ISSN 1750-4171

DEPARTMENT OF ECONOMICS

DISCUSSION PAPER SERIES

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WP 2010 - 04

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Productivity Changes and Risk Management in Indonesian Banking: An Application of a New Approach to Constructing Malmquist Indices

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ABSTRACT:

In this study, we utilise a new, non-parametric efficiency measurement approach which combines the semi-oriented radial measure data envelopment analysis (SORM-SBM-DEA) approach for dealing with negative data (Emrouznejad et al., 2010) with the slacks-based efficiency measures of Tone (2001, 2002) to analyse productivity changes for Indonesian banks over the period Quarter I 2003 to Quarter II 2007. Having constructed the Malmquist indices, using data provided by Bank Indonesia (the Indonesian central bank), for the banking industry and different bank types (i.e., listed and Islamic) and groupings, we then decomposed the industry's Malmquist into its technical efficiency change and frontier shift components. Finally, we analysed the banks' risk management performance, using Simar and Wilson's (2007) truncated regression approach, before assessing its impact on productivity growth.

The first part of the Malmquist analysis showed that average productivity changes for the Indonesian banking industry tended to be driven, over the sample period, by technological progress rather than by frontier shift, although a relatively stable pattern was exhibited for most of the period. However, at the beginning of the considered period, state-owned and foreign banks, as well as Islamic banks, exhibited volatile productivity movements, mainly caused by shifts in the technological frontier. With

∗ The opinions expressed in this paper do not necessarily reflect those of Bank Indonesia or its staff.

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respect to the risk management analysis, most of the balance sheet variables were shown to have had the expected impact on risk management efficiency. While the risk management decomposition of technical efficiency change and frontier risk components demonstrated that, by the end of the sample period, the change in risk management efficiency and risk management effects had the same dynamic pattern, resulting in the analogous dynamics for technical efficiency changes. Therefore, a strategy based on the gradual adoption of newer technology, with a particular focus on internal risk management enhancement, seems to offer the highest potential for boosting the productivity of the financial intermediary operations of Indonesian banks.

JEL Classification: C23; C52; G21

Keywords: Indonesian Finance and Banking; Productivity; Efficiency.

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1. Introduction

Indonesia has had little extensive research conducted on its financial system relative to other emerging economies around the World. This is surprising considering its growth in importance since the Asian financial crisis (AFC), both economically and politically (as a fledging democracy in the Muslim World). As a growing economy (GDP equal to US$511 billion in 2008), it is particularly important to US interests (Indonesia is the United States' 30th largest trading partner; in 2008, two-way exported trade and services equalled US$5.8 billion and US$1.6 billion respectively; and U.S. foreign direct investment in Indonesia was equal to US$10 billion in 2007, primarily in the mining sector (US$7 billion)) (Office of the United States Trade Representative, 2009). In addition, as a key member of the ASEAN group of countries (which also includes Brunei, Darussalam, Cambodia, Indonesia, Laos PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) - the group has a combined population of 583 million and a nominal GDP in 2008 of US$1,5 trillion – and also as a member of the G20 Group of Nations, it plays an important role in policy deliberations at both regional and global levels. Therefore, its banking system merits serious analysis given its interconnections with the global economy.

As far as the AFC is concerned, Indonesia was by far the worst affected economy (Djiwandono, 1999; IMF, 2007), experiencing, like Thailand and Korea, a mixture of currency, banking and debt crises. Moreover, under the terms of the IMF assistance it received, it had to agree to undertake financial sector "restructuring", including the closure of financial institutions (Jao, 2001, Chapter 2). The economic crisis led, in turn, to a social and political crisis, the latter resulting in the resignation of President Suharto in May 1998. The rapid propagation of the crisis was largely due to weak domestic economic and financial structures, including "crony capitalism" (see Kenward, 2002 and Enoch et al., 2003).

With respect to financial restructuring, the measures agreed with the IMF comprised, inter alia, the closing down of insolvent institutions, the provision of conditional emergency liquidity support to all commercial banks (through overdraft facilities), the establishment of an Indonesian Bank Restructuring Agency (IBRA) to act as an asset management company and restructure problem bank assets, the transfer of institutions to IBRA for "special surveillance", the merger of state-owned banks, preparation of state banks for privatisation, relaxation of the limits on private ownership of banks and the external audit of most major banks by overseas auditors. After the adoption of the IMF restructuring plan, the consolidation of the Indonesian banking Industry continued apace, with the number of banks down to 130 from a pre-crisis figure of 237 by June 2003. Then, in 2004, the authorities revealed a "masterplan" for the financial sector which called for a further reduction in the number of banks from 130 to 60-70. And finally, in June 2005, Bank Indonesia, the Indonesian central bank, revealed that 'consolidator'/'anchor' banks (i.e., those allowed to acquire other institutions) would be required, *inter alia*, to satisfy the following criteria: a minimum tier 1 capital adequacy ratio of 6%; a minimum overall risk-adjusted capital adequacy ratio of 12%; a minimum return on assets ratio of 1.5%; a NPL ratio of under 5%; and a minimum annual credit growth figure of 22%. All other banks would be expected, by the year 2010, to have a minimum paid up share capital of RP 100 billion (Rp 80 billion by 2007), and a minimum capital adequacy ratio of 10%. Around 16 banks were subsequently earmarked for closure/merger or a downgrade to rural bank status during 2007, with a similar number facing the same fate in 2008.

Today, Indonesia is in much better shape than immediately post-AFC. An accumulation of foreign exchange reserves - in 2008 they stood at US$51 billion, up from US$43 billion in 2006 - has allowed for the early repayment of IMF loans (the last repayment was made in October 2006). The current account is in surplus and the currency has appreciated, despite a "mini crisis" in August 2005, fuelled by loss of market confidence in monetary policy and concerns over the increasing oil price – the current exchange rate against the dollar is Rp 9,400. Positive growth has been recorded since the second quarter of 2006, when it was 5.2% at an annualised rate, reaching 6.3% in 2008. The stock market has risen, with the Jakarta Composite Index (JCI) currently standing at 2,610 (as at 29th January 2010). Public debt is under control. Interest rates and inflation have both fallen from their highs, the latter moving into single digit territory from 18.38% in November 2005 to 2.75% in August 2009. And FDI has increased from US$596 million in 2003 to US$7,918 million in 2008. However, not everything is rosy. Unemployment is still too high, with the national average declining from 9.1% in 2007 to 8.4% in 2008. Furthermore, private investment and FDI are still below pre-crisis levels.

The above discussion highlights why this study is both a timely and warranted analysis into the productivity changes that have taken place in Indonesian banking in recent years. As for the modelling approach adopted, we use a new non-parametric modelling technique – SORM-SBM-DEA – to construct the Malmquist indices, which are then decomposed into their technical efficiency change and frontier shift components to provide deeper insights into the drivers of productivity change in Indonesian banking. We then analyse the banks' risk management performance, using Simar and Wilson's (2007) truncated regression approach, before assessing its impact on productivity growth.

The paper is organised as follows. In the next section, we explain our SORM-SBM-DEA efficiency methodology, the estimation of 'risk management-adjusted' technical efficiency scores – see also Section 4 – and the estimation of the Malmquist productivity indices. Section 3 discusses the data and variables utilised. Section 4 presents our results and we summarise and conclude in Section 5.

2. Non-parametric modelling methodology

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 utilise Data Envelopment Analysis (DEA), which is a non-parametric method to construct a relative efficiency frontier through the envelopment of the Decision Making Units (DMUs) where the 'best practice' DMUs form the frontier. It originated from Farrell's (1957) seminal work and was later extended by Charnes et al. (1978), Banker et al. (1984) and Färe et al. (1985). However, the traditional DEA models require the non-negativity of inputs and/or outputs, and several ways have been suggested for dealing with negative data in construction of the non-parametric DEA frontier. For example: data can be transformed, or 'translated', where a sufficiently large scalar is added to the data (Ali and Seiford (1990), Pastor (1996)); absolute negative inputs or outputs can be treated as output or input respectively (Scheel (2001)); or various range directional measures can be used (Silva Portela et al. (2004), Sharp et al. (2006), Kenjegalieva et al. (2009)). Our preference, because it allows for use of the data directly, is for a recent technique based on the semi-oriented radial measure for dealing with negative data (SORM DEA) proposed by Emrouznejad et al. (2010), the first time, we believe, such an approach has been adopted in banking efficiency analysis. Using the slacks-based efficiency measure of Tone (2001), in recognition of Fried et al's (1999) critique of the standard DEA model, 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. In addition, we employ the super-efficiency SBM model proposed by Tone (2002) combined with SORM-DEA to differentiate between those on the frontier. And finally, we also utilise SORM-SBM-DEA and Malmquist indices (initially defined by Caves, Christensen and Diewert (1982) and extended by Färe et al., (1992)), to analyse the productivity of Indonesian banks and assess the impact of bank risk management on productivity growth.

Formally, the optimum level of inputs is given by the relevant frontier which represents the common technology T banks use to transform positive and negative inputs X ($m \times n$) into positive and negative outputs Y ($s \times n$), given by equation (1):

$$\hat{T} = \{(X,Y) \mid \quad X \quad can \quad produce \quad Y\}. \tag{1}$$

It is assumed that $\hat{T}$ is a consistent estimator of the unobserved true technology set.

Given these conditions, the individual input-oriented efficiency for each DMU in period *t* is computed relative to the estimated frontier of period *t* by solving the following input-oriented SORM SBM linear programming problem[1]:

$$\hat{\rho}(x_o^t, y_o^t \mid T^t(x)) = \arg\min\left\{ \rho = 1 - \frac{1}{m}\sum_{k=1}^{m} s_k^- / x_{ko}^t \;\middle|\; \begin{array}{l} x^t{}_o = X^t\lambda + s^-; y_o^t \le Y^t\lambda\ ; \\ y_o^{1,t} \le Y^{1,t}\lambda\ ; y_o^{2,t} \ge Y^{2,t}\lambda\ ; \\ \sum\lambda = 1; \lambda \ge 0; \quad s^- \ge 0. \end{array} \right\} \tag{2}$$

and negative outputs Y_{sj}^1 and Y_{sj}^2 are defined as

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

where $\hat{\lambda}$ is the estimated intensity variable and represents the peers of the considered bank.

In addition, if $\hat{\rho}(x_o^t, y_o^t \mid T^t(x)) = 1$, we employ the input-oriented Super-SORM SBM model using the following linear program to estimate $\hat{\delta}(x_0^t, y_0^t \mid T_*^t(x))$ [which replaces $\hat{\rho}(x_o^t, y_o^t \mid T^t(x))$]:

$$\hat{\delta}(x_0^t, y_0^t \mid T_*^t(x)) = \arg\min\left\{ \delta = \frac{1}{m}\sum_{k=1}^{m} \bar{x}_k / x_{k0}^t \;\middle|\; \begin{array}{l} \bar{x} \ge \sum_{j=1,\neq 0}^{n} \lambda_j x_j^t; \bar{y} \le \sum_{j=1,\neq 0}^{n} \lambda_j y_j^t; \\ \bar{y}^1 \le \sum_{j=1,\neq 0}^{n} \lambda_j y_j^{1,t}; \bar{y}^2 \ge \sum_{j=1,\neq 0}^{n} \lambda_j y_j^{2,t}; \\ \sum\lambda = 1; \lambda \ge 0; \quad \bar{x} \ge x_0; \\ \bar{y} = y_0; \quad \bar{y}^1 = y_0^1; \quad \bar{y}^2 = y_0^2. \end{array} \right\}. \tag{3}$$

An estimation of the productivity change of a bank involves evaluation of the bank's performance with respect to the frontiers of previous and subsequent years in addition to the frontier of the current year. Unlike traditional DEA models, to estimate

[1] Although, the linear programming problem (2) can be solved without including the SORM inequalities by translating negative variables, the inclusion of the former allows for the use of the data directly.

the slacks-based measure of the bank relative to the frontier other than the current frontier of the bank, constraints of the linear programming models need to be adjusted. In particular, the bank under question is also included in the production possibility set (for more details see Tone (2004) and Liu and Wang (2008)). In cases when the slacks-based performance measure of the DMU *o* is obtained relative to the frontier of another period, the following models are used, which measure the performance of DMU *o* operated in time *t* with respect to the frontier of time *t+1*:

$$\hat{\rho}(x_o^t, y_o^t \left| T^{t+1}(x)) = \arg\min \left\{ \rho = 1 - \frac{1}{m}\sum_{k=1}^{m} s_k^- / x_{ko}^t \right| \begin{array}{l} x^t{}_o = \sum_{j=1}^{n} x_j^{t+1}\lambda + x_o^t \lambda_{n+1} + s^-; \\ y^t{}_o \le \sum_{j=1}^{n} y_j^{t+1}\lambda + y_o^t \lambda_{n+1}; \\ y^{1,t}{}_o \le \sum_{j=1}^{n} y_j^{1,t+1}\lambda + y_o^{1,t} \lambda_{n+1}; \\ y^{2,t}{}_o \ge \sum_{j=1}^{n} y_j^{2,t+1}\lambda + y_o^{2,t} \lambda_{n+1}; \\ \sum_{j=1}^{n+1} \lambda_j = 1; \Lambda \ge 0, S^- \ge 0, S^+ \ge 0, l > 0 \end{array} \right\} \quad (4)$$

When $\hat{\rho}(x_o^t, y_o^t \left| T^{t+1}(x)) = 1,$ we employ the following specification of the Super-SORM SBM model to measure the super-efficiency performance measure $\hat{\delta}(x_0^t, y_0^t \left| T^{t+1}(x))$ which replaces $\hat{\rho}(x_o^t, y_o^t \left| T^{t+1}(x)):$

$$\hat{\delta}(x_0^t, y_0^t \left| T^{t+1}(x)) = \arg\min \left\{ \delta = \frac{1}{m}\sum_{k=1}^{m} \bar{x}_k / x_{k0}^t \right| \begin{array}{l} \bar{x} \ \ge \sum_{j=1}^{n} \lambda_j x_j^{t+1}; \bar{y} \ \ge \sum_{j=1}^{n} \lambda_j y_j^{t+1}; \\ \bar{y}^1 \le \sum_{j=1,\neq 0}^{n} \lambda_j y_j^{1,t+1}; \bar{y}^2 \ge \sum_{j=1,\neq 0}^{n} \lambda_j y_j^{2,t+1}; \\ \sum \lambda = 1; \lambda \ge 0; \bar{x} \ge x_0; \bar{y} = y_0; \\ \bar{y}^1 = y_0^1; \bar{y}^2 = y_0^2. \end{array} \right\}. \quad (5)$$

The SORM slacks-based performance measures $\hat{\rho}(x_o^{t+1}, y_o^{t+1} \left| T^t(x))$ and $\hat{\delta}(x_0^{t+1}, y_0^{t+1} \left| T \ (x))$ can be obtained using equations (4) and (5) by interchanging *t* and *t+1*.

To obtain the risk management adjusted technical efficiency scores, we first obtain the γ, the Risk Management Efficiency (*RME*) scores, which are then adjusted for the internal risk management conditions of a bank (see Pastor (1999) and (2002)). Accordingly, we estimate program (6), where *PROV* is total provisions, *L* is total loans of the bank, *OTH* is other earning assets, to obtain γ_j for bank *j*; then the $\hat{RME}_j$ scores are regressed on z_j, a vector of environmental variables of the *j*-th bank (equation (7)).

$$\hat{\gamma} = \arg\min\left\{ \gamma = \overline{PROV}_k / PROV_{k0} \;\middle|\; \begin{array}{l} \overline{PROV}_k \geq \sum_{j=1,\neq 0}^{n} \lambda_j PROV_j \,; \overline{L} \leq \sum_{j=1,\neq 0}^{n} \lambda_j L_j \,; \\ \overline{OTH} \leq \sum_{j=1,\neq 0}^{n} \lambda_j OTH_j \,; \\ \sum \lambda = 1; \lambda \geq 0; \;\; \overline{x} \geq x_0 \,; \\ \overline{L} = L_0 ; \;\; \overline{OTH} = OTH_0 \,. \end{array} \right\} \qquad (6)$$

$$0 \leq RME_j = \gamma_j = \psi(z_j, \eta) + \varepsilon_j \leq 1, \qquad (7)$$

That is, in equation (7): RME_j is the true Risk Management Efficiency measure of the *j*-th bank ($\hat{RME}_j$, calculated using program (6), is used as an estimate for RME_j); ψ is a smooth continuous function; η is a vector of parameters; and ε_j is a truncated random variable $N(0, \sigma_i^2)$ truncated at $(-\psi(z_j, \eta))$ and $(1 - \psi(z_j, \eta))$. The RME_j is then adjusted for bias using the first bootstrapping procedure of Algorithm 2 of Simar and Wilson (2007). Once $\hat{\gamma}$ is obtained, the variable 'total provisions' is then adjusted for the risk management factor, i.e., $\hat{\gamma} \cdot PROV$. Then the risk management-adjusted efficiency scores are calculated. For instance, the risk management-adjusted $RMEadj\hat{\rho}(x_o^t, y_o^t | T^t(x))$ is estimated using (3) with $\hat{\gamma} \cdot PROV$ used as an input measuring internal risk.

For the second stage of the analysis, the Malmquist productivity index of the DMU_o between periods *t* and *t+1* is estimated as follows, in line with Färe et. al. (1992):

$$M_o^{t,t+1} = \left[\frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \middle| T^t(x))}{\hat{\rho}(x_o^t, y_o^t \middle| T^t(x))} \frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \middle| T^{t+1}(x))}{\hat{\rho}(x_o^t, y_o^t \middle| T^{t+1}(x))} \right]^{1/2} . \qquad (8)$$

If the productivity measure, $M_o^{t,t+1}$, is greater than 1, then this implies a productivity gain of DMU_o between period t and t+1, and, contrarily, if $M_o^{t,t+1}$ is less than 1 it indicates a productivity loss. A $M_o^{t,t+1}$ equal to 1 implies that the DMU_o has no change in its productivity.

The productivity measure $M_o^{t,t+1}$ can be decomposed into two indices which capture technical efficiency change (TEC_o) between the periods *t* and *t+1*, and the technological (frontier) change (FS_o), i.e. the shift of the technology between the two periods:

$$M_o^{t,t+1} = TEC_o \times FS_o = \frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \middle| T^{t+1}(x))}{\hat{\rho}(x_o^t, y_o^t \middle| T^t(x))} \times \left[\frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \middle| T^t(x))}{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \middle| T^{t+1}(x))} \frac{\hat{\rho}(x_o^t, y_o^t \middle| T^t(x))}{\hat{\rho}(x_o^t, y_o^t \middle| T^{t+1}(x))} \right]^{1/2} . \qquad (9)$$

In equation (9), TEC_o measures the efficiency catching-up of the DMU_o, which, in the case of TEC_o=1, shows that the firm is still in the same position relative to the efficient boundary. When $TEC_o > 1$ the firm has moved closer to the frontier, whereas if $TEC_o < 1$ the firm has moved away from the frontier between two periods. With regard to the FS_o, which indicates the change in technology, $FS_o < 1$ indicates a negative shift of the frontier (or regression), $FS_o > 1$ a positive shift (progress) and $FS_o = 1$ implies no shift in the technological frontier.

Both *TEC* and *FS* can be further decomposed into 'risk management efficiency' and 'risk management effect' components, as follows:

$$TEC_o^{t,t+1} = \frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))}{\hat{\rho}(x_o^t, y_o^t \mid T^t(x))}$$

$$= \left[\frac{RMEadj\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))}{RMEadj\hat{\rho}(x_o^t, y_o^t \mid T^t(x))} \right] \cdot \left[\frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))}{\hat{\rho}(x_o^t, y_o^t \mid T^t(x))} \Big/ \frac{RMEadj\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))}{RMEadj\hat{\rho}(x_o^t, y_o^t \mid T^t(x))} \right]$$

$$= RMeffCH \cdot RMeffectCH \tag{10}$$

and

$$FS_o^{t,t+1} = \left[\frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^t(x))}{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))} \frac{\hat{\rho}(x_o^t, y_o^t \mid T^t(x))}{\hat{\rho}(x_o^t, y_o^t \mid T^{t+1}(x))} \right]^{1/2}$$

$$= \left[\frac{RMEadj\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^t(x))}{RMEadj\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))} \frac{RMEadj\hat{\rho}(x_o^t, y_o^t \mid T^t(x))}{RMEadj\hat{\rho}(x_o^t, y_o^t \mid T^{t+1}(x))} \right]^{1/2} \cdot$$

$$\cdot \left[\frac{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^t(x))}{\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))} \frac{\hat{\rho}(x_o^t, y_o^t \mid T^t(x))}{\hat{\rho}(x_o^t, y_o^t \mid T^{t+1}(x))} \Big/ \frac{RMEadj\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^t(x))}{RMEadj\hat{\rho}(x_o^{t+1}, y_o^{t+1} \mid T^{t+1}(x))} \frac{RMEadj\hat{\rho}(x_o^t, y_o^t \mid T^t(x))}{RMEadj\hat{\rho}(x_o^t, y_o^t \mid T^{t+1}(x))} \right]^{1/2}$$

$$= FSRMeff \cdot FSRMeffect \tag{11}$$

where the first component in each case captures technical efficiency change and frontier shift due to the risk management efficiency and the second component describes the impact of the risk management effect on technical efficiency change and frontier shift respectively.

3. Data and variables used

As shown in Table 1, at the end of June 2007 there were 130 banks operating in Indonesia with a combined balance sheet of over IDR 1,770 trillion (US$ 188 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 Section 1), and, more recently, through officially-encouraged mergers.

INSERT TABLE 1

It is also important to recognise the increasing role played by Islamic banks in an Indonesian 'floating market' of a possible customer base consisting of at least 75% of the population. This increasing role began with the passing of the Banking Act No. 7/1992, with Bank Muamalat being established as the first bank to offer Shari'ah compliant services. This was subsequently followed by Banking Act No. 10/1998, which allowed domestic and partly foreign-owned banks to open Islamic subsidiaries (recently, HSBC opened up a Shari'ah head office in Jakarta). And, finally, the switch from civil courts to religious courts to take over adjudication of Islamic banking disputes (Law No. 3/2006), further encouraged the development of Islamic banking. In 2000, the total deposits held in Islamic banks equalled Rp1.03 trillion increasing to Rp36.85 trillion in 2008, and financing increased from Rp1.27 trillion to Rp38.2 trillion over the same period. Although the share of total banking assets accounted for by Islamic banks is still small (1.67% in March 2007), this belies the aims and growth targets set by Bank Indonesia. Moreover, Islamic banking in the last 5 years has seen annualised growth rates exceeding 60%.[2]

In modelling the intermediation approach, we specify 3 outputs and 4 inputs, in line with Sealey and Lindley (1977). Quarterly data is based on the monthly supervisory data provided by Bank Indonesia. The first output is 'total commercial loans' (total customer loans + total other lending), the second output is 'other earning assets' (placements in Bank of Indonesia + interbank assets + securities held), and the third output is 'net total off-balance-sheet income' (income form dividends/fees/commissions/provisions + income from forex/derivative transactions + securities appreciation - securities depreciation - losses from forex/derivative transactions

[2] It is interesting to note that Indonesia has the aim of becoming a leading Islamic banking centre in the ASEAN region by 2010 (Bank Indonesia, 2008).

- losses from commission/provisions). The third output variable set is included in the analysis to reflect banks' diversification away from traditional financial intermediation (margin) business and into "off-balance-sheet" and fee income business. The inclusion of 'net total off-balance-sheet income' is therefore intended to proxy the non-traditional business activities of Indonesian banks.

The inputs estimated in the intermediation approach are: 'total consumer deposits and commercial borrowing' (demand deposits + saving deposits + time deposits); 'total employee expenses' (total salaries and wages + total educational spending); 'total non-employee expenses' (R & D + rent + promotion + repair and maintenance + goods and services + other costs); and 'total provisions' (allowances for loan losses). The last-mentioned input variable is included to account for risk (consistent with Laevan and Majnoni (2003)).

To assess the risk management performance of a bank we include variables measuring each bank's asset composition, liability composition, revenue breakdown, profitability and capital structure[3]. Asset composition variables include the ratio of total loans to total assets and the share of loans issued in foreign currency in the total loans of a bank. The latter measures the exposure of a bank's loan portfolio to exchange rate risk. Liability composition is measured by the ratio of total deposits to assets, and the shares of different types of deposits, such as demand, savings and time deposits, to total deposits. In addition, we include the ratio of foreign currency deposits to total deposits. We also include the ratio of non - interest income to interest income as a measure of each bank's reliance on off-balance sheet activities. And finally, profitability of a bank is captured by return on assets (RoA) and return on equity (RoE), while the ratio of equity capital to total assets is included to measure the leverage of banks.

INSERT TABLE 2

Summary statistics on the data are given in Table 2. The sample includes a balanced panel of 129 Indonesian banks covering the time span from 2003 quarter 1 to

[3] Risk management variables are somewhat similar to those used by Demsetz and Strahan (1997) and Stiroh (2006).

2007 quarter 2[4]. In the estimation period, observations totalled 18,060. It must be noted that separate frontiers were estimated for each time period to allow for comparisons with the Malmquist Index.

4. Results

The productivity measures of Indonesian banks are presented below. A detailed analysis of bank productivity performance with particular focus on productivity growth, technological progress and the efficiency catching-up of banks is given in Section 4.1. We then discuss risk management and its impact on banking performance in Section 4.2.

4.1 Productivity growth in Indonesian banking

Table 3 provides a summary of the SORM-SBM DEA Malmquist productivity indices and their components for Indonesian banks during the sample period. With respect to the Malmquist productivity analysis, the top and bottom halves of Figure 1 show, respectively, the dynamics of the average Malmquist productivity index by type and grouping of banks; while Figure 2 shows the average industry Malmquist index and its decomposition into technical efficiency change and frontier shift components. As can be seen from Figure 2, the average productivity of the sampled banks was relatively stable during the analysed period. However, at the beginning of the considered period, state-owned and foreign banks (as well as Islamic banks) experienced volatile productivity (see Figure 1), which was mainly caused by shifts in the technological frontier. The productivity decomposition results generally attribute productivity changes mainly to a deterioration/improvement in financial intermediation technology. Interestingly, in 2007 however, all banks experienced unstable patterns of technical efficiency change and frontier shift, with the two balancing out to more or less maintain stable productivity growth.

INSERT TABLE 3

[4] One state-owned bank is dropped from the sample due to the extremely volatile changes in its off-balance-sheet items.

INSERT FIGURES 1 AND 2

Although a study, by Margono et al. (2009), of Indonesian bank productivity during the period 1993-200 found that technological progress only occurred in the pre-crisis period, the finding that the main driver of the productivity change in the financial intermediary activities of Indonesian banks was the improvement in their intermediation technology is consistent with those of other studies on East Asian banking. For instance, Park and Weber (2006), using DEA and the Luenberger productivity index, found that during 1992-2002, banking productivity in Korea improved mainly due to technological progress. Williams and Nguyen (2005), using Stochastic Frontier Analysis (SFA) and a Fourier Flexible Form, also found that the productivity of East Asian banks improved over the period 1990-2003 and that technological change was the main instigator of productivity change. Finally, with respect to technical efficiency change (i.e., the catching-up effect), there appears to be a relatively stable pattern excepting the year 2007. This suggests that, although the efficiency levels of banks were at different levels, the relative efficiency position of banks had a tendency to remain unchanged.

4.2. Risk management and its impact on banking productivity

In Table 4 we present the expected and observed impact of the various balance sheet factors on the risk management of Indonesian banks. The observed influence of these factors is estimated using the truncated regression approach of Simar and Wilson (2007) and the first bootstrapping procedure of Algorithm 2.

Due to the specificity of the bootstrapped procedure of the truncated regression, we run eighteen cross-sectional regressions for each observed quarter. As can be seen from Table 4, most of the balance sheet variables had the expected impact on banking risk management efficiency (i.e., on risk). In terms of the asset composition, banks with a higher share of loans issued in foreign currency, for example, tend to be less risk management efficient, *ceteris paribus*, because of the exchange rate risk assumed. With respect to liability composition, the general result is that the more deposits a bank has the less risky it is (i.e., funding liquidity risk is low). Moreover, the results also suggest the composition of the deposit portfolio (i.e., the combination of demand, savings and time

deposits) does not have a significant impact on risk management efficiency. However, in cases where banks have a higher share of foreign currency deposits, their risk management tends to outperform those with a lower share of the same despite the increased exchange rate risk.

As expected, banks with higher RoA tend to exhibit poorer risk management efficiency because they engage in more risky activities. However, closer to the end of the considered sample higher RoA (and RoE) banks had better risk management, although this was not always statistically significant. This outcome is related to the leverage of the banks which is also captured by the ratio of equity capital to the total assets. Banks with stronger capital back-up tend to be practising better risk management.

With regards to ownership status, most banks in Indonesia were significantly less risk management efficient than the state-owned banks, which were used as the control group in the analysis. And listed banks tended to perform better than their non-listed counter parts. In addition, Islamic banks tended to be more risk management efficient (i.e., less risky) than non-Islamic banks, which can be attributed to the specificity of the Islamic banking operations.

INSERT TABLE 4

The average risk management efficiency results of the break-down of banking risk into that associated with external and internal factors are presented in Figure 3. The figure shows the average risk decomposition across all considered Indonesian banks, which is averaged using an arithmetic average. As can be seen from the figure, the proportion of internal risk in Indonesian banks was relatively stable during the analyzed period and ranged from 40% in Q2 2007 to 51% in Q1 2005 and in Q2 and Q3 2006.

INSERT FIGURE 3

The decomposition of the changes in technical efficiency (i.e., into the "catch-up" and frontier shift parts of the productivity index) and the impact of risk management on these components is given in Table 3 and illustrated in Figure 4. According to the results

of the two-stage decomposition, the impact of risk management on the technical efficiency of Indonesian banks was somewhat volatile in 2003 and 2004. In general, during that period the impact of the risk management efficiency change and the risk management effect on technical change offset each other, resulting in an overall stable pattern of technical efficiency change. From Q3 2004 the change in the risk management effect and efficiency change had the same dynamic pattern resulting in analogous dynamics in technical efficiency change.

INSERT FIGURE 4

The part of productivity change which appears in the form of technological change (or frontier-shift) and its decomposition into frontier shift due to the risk management efficiency change and risk management effect is shown in the bottom part of Figure 4. As per Table 3, the risk management effect component of the technological change is relatively stable during the considered period, although the change in risk management efficiency component is rather volatile.

5. Summary and Conclusions

In one of the first stand-alone analyses of Indonesian banking productivity, we have estimated Malmquist productivity indices for Indonesian banks over the period Q1 2003 to Q2 2007 using the non-parametric, slacks-based, semi-oriented radial measure approach for efficiency and super-efficiency estimation suggested by Tone (2001, 2002) and Emrouznejad et al. (2010). We used a unique dataset based on monthly data provided by the Central Bank of Indonesia, Bank Indonesia, to carry out this analysis.

With respect to the standard Malmquist analysis, the dynamics of the average productivity of banks were shown to be relatively stable during the analysed period, with the results suggesting that the main driver of the productivity change in the financial intermediary activities of Indonesian banks was the improvement in their intermediation technology. As for the risk management analysis, most of the balance sheet variables had the expected impact on risk management efficiency. Finally, the risk management decomposition of technical efficiency change and frontier shift components of

productivity suggests that, by the end of the analysed period, the change in risk management efficiency and risk management effect had the same dynamic pattern resulting in analogous dynamics for technical efficiency changes. Therefore, a strategy based on the gradual adoption of newer technology, with a particular focus on internal risk management enhancement, according to our results, seems to have the highest potential for boosting the productivity of the financial intermediary operations of Indonesian banks.

Acknowledgements

We are indebted to Ricky Satria, of Bank Indonesia, for his excellent assistance in compiling the data. We also thank G. Ravishankar, K. Kerstens and participants of the Young OR 16 Conference (Warwick University, UK), the XI European Workshop on Efficiency and Productivity Analysis (EWEPA) (Pisa, Italy) and of the 2009 UKEPAN Finance Conference for their valuable comments and suggestions.

Table 1

The Structure of the Indonesian Banking Industry at end-June 2007

Type of Bank*	Number of Banks	Total Assets (TA) (IDR tn.)		TA Share to the Banking Industry TA (%)	
State-owned banks	5 (4)	641.1	(472.9)	36%	(30%)
Foreign exchange private national banks	35 (35)	691.2	(691.2)	39%	(43%)
Non-foreign exchange private national banks	36 (36)	32.6	(32.6)	2%	(2%)
Regional government-owned banks	26 (26)	165.0	(165.0)	9%	(10%)
Joint venture banks	17 (17)	78.0	(78.0)	5%	(5%)
Foreign banks (branching)	11 (11)	162.9	(162.9)	9%	(10%)
Total	130 (129)	1770.8	(1602.6)	100%	(100%)

Note. * There are also 24 (23) listed banks, comprising 17 (17) foreign exchange private banks, 2 (2) non-foreign exchange private banks, 1 (1) regional government-owned bank, 1 (1) joint venture bank, and 3 (2) state-owned banks. As well as this there are 3 (3) Islamic banks, which comprise 2 (2) foreign exchange private banks and 1 (1) non- foreign exchange private bank. [Numbers in parentheses are the number of banks and their total assets of the sample – see footnote 4].

Table 2.

Summary Statistics for Indonesian Banks. Inputs and Outputs in IDR tn: Q I 2003 - Q II 2007

Variable	Mean	Minimum	Maximum	Std.Dev.
Inputs:				
Total consumer deposits and commercial borrowing	7385901	66	231144394	21996797
Total employee expenses	33540	259	1200971	103047
Total non-employee expenses	31449	81	2239957	95351
Total provisions	280240	51	11682029	1141625
Outputs:				
Total commercial loans	3626003	0*	79290094	9587807
Other earning assets	6850997	2508	345617374	25937641
Net total off-balance sheet income	24905	-1750422	11151124	252035

* Please note that this bank is a foreign bank which invests mainly in short-term government securities and has chosen not to make any commercial loans in Indonesia.

Table 3.

Average Malmquist productivity indices and decomposition components for Indonesian Banks - Q I 2003 - Q II 2007

	Q1/Q2'03	Q2/Q3'03	Q3/Q4'03	Q4'03/Q1'04	Q1/Q2'04	Q2/Q3'04	Q3/Q4'04	Q4'04/Q1'05	Q1/Q2'05
MI	0.999	1.020	1.016	1.048	0.999	1.076	0.964	1.074	0.996
TEC	1.060	1.023	0.979	1.009	1.009	0.995	0.970	1.036	1.053
- RM efficiency change	1.077	0.966	1.054	1.018	1.090	0.933	1.025	1.028	0.985
- RM effect on technical change	0.984	1.072	0.936	0.999	0.931	1.081	0.945	1.008	1.071
FS	0.956	0.999	1.028	1.037	1.002	1.099	0.997	1.047	0.951
- FS due to RM efficiency change	0.906	1.089	1.015	1.016	0.921	1.145	0.922	1.024	1.035
- FS due to RM effect	1.060	0.934	1.050	1.027	1.107	0.976	1.089	1.024	0.922

	Q2/Q3'05	Q3/Q4'05	Q4'05/Q1'06	Q1/Q2'06	Q2/Q3'06	Q3/Q4'06	Q4'06/Q1'07	Q1/Q2'07
MI	1.025	1.067	1.000	1.001	1.047	0.982	1.044	1.031
TEC	1.021	0.983	0.962	1.003	0.965	1.053	0.957	0.816
- RM efficiency change	1.024	1.011	0.961	0.998	0.988	1.037	1.009	0.865
- RM effect on technical change	1.003	0.977	1.002	1.007	0.977	1.014	0.948	0.945
FS	1.015	1.083	1.039	1.000	1.090	0.942	1.097	1.288
- FS due to RM efficiency change	1.024	1.047	1.043	0.996	1.061	0.955	1.100	1.276
- FS due to RM effect	0.994	1.037	0.998	1.006	1.026	0.987	0.999	1.016

Notes. MI – Malmquist Index; FS – Frontier Shift (technological change); TEC – Technical Efficiency Change; RM – Risk Management. Results by ownership and type can be obtained from the authors upon request.

Table 4.

Variables influencing the risk management of Indonesian banks - Q I 2003 - Q II 2007

	Expected impact	Q1 2003	Q2 2003	Q3 2003	Q4 2003	Q1 2004	Q2 2004	Q3 2004	Q4 2004	Q1 2005
Asset composition:										
Loans / Total Assets	-	-0.04	0.07	0.00	-0.08	0.09	0.18	0.26*	0.13	0.03
Foreign Currency Loans / Total Loans	-	-0.54*	-0.36**	-0.16	-0.26	-0.37*	-0.39*	-0.34**	-0.37**	-0.38**
Liability composition:										
Deposits / Total Assets	+	0.04	0.39*	0.30*	0.12	0.66*	0.33**	0.15	0.17	0.21
Savings Deposits / Deposits	+	0.28	0.26	0.26	0.29	0.27	0.34	0.30	-0.06	0.10
Time Deposits / Deposits	+	0.09	0.04	0.24	0.31*	0.11	-0.01	-0.03	-0.22	-0.03
Foreign Currency Deposits / Deposits	+	0.23	0.15	0.30	0.33	0.18	-0.05	-0.05	-0.08	0.25
Revenue breakdown:										
Non - Interest Income / Interest Income	-/+	0.0003	-0.0005	0.0007	-0.0012	-0.0036*	-0.0012	0.0002	-0.0004	0.0004
Profitability and capital structure:										
RoA	-	-0.78	-3.95**	-2.78*	-2.24*	-0.17	-2.43	-2.07	-0.96	-3.06
RoE	-	-0.0011	-0.0003	-0.0003	-0.0002	-0.0009	-0.0005	-0.0002	-0.0002	-0.0001
Equity Capital / Total Assets	+	0.01	0.01	0.01	0.00	0.06*	0.04*	0.03**	0.04**	0.04*
Ownership/type										
Listed	-/+	0.13*	0.11**	0.07	0.04	0.02	0.10	0.08	0.05	0.05
Islamic	-/+	0.14	0.15	0.19	0.16	0.22**	0.33*	0.15	0.14	0.10
Foreign Exchange Private	-/+	-0.42*	-0.53*	-0.46*	-0.40*	-0.59*	-0.36*	-0.28*	-0.23**	-0.19
Non Foreign Exchange Private	-/+	-0.34*	-0.40*	-0.38*	-0.32*	-0.53*	-0.35*	-0.27*	-0.25**	-0.22
Regional Government Owned	-/+	-0.41*	-0.44*	-0.28**	-0.24*	-0.52*	-0.33*	-0.25	-0.32*	-0.21
Joint Venture	-/+	-0.39**	-0.44*	-0.58*	-0.50**	-0.46*	-0.12	-0.13	-0.16	-0.26**
Foreign	-/+	-0.34	-0.43*	-0.51*	-0.54*	-0.47*	-0.13	-0.07	-0.13	-0.26
Constant		0.75*	0.60*	0.49*	0.59*	0.32**	0.41*	0.50**	0.75*	0.58*
$\hat{\sigma}_{\varepsilon}$		0.23*	0.22*	0.22*	0.21*	0.20*	0.21*	0.22*	0.23*	0.23*

Notes: Statistical significance: * denotes statistically significant at the 5% level; and ** denotes statistically significant at the 10% level.

Table 4 (continued)

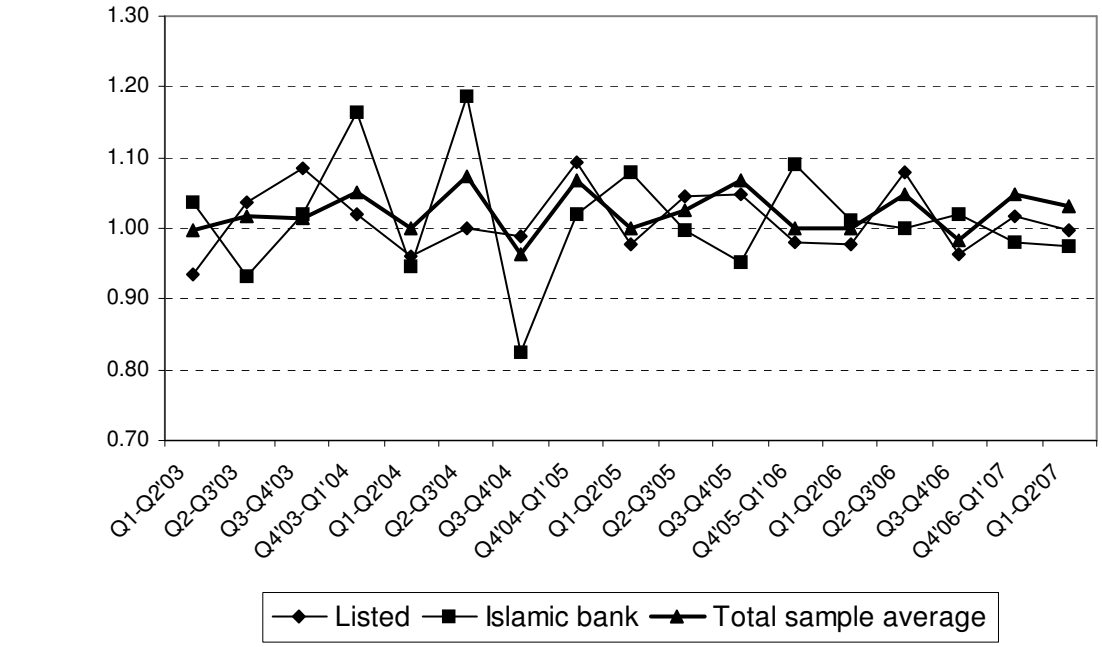
Variables influencing the risk management of Indonesian banks - Q I 2003 - Q II 2007

	Expected impact	Q2 2005	Q3 2005	Q4 2005	Q1 2006	Q2 2006	Q3 2006	Q4 2006	Q1 2007	Q2 2007
Asset composition:										
Loans / Total Assets	-	0.11	0.10	0.12	0.10	0.09	0.16	0.06	-0.04	-0.10
Foreign Currency Loans / Total Loans	-	-0.03	-0.05	0.10	-0.03	-0.14	-0.20	-0.26	0.11	-0.05
Liability composition:										
Deposits / Total Assets	+	0.44*	0.36**	0.40*	0.60*	0.76*	0.72*	0.78*	0.70*	0.68*
Savings Deposits / Deposits	+	-0.07	-0.18	-0.12	0.14	0.17	0.14	-0.02	0.18	0.16
Time Deposits / Deposits	+	-0.11	-0.20	-0.08	0.03	0.19	0.21	0.02	0.28	0.27
Foreign Currency Deposits / Deposits	+	-0.14	-0.06	-0.39	0.40	0.79*	0.68*	0.62**	0.40	0.60*
Revenue breakdown:										
Non - Interest Income / Interest Income	-/+	-0.0012	-0.0012	0.0007	0.0026*	-0.0003	0.0008	-0.0005	0.0071	0.0001
Profitability and capital structure:										
RoA	-	-0.72	-1.41	-0.66	-2.55	-0.96	-0.50	-1.00	0.41	0.37
RoE	-	0.0002	-0.0001	-0.0001	0.0026*	0.0003	0.0004**	0.0002	0.0006	0.0004
Equity Capital / Total Assets	+	0.05*	0.04	0.07	0.26*	0.39*	0.31*	0.35*	0.33*	0.38*
Ownership/type:										
Listed	-/+	0.08	0.12**	0.11*	0.13*	0.10	0.08	0.10	0.10	0.18*
Islamic	-/+	0.20	0.16	0.14	0.16	0.19	0.15	0.07	0.06	0.05
Foreign Exchange Private	-/+	-0.25**	-0.19	-0.20	-0.27*	-0.26*	-0.27*	-0.31*	-0.29*	-0.34*
Non Foreign Exchange Private	-/+	-0.28**	-0.19	-0.26**	-0.25**	-0.28*	-0.36*	-0.37*	-0.42*	-0.47*
Regional Government Owned	-/+	-0.35*	-0.31**	-0.28**	-0.22	-0.18	-0.29**	-0.32*	-0.24	-0.24
Joint Venture	-/+	-0.28**	-0.25**	-0.17	-0.45*	-0.56*	-0.55*	-0.46*	-0.47*	-0.45*
Foreign	-/+	-0.22	-0.14	-0.01	-0.32**	-0.37*	-0.43*	-0.34**	-0.39*	-0.40*
Constant		0.47**	0.53*	0.44**	0.13	-0.11	-0.03	0.14	-0.02	-0.03
$\hat{\sigma}_{\varepsilon}$		0.23*	0.23*	0.22*	0.22*	0.22*	0.23*	0.23*	0.23*	0.22*

Notes: Statistical significance: * denotes statistically significant at the 5% level; and ** denotes statistically significant at the 10% level.

Figure 1

Dynamics of Indonesian Bank Productivity (Malmquist Representation): Q I 2003 – Q II 2007



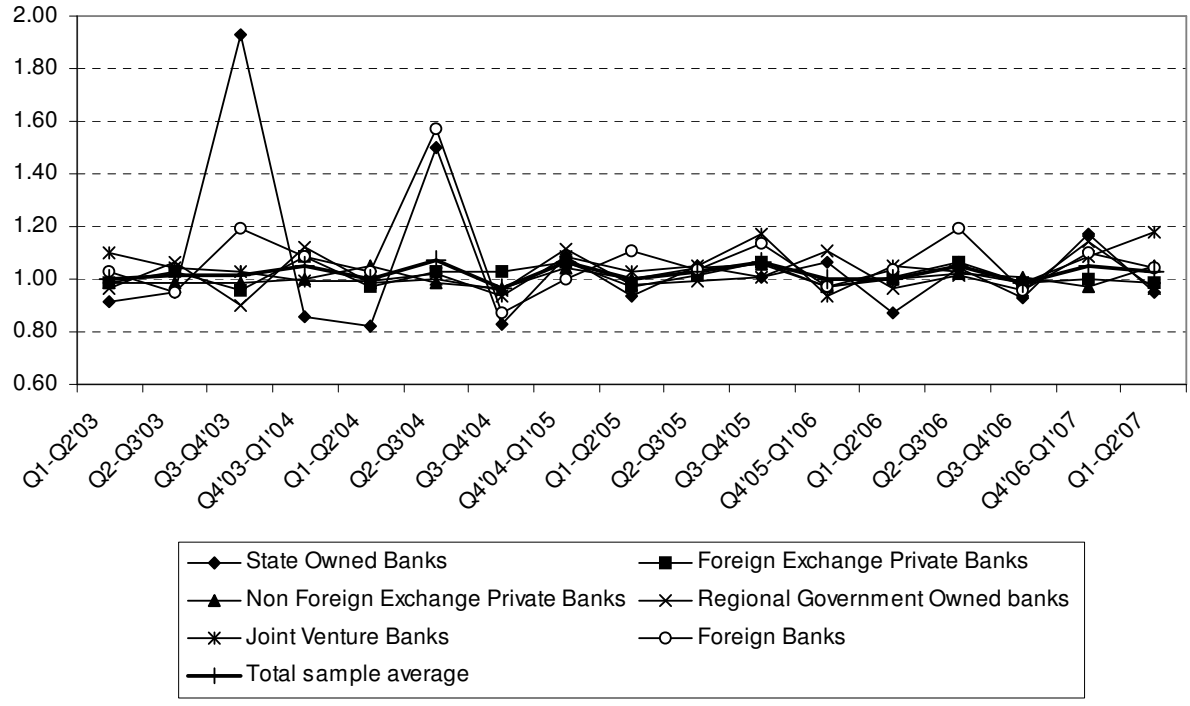


Figure 2

SORM-SBM DEA Malmquist Productivity of the Indonesian Banking Industry

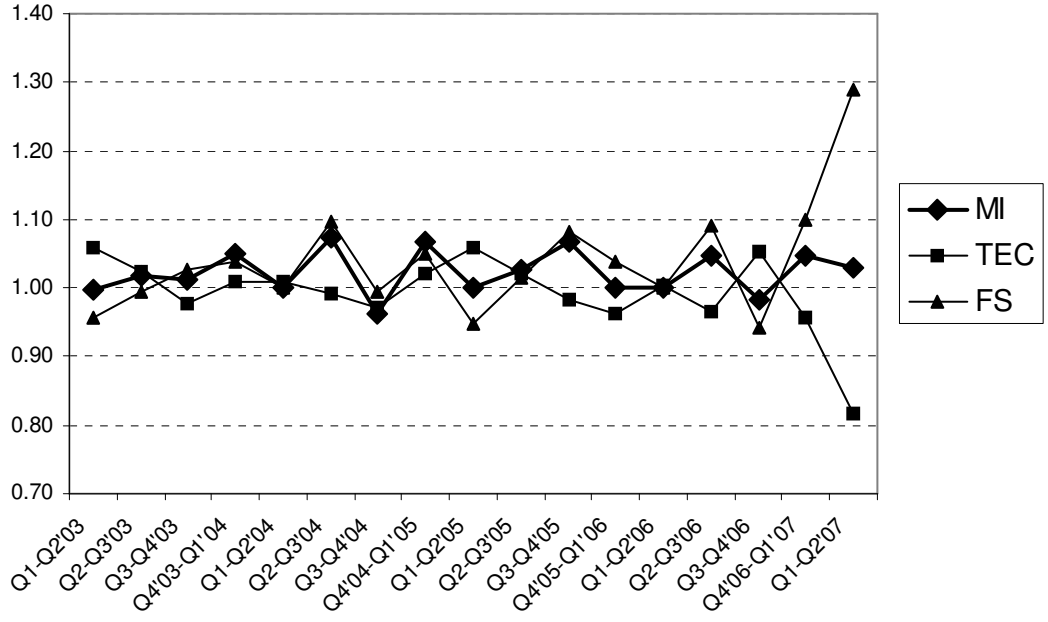


Figure 3

Risk decomposition for Indonesian banks (Q1 2003 – Q2 2007).

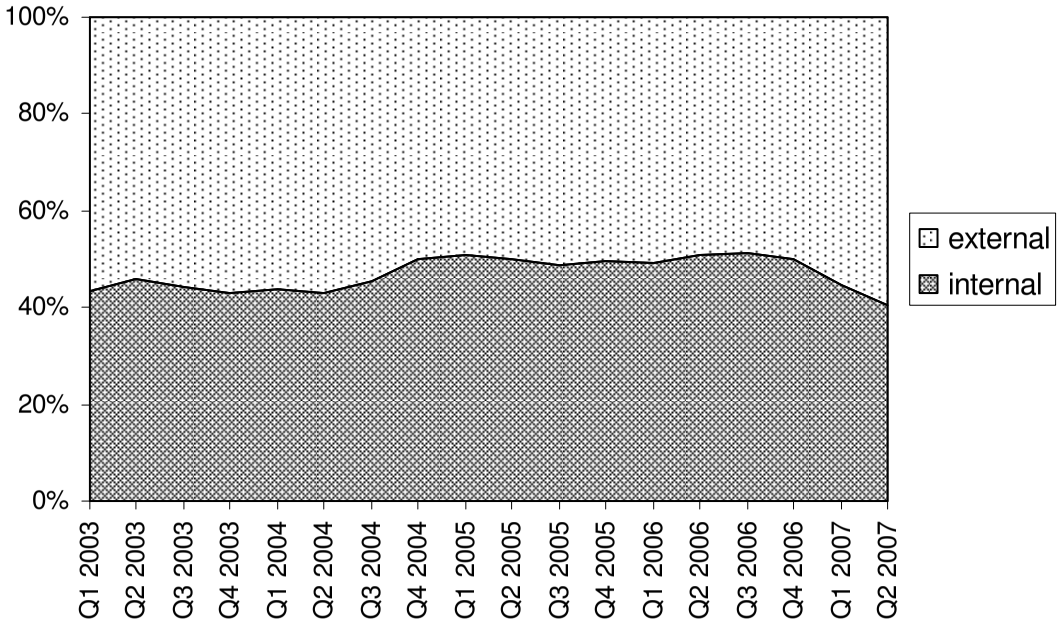
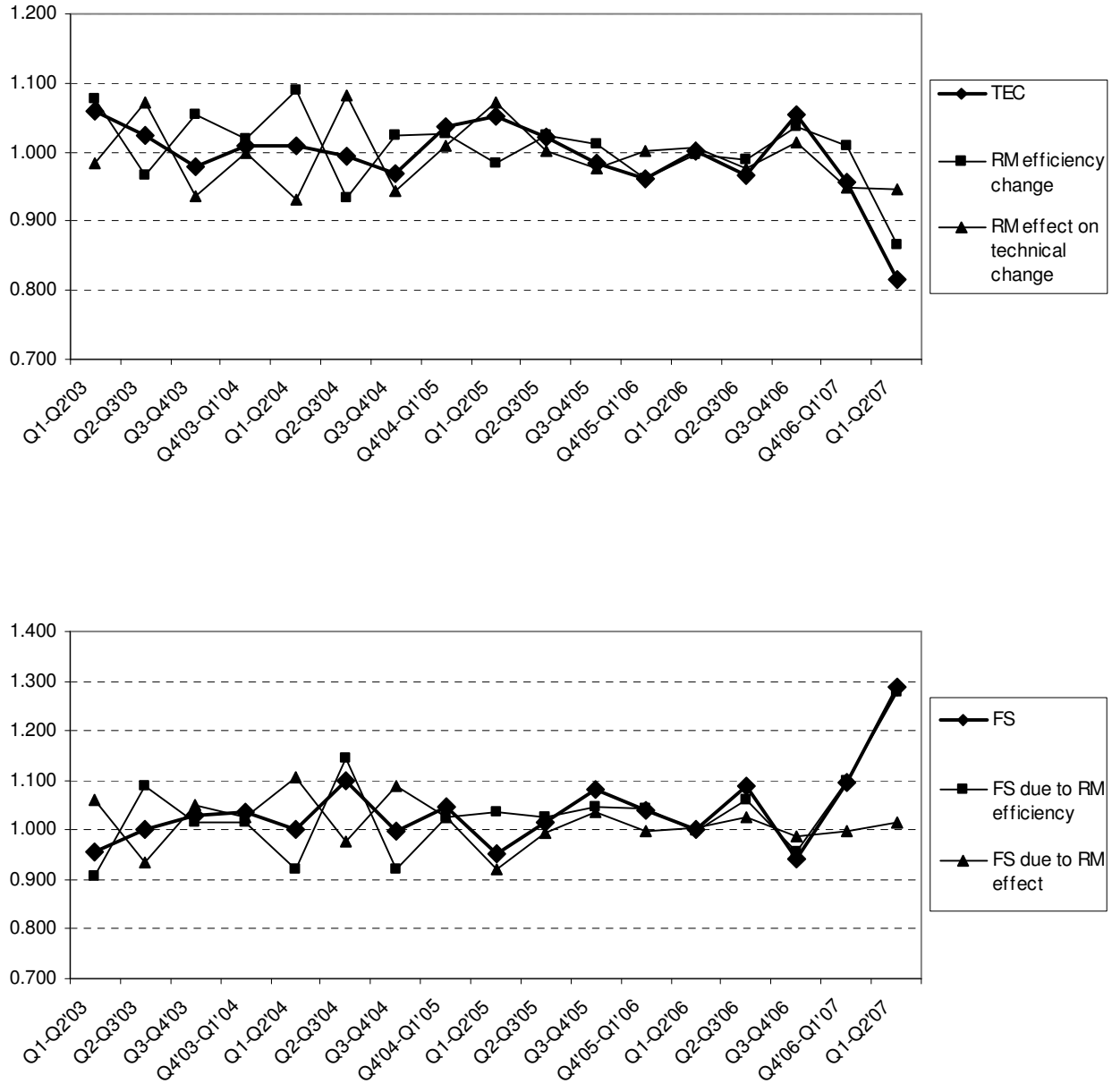


Figure 4

Risk management efficiency and risk management components of Indonesian banking technical efficiency change and frontier shift



Notes. FS – Frontier Shift (technological change); TEC – Technical Efficiency Change; RM – Risk Management.

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