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A new approach to dealing with negative numbers in efficiency analysis: An application to the Indonesian banking sector

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ABSTRACT

Using a new approach, 'SORM SBM' DEA, this paper analyses the efficiency of Indonesian banks during the period 2003–2007. The results prove highly sensitive to both the choice of modelling methodology used to handle negative numbers (i.e., Silva Portela et al., 2004 or Emrouznejad et al., 2010), and to the choice of risk control variable, namely loan loss provisions or equity capital. The most efficient bank grouping is generally found to be the 'state-owned' banks with the least efficient the 'regional government-owned' banks. The results of the impact of scale on the efficiency scores are ambiguous.

1. Introduction

Empirical studies of bank efficiency have mushroomed in recent years as interest has spread beyond banking markets in North America and Western Europe and modelling methodologies have evolved to tackle the increasingly-complex nature of banking operations and their diverse operating environments. On the modelling front, there is a schism between the proponents of parametric and non-parametric approaches to assessing bank efficiencies, while elsewhere debates rage about the appropriate form of the input/output specifications – the traditional 'intermediation-based' approach versus the 'production' or 'profit/revenue' approaches (see Drake, Hall, & Simper, 2009) – to be adopted, the merits of allowing for 'slacks' in non-parametric modelling, the optimal orientation of the model (input versus output versus non-oriented) and the best way to control for risk (for a recent literature review addressing all these issues see Fethi & Pasiouras, 2010). Our personal preferences are as follows. Firstly, we prefer to use Data Envelopment Analysis (DEA) rather than stochastic frontier analysis (SFA) because it does not require any assumptions to be made about the distribution of the inefficiency nor require a particular functional form in the construction of the frontier. Secondly, we believe that, in this study, the intermediation approach rather than the production or profit/revenue approaches should be adopted because of the Indonesian banking industry's state of development (i.e., it has moved beyond the basic level but is not as sophisticated as more mature Western systems fully engaged in derivatives markets, heavily involved in 'structured' products and widely diversified in off-balance-sheet activities). Thirdly, we favour an input-orientated model because we would argue that Indonesian bank managers are likely to have more control over inputs than outputs. Fourthly, we prefer equity capital to loan loss provisions as the risk control variable on the grounds that the latter are designed to cover only expected-and not unexpected-losses, unlike the former. As for the chosen approach for handling negative numbers, however – see below – we use a robustness check, in this case using loan loss provisions instead of equity capital. As for the chosen approach for handling negative numbers – we use another robustness check, in this case using equity capital instead of loan loss provisions. And fifthly, we opt for Tone's (2001) Slacks Based Model (SBM), because standard DEA models fail to allow for additional potential input reductions (i.e., due to the existence of 'non-radial input slacks'; see Fried, Schmidt, & Yaisawarng, 1999).

For these reasons, we choose to adopt a non-parametric approach to efficiency estimation (input-oriented DEA), based upon the intermediation activities of banks and accounting for output and input slacks. However, to handle the negative numbers in the data, we use the approach suggested by Emrouznejad, Anouze, and Thanassoulis (2010), but with a robustness check provided by the application of Silva Portela, Thanassoulis, and Simpson's (2004) range-directional approach. This methodology is used to address the issue of how efficient Indonesian banks were during the period 2003–2007 and which type of banks (by ownership and status, that is, listed/non-listed, Islamic/conventional) were the most efficient.

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Furthermore, the differences in efficiencies between different ownership, status and asset-sized groups, were then formally tested using the bootstrapping procedures of Simar and Wilson (2007).

This paper represents one of the first attempts to analyse Indonesian banks on a stand-alone basis. The analysis of banking markets in Indonesia is long overdue given the country's growing importance within the resurgent region of South East Asia and its significance as a major ASEAN nation. Moreover, it is one of only a few studies to analyse bank efficiency in this region since the end of the Asian financial crisis (AFC). Accordingly, it represents a timely and warranted addition to the extant empirical literature on banking efficiency, especially for the South East Asian region.

The paper is structured as follows. In Section 2, we briefly set out the structure of the Indonesian banking system, highlighting the respective asset shares of the different groups. In Section 3 we present the modelling methodology, the nature of the dataset used, and the input/output variables deployed in the intermediation-based efficiency analysis. In Section 4 we set out our results, and explain their policy implications. And, in Section 5, we summarise and conclude.

2. The Indonesian banking industry: a brief structural review

As shown in Table 1, at the end of 2007 there were 130 banks operating in Indonesia with a combined balance sheet of over IDR 1986 trillion (US$ 213 billion). This comprised 5 state-owned banks, 35 foreign exchange private banks, 36 non-foreign exchange private banks, 26 regional government-owned banks, 17 joint-venture banks and 11 foreign banks. This number compares with a total of 222 banks which were in existence at the end of December 1997 and reflects a post-Asian financial crisis policy of consolidation through liquidation and suspension, as agreed with the IMF following the country's bailout (see Jao, 2001, Chapter 2), and more recently, though officially-encouraged mergers. The asset shares of the various groups are highlighted in Table 1.

3. Data and modelling methodology

3.1. Estimation of efficiency

Estimation of a bank's level of efficiency involves a comparison of its actual and best possible performances, given the inputs and outputs specified. In this study, we focus on input-reduction strategies and evaluate input-oriented efficiency measures estimating by how much banks could reduce the usage of their resources (inputs) given the outputs they produce. Formally, the optimum level of inputs is given by the relevant frontier which represents the common technology T banks use to transform inputs X $(m \times n)$ into outputs Y $(s \times n)$, given by:

$$T = \{(X, Y) | X \text{ can produce } Y\} \tag{1}$$

However, given that the true frontier is not observable, it can be approximated by a 'best-practice' frontier, in which the literature has posited two estimation approaches, the non-parametric and parametric methodologies. The former approach is based on mathematical programming and the latter makes use of econometric estimation techniques. The main advantage of the non-parametric technique is that it does not assume any functional form in the construction of the frontier, unlike its parametric counterparts (for further discussion see Coelli, Rao, O'Donnell, & Battese, 2005). In addition, the individual input-oriented efficiency of each bank is computed relative to the estimated frontier by solving the model based on semi-oriented methodology, suggested by Emrouznejad et al. (2010), and Tone's (2001) slacks-based measure. The 'SORM SBM' efficiency estimator duly accounts for negative data in an original way[2] and also takes into account the slacks of resources arising in a bank's production, in recognition of Fried et al.'s (1999) critique of standard DEA techniques.

We thus use the following formula to estimate the efficiency scores:

$$\hat{\rho}(x_o, y_o | T^t(x)) = \operatorname{argmin} \left\{ \rho = 1 - \tfrac{1}{m} \sum_{k=1}^{m} s_k^- / x_{ko} \;\middle|\; \begin{array}{l} x_o = X\lambda + s^-; \quad y_o \leqslant Y\lambda \\ y_o^1 \leqslant Y^1\lambda; \quad y_o^2 \geqslant Y^2\lambda \\ \sum \lambda = 1; \quad \lambda \geqslant 0; \quad s^- \geqslant 0 \end{array} \right\} \tag{2}$$

where the negative outputs of banking production (e.g., in the profit/loss accounts) Y_{sj}^1 and Y_{sj}^2 are defined as

$$Y_{sj}^1 = \begin{cases} Y_{sj} & \text{if} \quad Y_{sj} \geqslant 0 \\ 0 & \text{if} \quad Y_{sj} < 0 \end{cases} \quad \text{and} \quad Y_{sj}^2 = \begin{cases} 0 & \text{if} \quad Y_{sj} \geqslant 0 \\ -Y_{sj} & \text{if} \quad Y_{sj} < 0 \end{cases}$$

Formula (2) estimates non-radial efficiency scores, i.e., it allows banks to minimise resources in different proportions. Most of the traditional input-oriented models for efficiency estimation assume radial contraction of the resources. For a robustness check of our model, we also perform the range-directional model (RD) suggested by Silva Portela et al. (2004):

$$\hat{\theta}(x_o, y_o | T^t(x)) = \operatorname{argmin} \left\{ \theta \;\middle|\; \begin{array}{l} x_o = X\lambda - \beta_o R_{io}; \quad y_o \leqslant Y\lambda; \\ \sum \lambda = 1; \quad \lambda \geqslant 0. \end{array} \right\} \tag{3}$$

In formula (3), $R_{io} = x_{io} - \min\{x_{ij}\}$ is a range directional vector and captures all possible reductions of bank o's resources.

Finally, to test which bank-specific factors have an impact on banking efficiency, in the second stage of this analysis the efficiency measure $\hat{\rho}_j$, estimated using programs (2), (3), is regressed on z_j, a set of explanatory variables such as ownership, status and size dummy variables. The specification of the truncated regression used in this paper is as follows:

$$0 \leqslant \rho_j = \alpha + z_j\beta + \varepsilon_j \leqslant 1 \tag{4}$$

where β is a vector of parameters associated with each factor to be estimated. The distribution of the error term ε_j is assumed to be

Table 1
The structure of the Indonesian banking industry at end-December 2007.

Type of bank[a]	Number of banks	Total assets (IDR tn.)	Total assets share (%)
State-owned banks	5	742.0	36
Foreign exchange private national banks	35	768.7	39
Non-foreign exchange private national banks	36	39.0	2
Regional government-owned banks	26	170.0	9
Joint venture banks	17	90.5	5
Foreign banks (branching)	11	176.3	9
Total	130	1986.5	100

[a] From amongst this group of 130 banks, there are 24 listed banks, comprising 17 foreign exchange private banks, 2 non-foreign exchange private banks, a regional government-owned bank, a joint venture bank, and 3 state-owned banks. As well as this, there are 3 Islamic banks, which comprise two foreign exchange private banks and a non-foreign exchange private bank.

[2] Alternative ways to deal with negative data in construction of the non-parametric DEA frontier are: to transform (i.e., 'translate') the data, adding a sufficiently large scalar to the data (Ali & Seiford, 1990; Pastor, 1996); to treat absolute negative inputs or outputs as output or input respectively (Scheel, 2001); or to use range directional measures (Sharp, Meng, & Liu, 2006; Silva Portela et al., 2004). Our preference, in part because it allows for the use of the data directly but also because it has never been used before, is for Emrouznejad et al.'s (2010) SORM approach, but Silva Portela et al.'s (2004) range – directional measure is used a robustness check in recognition of the novelty of the approach adopted – see below.