that liberalized its banking sector hastily. In the 1980s, the government of Indonesia, among others, removed interest rates and credit controls, lowered capital requirements and partially lifted restrictions on foreign banks to open branches, which proliferated bank establishments. During the 1997 Asian financial crisis, the industry experienced a severe banking crisis and the Indonesian economy fell into recession. It would be interesting to learn, therefore, how the different types of banks performed as the government restructured the banking sector and the economy recovered.⁴

Our results show that, in the aftermath of the 1997 Asian financial crisis, the cost efficiency of all banks improved over time. However, we find that, in most specifications, state-owned banks were the least efficient banks, while joint-venture banks and foreign-owned banks were the most efficient. District-government-owned banks seem to perform well too. There is also some evidence that the transfer of ownership of recapitalized banks to strategic foreign investors in the aftermath of the financial crisis helped to improve their cost efficiency.

2. Methodology

We examine the relationship between bank ownership types and cost efficiency using stochastic frontier analysis (SFA). We estimate banks' cost frontiers, which represent the banks' minimum costs given their technology, mix of outputs, input prices and other banks' characteristics. A cost frontier incorporates two elements: a deterministic cost function, and bank- and time-specific idiosyncratic terms that locate the bank's own stochastic frontier around the deterministic component. Any departure of observed banks' costs from their own frontiers can be attributed to banks' inefficiency.⁵

We use panel stochastic frontier models developed by Greene (2005a,b), the “true” panel data stochastic frontier models. The “true” random effect model, for example, is written as follows:

$$c_{it} = \alpha_0 + \alpha_i + \beta x_{it} + v_{it} + u_{it} \quad (1)$$

where c_{it} is the logarithm of costs of bank i at time t , α_i is bank random effects representing bank-specific heterogeneity, βx_{it} is the deterministic core of the cost function of bank i at time t (x_{it} is the argument of the cost function, i.e. a vector of input prices and outputs), v_{it} is the error term, and u_{it} is the cost inefficiency component. We assume that the error term v_{it} is white noise, i.e. $v_{it} \sim N(0, \sigma_v^2)$; the inefficiency term u_{it} is distributed half-normal or truncated-normal, i.e. $u_{it} \sim N^+(\mu, \sigma_u^2)$.

This model differs from the standard panel stochastic frontier models because it takes unobserved heterogeneity more properly into account. Pitt and Lee (1981), for example, propose the random effect stochastic frontier model as

$$c_{it} = \alpha + \beta x_{it} + v_{it} + u_i, \quad (2)$$

which they rewrite as

$$c_{it} = \alpha_i + \beta x_{it} + v_{it} \quad (3)$$

where $\alpha_i = \alpha + u_i$.⁶

This Pitt and Lee's (1981) random effect model has two shortcomings. One, the individual random effects, α_i , absorb time-invariant heterogeneity and the inefficiency term u_i . Therefore, using this standard random effect stochastic frontier model, we cannot distinguish the inefficiency from the unobserved heterogeneity. Two, the inefficiency term is assumed fixed over time, which is unrealistic for banks in the aftermath of a financial crisis. Over the 5-year period of analysis after the 1997 Asian financial crisis, the inefficiency terms of Indonesian banks are likely to vary considerably.

In contrast, we can use Greene's “true” panel data stochastic frontier models to estimate the inefficiency terms and to control for unobserved heterogeneity at the same time.⁷ In the basic specifications, we allow bank ownership types to directly affect the cost function by including a set of indicators of the ownership types in the stochastic frontier. We, therefore, write the cost frontier as

$$c_{it} = \alpha_i + \beta x_{it} + \gamma z_i + v_{it} + u_{it} \quad (4)$$

where z_i is the ownership type indicator of bank i .

This model allows different types of banks to have different cost frontiers and the coefficient of z_i would tell us how much larger the costs of one type of bank are compared with others. A negative coefficient of an ownership type indicator, for example, indicates that these banks' cost frontier is, on average, lower than the frontier of the group of banks in the excluded category, which means that the banks are more efficient than banks in the excluded category.

Because input prices and outputs possibly correlate with bank-specific effects, which means that random effect estimation of the frontier leads to biased results, we also estimate the cost frontiers using Mundlak's correlated random-effects models.⁸ We model bank-specific effects as a function of the means of all time-varying explanatory variables, i.e. $\alpha_i = \rho \bar{x}_{it} + \xi_i$ in which $\bar{x}_{it}$ is a vector of the averages of output and

input prices, and ξ_i is independent and identically distributed. Modeling the bank-random effects α_i this way in equation (4) would yield an estimator that is equivalent to the fixed effects estimator.

3. The Indonesian Banking Sector

The Government of Indonesia liberalized the Indonesian banking sector in 1983. Subsidized liquidity credits were reduced, and credit ceilings and interest rate controls were removed. In 1988, the government further removed entry barriers and various advantages enjoyed by state-owned banks.⁹

These reforms proliferated bank establishments. By 1991, the number of banks in Indonesia rose to 182 from 101 in 1988. These banks, private-domestic banks in particular, expanded rapidly so that by 1994 private-domestic banks replaced state-owned banks as the dominant group of banks in terms of loans and deposits. By 1996, the assets of private-domestic banks were 40% larger than those of state-owned banks.¹⁰ The banking sector remained highly concentrated, however. In 1996, the six state-owned banks and 10 largest private-domestic banks had 75% of total bank assets. Most of the private-domestic banks were, therefore, small banks.

When the Asian financial crisis hit Indonesia in 1997, it triggered an economic recession and a severe banking crisis. These banks were caught off guard without sufficient capitals to withstand the crisis. The banks' capital deteriorated and many of the banks collapsed, which prompted the government to establish an asset management company to close or recapitalize some banks, and eventually to sell some of them to strategic foreign investors. As the government restructured the banking sector, the Indonesian economy recovered, and these banks improved their performances.

In this paper, we look into how these Indonesian banks performed during the economic recovery in the aftermath of the 1997 crisis.

We examine the six types of bank ownership in Indonesia: state-owned banks, large private-domestic banks, small private-domestic banks, district-government-owned banks, joint-venture banks, and foreign-owned banks. In 2004, for example, there were five state-owned banks, 35 large private-domestic banks, 37 small private-domestic banks, 26 district-government-owned banks, 18 joint-venture banks and 11 foreign-owned banks.¹¹

Only large banks such as state-owned and large private-domestic banks are allowed to engage in foreign-exchange transactions. District-government-owned banks are

Table 1. Indonesian Banks by Type of Ownership in the Sample

Types of Ownerships	Numbers of banks					
	2000	2001	2002	2003	2004	2005
State owned	5	4	5	5	5	5
Large private-domestic	39	37	36	35	35	35
Small private-domestic	41	38	39	37	37	37
District-government owned	26	26	23	26	26	25
Joint venture	23	17	17	17	18	18
Foreign owned	10	8	10	11	11	11
<i>Total</i>	144	130	130	131	132	131

Note: The numbers of banks are end-of-year figures except for 2005, which are first quarter figures.

similar to the state-owned banks, except that they are smaller and are not allowed to engage in foreign-exchange transactions. Joint-venture banks are owned by domestic owners and foreign investors. Foreign-owned banks are exclusively owned by foreign investors—they can establish branches only in some designated large cities.

4. The Data

We use the quarterly financial statements that banks submit to Bank Indonesia's Department of Banking Statistics. The data cover all commercial banks in Indonesia, which include more than 130 banks, over a 5-year period from 2000Q4 to 2005Q2.

Following Kaparakis et al. (1994), we consider a bank as a financial firm that transforms financial- and physical inputs into outputs. We include three inputs: labor, deposits and purchased funds, and capital. Because direct measures of input prices are unavailable, we create some proxies of these prices. As a measure of the price of labor (W_1), we use the ratio between personnel expenses and total amounts of assets. As a proxy for the price of deposits and purchased funds (W_2), we use the ratio between interest expenses and the amounts of interest-bearing liabilities. As a proxy for the price of capital (W_3), we use the ratio between non-personnel expenses and the amounts of fixed assets.¹² We include four outputs: the amount of banks' loans (Y_1), government bond holdings (Y_2), securities holdings (Y_3), and other assets (Y_4).

For simplicity, we model banks' cost function using a Cobb–Douglas functional form. We impose linear homogeneity in prices by dividing the total costs ($Cost$), the price of labor as well as the price of deposits and purchased funds by the price of capital. We express these costs, prices and outputs in logarithmic form, i.e. $c_{it} = \ln(Cost_{it}/W_{3it})$, $w_{jit} = \ln(W_{jit}/W_{3it})$, $j = 1, 2$, and $y_{kit} = \ln(Y_{kit})$, $k = 1, 2, 3, 4$.

We then rewrite the “true” panel data model equation (4) as

$$c_{it} = \alpha_0 + \alpha_i + \sum_{j=1}^2 \beta_j w_{jit} + \sum_{k=1}^4 \delta_k y_{kit} + \gamma z_i + v_{it} + u_{it}. \quad (5)$$

The variables of interest are the set of ownership type dummies, z_i , which includes six types of ownerships indicators: state-owned banks, large private-domestic banks, small private-domestic banks, district-government-owned banks, joint-venture banks and foreign-owned banks.

Table 2 presents the summary statistics of the key variables. Joint-venture and foreign-owned banks seems to have the lowest costs, 3.8% and 4.5% of assets, respectively. The costs of other types of bank are higher than 6% of assets.

The banks' assets profiles vary across types of ownership. State-owned banks hold a large amount of government bonds, 45% of total assets on average; small private-domestic and joint-venture banks have a large part of their assets as loans, 57% and 64% of their assets, respectively; district-government-owned, joint-venture and foreign-owned banks have a large amount of assets not classified as loans, securities or government bonds.

The prices of inputs paid by the banks also vary. Small private-domestic and district-government-owned banks have larger personnel costs to assets ratios; district-government-owned, joint-venture and foreign-owned banks pay the cheapest prices of deposits and purchased funds. In terms of prices of capital, foreign-owned banks' capital seems to be the most expensive and small privately owned banks' the lowest.

Table 2. Summary Statistics

	Unit	State owned	Large private domestic	Small private domestic	District government owned	Joint venture	Foreign owned
Assets	Rp billion	97,700 (85,500)	11,000 (21,800)	497 (620)	2,317 (2,486)	2,244 (1,861)	8,647 (7,529)
Costs	Rp billion	6,033 (6,449)	673 (1,392)	42 (68)	138 (187)	84 (101)	392 (413)
Loans	Rp billion	32,800 (25,200)	3,795 (5,883)	285 (408)	965 (1,334)	1,435 (1,266)	3,914 (3,637)
Securities	Rp billion	2,823 (2,891)	608 (1,221)	44 (132)	57 (179)	91 (201)	712 (1,254)
Government bonds	Rp billion	44,300 (49,700)	3,321 (9,562)	19 (71)	40 (89)	24 (87)	624 (1,353)
Other assets	Rp billion	18,100 (15,200)	3,002 (6,648)	135 (154)	1,130 (1,195)	848 (754)	3,734 (3,272)
Wage		0.008 (0.009)	0.009 (0.007)	0.015 (0.011)	0.015 (0.010)	0.007 (0.008)	0.009 (0.007)
Interest		0.051 (0.030)	0.054 (0.032)	0.063 (0.036)	0.035 (0.021)	0.032 (0.024)	0.031 (0.029)
Price of capital		1.106 (1.761)	0.536 (0.788)	0.401 (0.479)	0.561 (0.418)	1.060 (0.857)	1.540 (1.291)

Notes: The numbers in parentheses are standard deviations. The number of observations for state banks, large private national, small private national, district-government owned, joint venture and foreign banks are, respectively, 90, 647, 698, 449, 331 and 178.

5. Results

Basic Results

Table 3 presents the basic results. The upper-, middle- and lower panels provide the estimates of ownership type indicators, those of the parameters of the cost function and those of the parameters of the inefficiency component (u), and the error term (v). In all specifications, the group of state-owned banks is the excluded category.

Column 1 shows the results of a pooled-ordinary least squares (OLS) estimation. The cost frontiers of private-domestic and district-government-owned banks are higher than those of state-owned banks—those of joint-venture and the foreign-owned banks are lower. These results indicate private-domestic and district-government-owned banks are less efficient than state-owned banks, while joint-venture and foreign-owned banks are more efficient. The difference between foreign-owned and state-owned banks is statistically insignificant at the conventional level of significance, however.

Columns 2–3 provide the estimates of random effects models, without- and with Mundlak's formulation, respectively. Column 2 suggests private-domestic and joint-venture banks are more efficient than state-owned banks, although only the estimate of joint-venture banks is statistically significant. All estimates in column 3 are positive, which indicate state-owned banks are the most efficient banks. They are statistically insignificant, however.

Table 3. Basic Results

Dependent variable: $\ln(\text{cost})$

	<i>Pooled</i> (1)	<i>RE</i> (2)	<i>RE–</i> <i>Mundlak</i> (3)	<i>True</i> <i>RE</i> (4)	<i>True RE–</i> <i>Mundlak</i> (5)
<i>Bank types</i>					
Large private domestic	0.11 (0.03)	–0.36 (0.19)	0.22 (0.22)	–0.01 (0.01)	0.05 (0.01)
Small private domestic	0.20 (0.04)	–0.34 (0.20)	0.43 (0.24)	–0.64 (0.01)	0.18 (0.02)
District government owned	0.12 (0.04)	0.07 (0.21)	0.40 (0.24)	–0.27 (0.01)	–0.10 (0.02)
Joint venture	–0.15 (0.03)	–0.88 (0.19)	0.06 (0.23)	–0.45 (0.01)	–0.11 (0.02)
Foreign owned	–0.06 (0.04)	0.10 (0.24)	0.18 (0.21)	–0.50 (0.01)	–0.08 (0.02)
<i>Cost function</i>					
Loans	0.47 (0.01)	0.25 (0.002)	0.25 (0.003)	0.28 (0.001)	0.27 (0.001)
Securities	0.02 (0.002)	0.02 (0.001)	0.01 (0.001)	0.01 (0.0004)	0.01 (0.001)
Government bonds	0.02 (0.001)	0.01 (0.001)	0.01 (0.001)	0.01 (0.0004)	0.01 (0.0004)
Other assets	0.50 (0.01)	0.36 (0.004)	0.34 (0.004)	0.38 (0.002)	0.35 (0.003)
Wage	0.26 (0.01)	0.16 (0.004)	0.16 (0.004)	0.17 (0.002)	0.16 (0.003)
Interest	0.67 (0.01)	0.52 (0.004)	0.51 (0.004)	0.54 (0.002)	0.53 (0.002)
<i>Parameters of u and v</i>					
Lambda		6.97 (1.55)	3.44 (0.88)	2.82 (0.06)	2.98 (0.07)
Sigma	0.19 (0.004)	1.22 (0.10)	0.60 (0.08)	0.27 (0.002)	0.27 (0.002)
Theta	3.97 (0.10)				

Notes: Each column is the result of stochastic frontier analysis in which the types of ownership entered the regression directly. In all models, we assume v to be normally distributed while u to be half-normal, except in Regression 1 in which we assume u to be exponentially distributed. RE is the Pitt and Lee's (1981) random effect model. RE–Mundlak is the random effect model with Mundlak's formulation. True RE is the Greene's (2005a,b) "true" random effect model. True RE–Mundlak is the Greene's (2005a,b) "true" random effect model with Mundlak's formulation. The numbers in parentheses are standard errors. The number of observations is 2,393. The number of banks is 144.

We need to interpret the results in columns 1–3 cautiously. Unlike Greene’s “true” fixed effects or “true” random effects stochastic frontier models, the pooled-OLS estimation in column 1 does not control for time-invariant bank-specific characteristics. The random effect estimations in columns 2–3 do; but they neither take the time-invariant heterogeneity properly into account, nor allow the inefficiency term to vary over time.

Columns 4–5 present the results of Greene’s “true” random effects estimations, without- and with Mundlak’s formulation, respectively. Column 4 shows state-owned banks are the least efficient banks. Column 5 provides a somewhat different picture. Private-domestic banks are less efficient than state-owned banks, while district-government-owned, joint-venture and foreign-owned banks are more efficient than state-owned banks. Among these three groups of banks, joint-venture banks are the most efficient, followed by district-government-owned and foreign-owned banks, although statistically the differences among the three groups are insignificant.

The estimates of ownership type indicators using the “true” random effects model with Mundlak’s formulation, which accounts for potential correlation between unobserved bank-specific heterogeneity with outputs and input prices, in column 5 are statistically and economically significant. Controlling for the banks’ outputs and input prices, private-domestic banks incur 5–18% higher costs on average; district-government-owned, joint-venture and foreign-owned banks incur about 10% less.

These basic results show state-owned banks are less efficient than joint-venture and foreign-owned banks, but they are more efficient than private-domestic banks. State-owned banks are also less efficient than district-government-owned banks.

The middle panel shows the estimates of the parameters of the cost function. The estimates of random effect models in columns 2–5 are similar; only those of the pooled-OLS estimation that differ, perhaps because we assume u is exponentially distributed in the pooled-OLS estimation, not normally distributed.¹³

All models give estimates that satisfy the basic properties of a cost function. The coefficients of input prices are positive: the estimated cost function is non-decreasing in prices. The coefficients of outputs are also positive; hence, the cost function is non-decreasing in output. The Hessian of the cost function is negative semi-definite: the function is concave in input prices. The cost function is homogeneous of degree one in input prices by assumption—we impose this restriction when we construct the input prices, outputs and costs.¹⁴

The estimates of λ —the ratio of the standard deviation of the inefficiency component σ_u and that of the error term σ_v —are more than one in all cases. These ratios suggest that the variation of the inefficiency components is larger than that of the error terms. In the cases of the “true” random effect models, the variation of the inefficiency component is about three times larger than that of the error term. Among the random effect models, the estimates of σ —the standard deviation of the composite disturbance—are smaller in the cases of both “true” random effect models.

Extensions

We do some extensions. First, we use an alternative approach to analyze the effects of types of ownerships on efficiency. Following, among others, Battese and Coelli (1992, 1995), we model the inefficiency component u_{it} as a function of the ownership types. Specifically, we drop z_i in equation (5) and we write u_{it} as $u_{it} = \gamma z_i + \omega_{it}$ where z_i is a vector of types of ownerships indicators and ω_{it} is a random variable that follows truncated-distribution with zero mean and variance σ_{ω}^2 . Because $u_{it} > 0$, the point of

truncation is $-\gamma z_i$. Therefore, the inefficiency term has a truncated-normal distribution and its point of truncation depends on the ownership types.

We estimate this model using one-step procedure, which is more appropriate than the two-step estimation often used in the literature such as Bonin et al. (2005). As Wang and Schmidt (2002) argue, the two-step procedures produce biased estimates. Besides, these two-step procedures do not consistently obey their econometric assumptions. One, in the first stage, the inefficiency term u_{it} is assumed to be independently and identically distributed. In the second stage, however, the inefficiency term is specified as a function of ownership type indicators z_i . Two, if u_{it} is indeed a function of z_i , the estimates of the coefficients of z_i would be biased too.

Despite being more attractive econometrically, estimations of the normal-truncated normal stochastic frontier in one step are difficult in practice.¹⁵ Therefore, we report the results of random effect models only, with- and without Mundlak's formulation.

Panel A of Table 4 presents the results. The estimates using random effect model show private-domestic, district-government-owned, joint-venture and foreign-owned banks are more efficient than state-owned banks. Among these groups of banks, joint-venture banks seem to be the most efficient. All estimates are significant statistically. Using the Mundlak's formulation of random effect model, similar results appear. Again, joint-venture banks are the most efficient while state-owned banks are the least efficient. Only the estimate of joint-venture banks is statistically significant at conventional level, however.¹⁶

Second, we examine the robustness of the basic results to some changes in the basic specifications and to the use of different subsamples. We consider a subsample of more homogenous banks. Panel B shows the results in which we use the subsample of large- and foreign banks only. We find state-owned banks are the least efficient banks and joint-venture banks are the most efficient ones, followed by foreign-owned banks.

Three, we assume the inefficiency term u is truncated-normally distributed rather than half-normally distributed. Panel C shows that state-owned banks are the least efficient banks and joint-venture banks are the most efficient ones.

Four, some banks are sold to strategic foreign investors during the period of analysis, and these changes of ownership may affect the efficiency of these banks. We therefore introduce an indicator for banks that are sold to strategic foreign investors. We also include an indicator for publicly listed banks. Panel D presents the results. The estimates suggest that the basic results are quite robust. Using "true" random effect model, we find that small private-domestic, district-government-owned, joint-venture and foreign-owned banks are more efficient than state-owned banks. Selling banks to strategic foreign investors also improves cost efficiency.¹⁷ Having banks publicly listed does not seem to improve efficiency, however. Controlling for having strategic sale and listed in the stock market, we find large private-domestic banks to be less efficient than state-owned banks. Small private-domestic banks seem to be the most efficient banks, followed by foreign-owned and joint-venture banks.

Mundlak's formulation of random effect model offers a somewhat different picture. Strategic sale still improves cost efficiency. However, we find that only joint-venture banks are now more efficient than state-owned banks.¹⁸

Averages of Inefficiency Terms

There are some concerns that the "true" random effect model with Mundlak's formulation does not fully account for the potential correlation of unobserved bank-specific heterogeneity with outputs and input prices. To get another picture of the

Table 4. Extensions

Dependent variable: $\ln(cost)$									
		Large private domestic	Small private domestic	District gov't owned	Joint venture	Foreign owned	Sold to strategic foreign investors	Publicly listed	
A. How efficiency is modeled									
<i>Bank types in u</i>									
RE	(1)	-1.86 (0.32)	-3.23 (0.38)	-2.68 (0.42)	-3.63 (0.43)	-2.32 (0.53)			
RE-Mundlak	(2)	-0.55 (0.52)	-0.55 (0.65)	-0.87 (0.68)	-1.55 (0.62)	-0.86 (0.63)			
B. Samples									
<i>Large- and foreign banks only</i>									
True RE	(3)	-0.13 (0.01)			-1.43 (0.02)	-0.46 (0.02)			
True RE-Mundlak	(4)	-0.08 (0.02)			-0.32 (0.02)	-0.26 (0.02)			
C. Distribution of u									
<i>Truncated normal</i>									
True RE	(5)	-0.12 (0.01)	-0.95 (0.01)	-0.15 (0.01)	-1.18 (0.01)	-0.07 (0.02)			
True RE-Mundlak	(6)	-0.08 (0.01)	-0.06 (0.02)	-0.21 (0.02)	-0.37 (0.02)	-0.21 (0.02)			
D. Include other ownership indicators									
<i>Truncated normal</i>									
True RE	(7)	0.06 (0.01)	-0.61 (0.01)	-0.23 (0.01)	-0.32 (0.01)	-0.48 (0.01)	-0.18 (0.02)	0.08 (0.01)	
True RE-Mundlak	(8)	0.03 (0.02)	0.05 (0.02)	-0.02 (0.02)	-0.13 (0.02)	0.05 (0.02)	-0.23 (0.02)	0.02 (0.01)	

Notes: Except in regressions (1) and (2), each row is the result of stochastic frontier analysis in which the types of ownership enter the regression directly. We assume v to be normally distributed while u to be half-normal, except in regressions (5) and (6) in which it is truncated-normally distributed. We do not report the estimates of the coefficients of the cost function for brevity. "Large- and foreign banks only" excludes small private domestic- and district government owned banks. RE is the Pitt and Lee's (1981) random effect model. RE-Mundlak is the random effect model with Mundlak's formulation. True RE is the Greene's (2005a,b) "true" random effect model. True RE-Mundlak is the Greene's (2005a,b) "true" random effect model with Mundlak's formulation. The numbers in parentheses are standard errors. The number of observations is 2,393. The number of banks is 144.

Table 5. Averages of Efficiency Terms

		<i>State owned</i>	<i>Large private domestic</i>	<i>Small private domestic</i>	<i>District government owned</i>	<i>Joint venture</i>	<i>Foreign owned</i>
Pooled	(1)	0.33 (0.25)	0.24 (0.18)	0.25 (0.18)	0.21 (0.10)	0.21 (0.27)	0.46 (0.88)
RE	(2)	2.51 (0.89)	1.58 (0.57)	1.01 (0.27)	1.22 (0.26)	0.94 (0.25)	1.34 (0.31)
RE–Mundlak	(3)	0.68 (0.11)	0.70 (0.12)	0.78 (0.14)	0.79 (0.13)	0.77 (0.19)	0.94 (0.56)
True RE	(4)	0.25 (0.23)	0.19 (0.12)	0.19 (0.12)	0.18 (0.10)	0.19 (0.14)	0.25 (0.26)
True RE–Mundlak	(5)	0.26 (0.24)	0.19 (0.13)	0.19 (0.12)	0.19 (0.11)	0.19 (0.14)	0.24 (0.25)
True FE	(6)	0.45 (0.27)	0.43 (0.28)	0.40 (0.23)	0.34 (0.17)	0.38 (0.24)	0.41 (0.40)

Notes: These numbers are the averages of inefficiency terms from stochastic frontier analyses in which the types of ownership do not enter the regression. In all models, we assume v to be normally distributed while u to be half-normal, except in regressions (1) in which it is truncated-normally distributed. We do not report the estimates of the coefficients of the cost function for brevity. RE is the Pitt and Lee's (1981) random effect model. RE–Mundlak is the random effect model with Mundlak's formulation. True RE is the Greene's (2005a,b) "true" random effect model. True RE–Mundlak is the Greene's (2005a,b) "true" random effect model with Mundlak's formulation. True FE is the Greene's (2005a,b) "true" fixed effect model. The numbers in parentheses are standard deviations. The number of observations is 2,393. The number of banks is 144.

relationship between inefficiency terms and types of bank of ownership, we estimate cost frontiers without introducing ownership type indicators, either in the inefficiency term or directly in the cost function, using various models, including the "true" fixed effect model.¹⁹ Then, we calculate the averages of the inefficiency terms of each type of ownerships and their standard deviation.

Table 5 presents the averages of inefficiency terms. The results of "true" random effect models in rows 4–5 suggest that state-owned banks are the least efficient banks. The differences among them are not statistically significant, however.

The results of the "true" fixed effects models in row 6, which allow for correlation between unobserved bank-specific heterogeneity and the independent variables, present a picture that is similar to the basic results: state-owned banks are the least efficient banks. We also find that district-government-owned and joint-venture banks are the most efficient banks. The differences in their efficiencies are statistically insignificant, however.

6. Concluding Remarks

Using Greene's "true" panel data stochastic frontier model, which takes unobserved heterogeneity among banks more properly into account, we find that, as Indonesian banks improve their efficiency in the aftermath of the 1997 financial crisis, state-owned banks remain the least cost efficient banks while joint-venture banks are the most efficient ones in most specifications. There is also some evidence that foreign-owned banks are among the most efficient banks. We also find strategic sales, which transfer bank ownerships to foreign investors, improve banks' efficiency.

These findings are in line with the literature on the effects of privatization and foreign ownerships.²⁰ We go beyond the literature by showing that, even after taking unobserved heterogeneity more properly into account and allowing the inefficiency terms to vary over time, we still find that, in the aftermath of the 1997 financial crisis, state-owned banks are the least efficient banks and joint-venture banks are the most efficient ones.

It is somewhat surprising that foreign-owned banks perform less impressively than we had expected. They are more cost efficient than state-owned banks in most specifications, but they are less efficient than joint-venture banks. In some specifications, they are even less efficient than district-government-owned banks.

As for future research, it would be interesting to explore why foreign-owned banks are not the most efficient banks in Indonesia in the aftermath of the 1997 financial crisis. Perhaps, this is because the bank regulator in Indonesia allows foreign-owned banks to establish branches in large cities only, which prevents foreign-owned banks from enjoying economies of scale or economies of scope. It would be also important to explore the mechanisms through which the different types of banks improve their efficiency during the period of analysis.

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Notes

1. Some papers such as Berger et al. (2001) find the opposite conclusion. See also Lensink et al. (2008) for a summary of empirical findings on the relationship between bank ownership and efficiency.
2. Domestic banks are often further divided into state-owned and privately owned domestic banks.
3. Berger et al. (2009) is an exception. They classify banks into majority state-owned banks with and without minority foreign ownership, majority private-domestic banks with and without foreign ownership, and majority foreign-owned banks.
4. See, for example, Chortareas et al. (2011) on how banks' efficiency changes as governments liberalize banking sectors and the banks later consolidate.
5. See Kumbhakar and Lovell (2000) for an exposition of stochastic frontier analysis.
6. They define the estimate of inefficiency as $\hat{u}_i = \hat{\alpha}_i - \min_i(\hat{\alpha}_i)$.
7. Greene assumes that the error- and inefficiency terms follow some distributions. This model, therefore, is not a random effect estimator. Instead, Greene estimates this model using maximum likelihood. See Greene (2005a) for the details of the likelihood function derivation. We could estimate the inefficiency terms using the conditional estimator of u_{it} as proposed by Jondrow et al. (1982). The estimate $\hat{u}_{it}$ then equals $E(u_{it} | \varepsilon_{it})$ where $\varepsilon_{it} = u_{it} + v_{it}$. Our focus, however, is not on the magnitude of the inefficiency terms, but rather on how the banks' costs correlate with some environment variables, i.e. bank ownership types.
8. Among various correlated-random-effects models, we choose Mundlak's (1978) formulation for its simplicity.
9. The government, among others, allowed new entry, relaxed branching requirements, reduced the reserve requirement ratios, and allowed state-owned enterprises to deposit up to 50% of their deposits in non-state banks.
10. See, for example, Pangestu and Habir (2002) for a brief review of the development of the Indonesian banking sector.
11. See Table 1 for the number of banks by type of ownership during the period of analysis.
12. These non-personnel expenses are defined as the sum of other-operating and non-operating expenses.

13. The estimation of pooled-OLS in which u is assumed half-normally distributed does not converge.
14. See, for example, Mas-Colell et al. (1995) for a theoretical discussion of the properties of a cost function.
15. As the user guide of Limdep points out (Limdep, 2002), identification may be unstable, and the model often fails to converge. The problem is even more severe for the fixed effect models. Developers of Limdep themselves have “extremely limited success” with the normal-truncated normal-fixed effect model and they suggest that estimations of this model are “likely to be extremely problematic in all but the most favorable of cases”.
16. We also try to use a translog cost function instead of the Cobb–Douglas cost function. The estimations fail to converge, unfortunately.
17. This result is in line with the findings of Parinduri and Riyanto (2012), who analyze the effects of strategic sales of Indonesian banks on cost efficiency using fixed effect models.
18. The estimates we present in this section also satisfy the basic properties of a cost function.
19. Because we estimate a simpler model and we do not include the indicators of types of ownerships in the model, we manage to get the results of the “true” fixed effect model.
20. See, for example, Jones and Mygind (2002) on the effects of privatization on efficiency. See also Clarke et al. (2005) for a survey of this literature.