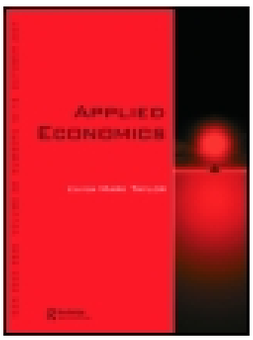

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Economic liberalization and sources of productivity growth in Indonesian Banks: is it efficiency improvement or technological progress?

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ABSTRACT

This article investigates the sources of productivity growth in the Indonesian banking sector during 23 years period from 1993 to 2015. The industry has gone through several episodes of policy reforms, starting from the radical deregulation in the late 1980s, the restructuring period following the 1997 Asian financial crisis, the consolidation period in the mid-2000s to the economic expansion in the 2010s. Using panel data of 98 commercial banks, we explore productivity growth using *Malmquist* indices complemented with bootstrapping technique to provide measures of the statistical precision of the results. The Malmquist index measures total factor productivity, efficiency change and technological change. Results show that productivity improves moderately and appears to be less volatile towards the end of the period. Furthermore, efficiency change tends to be the main source of productivity improvement rather than technological change.

KEYWORDS

Productivity; banking; data envelopment analysis; bootstrap; Malmquist indices

JEL CLASSIFICATION

G21; C14; C61

I. Introduction

As in many other countries, the Indonesian financial sector has experienced several major policy shifts in the last two decades. Starting from a closed or repression era and moving to the economic liberalization era, the banking sector of Indonesia has evolved following several changes in regulations. Radical reform in the late 1980s contributed to the massive increase in the number of banks until the 1997 Asian financial crisis struck the country severely and forced the regulator to close unsound banks. The initial sequence of the financial reform resulted in eliminating government intervention, increasing competition among banks by easing entry requirements in the industry and improving the intermediary role of the banking sector. Nonetheless, the lack of proper supervision systems, inadequate deposit guarantee schemes and poor economic fundamentals have contributed to the weakness of the banking sector during the reform process and thereafter. Recently, consistent policies towards a stronger banking structure have been supported by the establishment of mandatory regulatory institutions, such as the Indonesian Deposit Insurance Corporation (IDIC) and the Financial Service Authority (FSA). The latter institution serves as the integrated supervision agency, which supervises all financial institutions.

Given that the banking sector functions as the main engine in the Indonesian financial system, these changes should have affected the bank productivity. There are four major channels through which economic liberalization may affect productivity of banks. These are, competition, access to imported inputs (i.e. capital goods), technology transfer and managerial and technical knowledge spillovers (for details about these channels see Islam, Salim, and Bloch 2016). Berger and Humphrey (1997) note that deregulation is typically aimed to improve market competition by reducing barriers to competition, reducing subsidies to protected sectors and improving the regulatory and contracting environment. Therefore, deposits and credits should be intermediated more effectively, reducing inefficiency in the system, boosting productivity and enhancing economic growth.

Studies on the measurement of banks' efficiency and productivity growth are voluminous in the

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literature. However, studies on the sources of Indonesian bank's productivity growth are limited to Omar et al. (2007), Haddad et al. (2010, 2011) and the most recent study by Defung, Salim, and Bloch (2016). These studies bear significance as the pioneering studies in Indonesia, but they suffer from the following shortcomings. First, they are dated except Defung, Salim, and Bloch (2016). However, these authors conducted partial analysis as they investigated the impact of economic liberalization on technical efficiency, a component of productivity analysis. Second, they only investigate the performance of a particular group of banks (Omar, Majid and Rulindo Omar et al. 2007; Hadad et al. 2008, 2011; Afiatun and Wiryono 2010). Third, these studies apply data envelopment analysis (DEA)-based conventional Malmquist Indices, a non-parametric measure to estimate productivity growth, results from which are often contaminated with statistical noise and may not provide reliable sources of productivity growth estimates or lead to correct policy implications.

The objective of this article is to investigate the productivity growth and its sources for Indonesian banks by using the bootstrap Malmquist productivity index (MPI) approach and data for the period 1993–2015. The bootstrap procedures to measuring total factor productivity (TFP) Malmquist indices take into account the statistical noise from the efficiency measures and thus provide consistent estimates of productivity growth. Panel data models are constructed using both the intermediation (Model A) and revenue (Model B) approaches. With the longer period of data and provision of statistical tests on the result, this article presents an important extension to the literature using the example of Indonesian banks.

The remainder of this article is organized as follows: the next section briefing reviews the Indonesian banking sector followed by a discussion on related studies in Section 3. Section 4 presents data and variables employed in this study. The empirical analysis, which includes the empirical model and estimation results, is discussed in Section 5. Section 6 concludes the article.

II. The indonesian banking industry

The Indonesian banking system is made up of commercial banks and rural banks. Business line and operational coverage differentiate these two classes of banks. Based on the current Indonesian Banking Act, each of the classifications is further classified into the conventional bank and Islamic (sharia) banks. Table 1 shows the distribution of total assets, number of banks and number of branches for each classification. Despite the large and increasing number of rural and Islamic banks, the conventional commercial banks still dominate the industry by holding, on average, above 70% of the total assets.

After the 1997/1998 financial crisis, a series of policies and regulations were introduced to restructure and promote the banking sector towards a stronger and resilient industry. A number of bank closures, mergers and acquisitions occurred following the policy. The reforms resulted in a decreasing trend in the number commercial banks, while the assets and number of branches are moving in an upward direction (see Table 1).

Officially, the commercial banks are classified into six bank groups based on the ownership and or type of authorisation, namely, state owned banks, foreign exchange commercial banks, non-foreign exchange commercial banks, regional development banks, joint venture banks and foreign owned banks (see Figures 1 and 2). Figure 1 presents the total assets and Figure 2 the number of banks per bank group. The shift of leadership in assets from state owned banks to foreign exchange commercial banks, from 2005 onward, is noticeable. Prior to that period, the state-owned banks dominated the total assets of the industry, although the number of state-owned banks is the smallest among the groups. The decreasing number of banks is mainly contributed by non-foreign exchange commercial and joint venture banks.

The financial reforms and economic liberalization changed the structure of bank ownership in the industry. Before the crisis (1996), the share of domestic private banks to the banking industry was more than half, followed by the share of state owned at 39%, and with the foreign share less than 10%. Afterwards, foreign ownership increased steadily and reached almost half of the industry assets in 2008, before the increase slowed down in 2009. The foreign presence is not merely in the form of full ownership, but also in the form of various joint venture businesses. The share of domestic private banks has dropped gradually moving to less than 10% share in the industry. Government ownership enlarged its share sharply during the recovery period before declining from 2005 to 2008.

Table 1. Distribution of total assets, total banks and total bank branches.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total assets (Millions IDR):												
Conventional commercial banks	1,038,134	1,097,199	1,108,633	1,206,939	1,259,554	1,452,716	1,672,699	1,959,215	2,276,521	2,486,092	2,929,667	3,535,902
Sharia comercial banks	1721	2500	3571	6579	12,527	17,111	21,151	27,286	34,036	48,014	79,186	116,930
Rural banks	4731	6474	9080	12,635	16,707	20,393	23,045	27,741	32,533	37,554	45,742	55,799
Sharia rural banks	-	-	-	-	-	585	896	1215	1693	2123	2739	3520
Total	1,044,586	1,106,173	1,121,284	1,226,153	1,288,788	1,490,805	1,717,791	2,015,457	2,344,783	2,573,783	3,057,334	3,712,151
Total banks :												
Conventional commercial banks	149	143	139	136	130	128	127	127	119	115	111	109
Sharia comercial banks	2	2	2	2	3	3	3	3	5	6	11	11
Rural banks	4731	2355	2141	2141	2158	2009	1880	1817	1772	1733	1706	1669
Sharia rural banks	-	-	-	-	-	92	105	114	131	139	150	155
Total	4882	2500	2282	2279	2291	2232	2115	2061	2027	1993	1978	1944
Total banks offices :												
Conventional commercial banks	6492	6681	6888	7541	7676	7935	8764	9282	10,157	12,017	12,622	13,407
Sharia comercial banks	55	84	113	189	263	301	346	398	711	820	1215	1390
Rural banks	1482	2432	2747	3299	3472	3110	3173	3250	3367	3644	3910	4172
Sharia rural banks	-	-	-	-	-	92	105	185	202	225	286	364
Total	8029	9197	9748	11,029	11,411	11,438	12,388	13,115	14,437	16,706	18,033	19,333

Source: Indonesian Banking Statistics, Bank Indonesia, various editions.

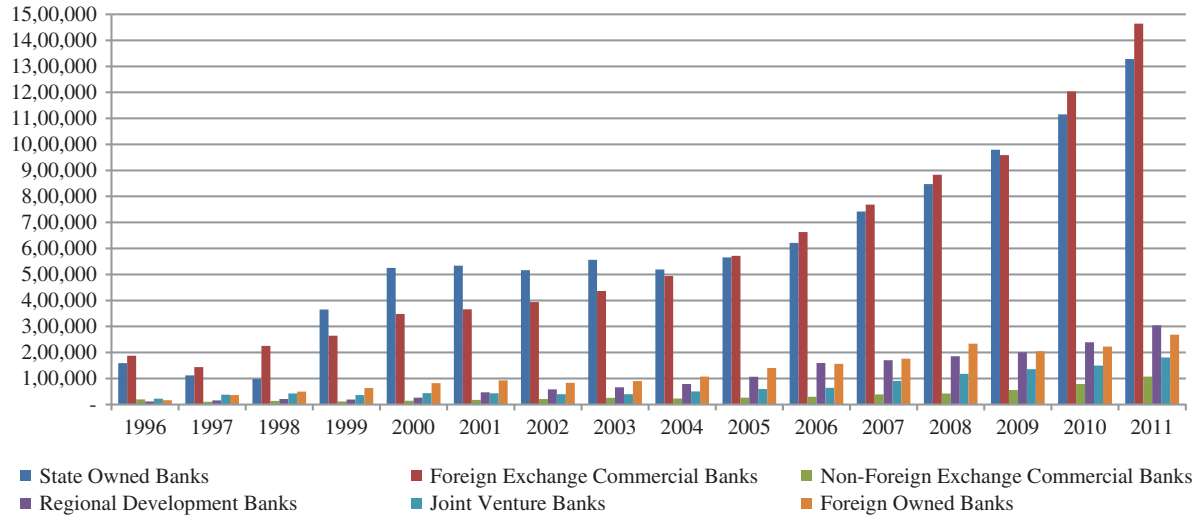

Figure 1. Total assets (Billion IDR).
Source: Indonesia Banking Statistics, Bank Indonesia, various editions.

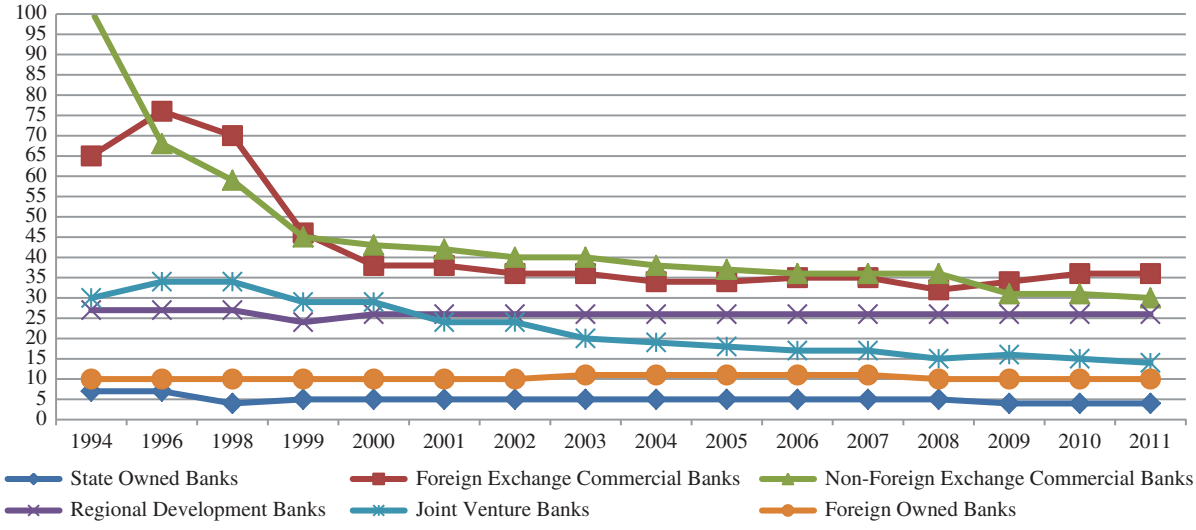

Figure 2. Number of Banks by Group.
Source: Indonesia Banking Statistics, Bank Indonesia, various editions.

III. A critical review of related studies

Over the last decade, research interest on bank efficiency and productivity has expanded from developed countries to developing and emerging economies, including Asian countries. Some cross-country studies concentrating on bank performance related to the 1997 Asian financial crisis, which include Indonesian banks in their analysis are Laeven (1999); Williams and Nguyen (2005); Ariff and Can (2009) Gardener, Molyneux, and Nguyen-Linh (2011) and Thoraneenitiyan and Avkiran (2009). Their results show the Indonesian banks tend to lag other countries in terms of efficiency or productivity.

The literature shows there are two basic approaches used to estimate productivity change: the parametric approach, which is the econometric estimation of a production function; and the non-parametric approach, which is done through the construction of index numbers. This study adopts the latter because it does not require specifying a functional form for the structure of the production technology.

We use the non-parametric MPI approach of Caves, Christensen, and Diewert (1982), which is

widely employed in measuring TFP growth in the banking industry. A survey by Fethi and Pasiouras (2010) shows that most bank performance measurement studies employ a DEA-like Malmquist index to estimate TFP growth in banking. Among others, studies that employ the MPI method in the banking industry are Berg, Førsund, and Jansen (1992) for Norwegian banks, R Alton and Wilson (1998) for Korean banks, Sathye (2002) and Salim, Hoque, and Suyanto (2010) for Australian banks, Isik and Kabir Hassan (2003) for Turkish and Matthews and Zhang (2010) for Chinese banks.

The scholarly studies focussing on Indonesian banks that use the MPI method are Omar et al. (2007), Hadad et al. (2010) and Hadad et al. (2011). Omar et al. (2007) assess private national banks and find that TFP improves during the period of 2002–2004, with the year 2003–2004 noted as having the highest growth. Technical change is found to be the main contributor to the TFP growth. Hadad et al. (2010) research Indonesian listed bank productivity using monthly data from 2003 to 2007 and report that their productivity fluctuates and that productivity mainly is driven by the shiftin production frontier. Using quarterly data of 2003 through 2007, Hadad et al. (2011) find that the main source of productivity change in the financial intermediary activities of Indonesian banks is improvement in their intermediation technology.

Despite their important findings, these studies investigate the industry partially with no further update for data beyond 2007. Also, a key criticism is that the standard Malmquist index does not provide statistical properties. However, there are now a small number of studies using bootstrap MPI. Research using this method includes Tortosa-Ausina et al. (2008), Arjomandi, Valadkhani, and Harvie (2011) and Wheelock and Wilson (1999). We add to the literature by extending that data sample to 2015 and by adopting the bootstrap MPI method.

IV. Data and variables

We obtain our data set from individual bank financial statements published by the Indonesian Central Bank (*Bank Indonesia*) over the period 1993–2015. The data set is comprised of annual observations of 98 commercial banks, which include state banks (4 banks), private banks (51 banks), regional development banks (25 banks), joint venture banks (10 banks) and foreign banks (8 banks). Retaining a balanced panel data for more than two decades' length is challenging, especially when the banking industry has gone through extensive restructuring. Therefore, some adjustment has to be made. The banks that are included in the data set are all those that existed continuously from 1993 until 2015. Excluded are banks that liquidated or closed during the period of study, have extensive missing data, or were just established within the covered period. Yet, the included banks represent 96% of total commercial banks' assets over the period of analysis.

The two main methods that appear frequently in the literature for modelling the bank production process are the intermediation and production approaches. The first approach, developed by Sealey and Lindley (1977), focuses on the function of banks in intermediating funds from depositors to borrowers, with deposits used to produce loans and other assets. The second approach views banks as production centres, where banks utilize physical inputs (labour and capital) to produce deposits and other outputs (Denizer 2000). Berger and Humphrey (1997) emphasize that the intermediation approach is suited to measuring efficiency for the whole financial institution, while the production approach is properly used for the bank branch level.

We utilize both approaches and specify inputs and outputs under two models, Model A and Model B. Under Model A, total deposits and fixed assets are set as inputs, while total loans and other earning assets are set as outputs. In Model B, the inputs include interest expenses and non-interest expenses, whereas the outputs comprise of interest income and non-interest income. Details of the inputs and outputs are presented in Table 2.

V. Empirical results

Methodology

Following Färe et al. (1994) the output-orientated Malmquist TFP index is expressed using the distance

Table 2. Input and output variables.

Model	Outputs	Inputs
Model A	Total loans (y_1)	Total deposits (x_1)
	Other earning assets (y_2)	Fixed assets (x_2)
Model B	Interest income (y_1)	Interest expenses (x_1)
	Non-interest income (y_2)	Non-interest expenses (x_2)

function with respect to two periods, period s (the base period) and period t as follows:

$$m_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(x_t, y_t)}{d_0^s(x_s, y_s)} \times \frac{d_0^t(x_t, y_t)}{d_0^t(x_s, y_s)}\right]^{1/2}, \tag{1}$$

where $d_0^s(x_s, y_s)$ and $d_0^t(x_s, y_s)$ are measures of technical efficiency in period s and period t respectively. $d_0^s(x_t, y_t)$ is the distance function from the period t observation to the period s technology. $d_0^t(x_s, y_s)$ is the distance function from the period s observation to the period t technology and $m_0(y_s, x_s, y_t, x_t)$ is the MPI. If the value of m_0 is greater than one then there is positive growth of TFP from period s to period t, whereas a value less than one implies a declining TFP between the two periods.

Färe and Lovell (1978) show that the MPI can be decomposed into two elements to find the catching-up effect and frontier-shift effect by rewriting the productivity index as follows:

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(x_t, y_t)}{d_0^s(x_s, y_s)} \left[\frac{d_0^s(x_t, y_t)}{d_0^t(x_t, y_t)} \times \frac{d_0^s(x_s, y_s)}{d_0^t(x_s, y_s)}\right]^{1/2}. \tag{2}$$

The term outside the square brackets in Equation (2) represents the change in the output-oriented measure of Farrell technical efficiency between periods s and t. The term in the square brackets stands for the technical change between period s and t.

Equation (2) does not inform about the statistical reliability of the change in productivity, efficiency or technology. Thus, a consistent bootstrapping procedure is employed in obtaining confidence intervals for the Malmquist index and its components, efficiency change and technological change. In adapting the bootstrapping procedure for Malmquist indices Simar and Wilson (1999) use a bootstrap algorithm for efficiency scores with bivariate smoothing procedures to avoid any temporal correlation.

This process can be summarized as follows:

(1) Calculate the MPI $\hat{M}_i(t_1, t_2)$ for each bank $(i = 1, \ldots, N)$ at time(t_1 and t_2) by solving the linear programming model (see e.g. Coelli et al. (2005, 297)).
(2) Construct a pseudo-data set $\{(x_{it}^*, y_{it}^*);\ i = 1, \ldots, N; t = 1, 2\}$ to form the reference bootstrap technology using the bivariate kernel density estimation and the reflection method proposed by Simar and Wilson (1999).
(3) Calculate the bootstrap estimate of the Malmquist index $\hat{M}_i(t_1, t_2)$ for each bank using the original estimators for the pseudo-sample obtained in step 2.
(4) Repeat steps 2 and 3 B times (in this study, B = 2000 times), to facilitate a set of estimates for each bank.
(5) Construct the confidence intervals for the Malmquist indices accordingly.

Once the bootstrap estimates of the MPI are obtained, a multivariate regression model is employed to estimate the determinants of productivity using a regression equation of the form:

$$Y_{it} = z_i\beta_i + \varepsilon_i, \tag{3}$$

where Y is a measure of the productivity index of bank i in period t. z_i is the vector of observed variables explaining bank productivity, which includes macroeconomic conditions, market concentration, bank-specific factors, bank restructuring, regulatory change, bank status and ownership structure. β is the vector of parameters to be estimated and ε denotes an error term.

Productivity of the indonesian banking sector

Table 3 reports the annual average change in productivity, efficiency and technology for each year from 1993 to 2015. The results of each model show that the industry has exhibited progress in TFP based on the movement of the mean value over the considered period. Model B appears to have higher mean TFP growth (7.48%) than Model A (3.85%). On average, both efficiency change and technical change (progress) are positive and contribute to productivity growth in both models, but efficiency change has a faster rate of imrpovement. In Model A, gains in efficiency have an annual average change of 11.9%, whereas technological change grows at 3.9%. Similar result is obtained in Model B in that the efficiency change and technological change turn out to be 16% and 11%, respectively.

Table 3. Annual mean of TFP, efficiency and technological change.

	TFP		Efficiency change (EC)		Technological change (TC)		Pure efficiency (PE)		Scale efficiency (SE)		Pure technology(PT)		Scale of technology (ST)	
Year	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1993–94	1.035	1.009	1.279	1.008	0.849	1.002	1.053	1.015	1.233	0.999	1.020	1.006	0.852	1.005
	(0.026)	(0.014)	(0.043)	(0.014)	(0.020)	(0.004)	(0.032)	(0.013)	(0.029)	(0.012)	(0.017)	(0.008)	(0.025)	(0.013)
1994–95	0.924	1.083	1.659	1.065	0.597	1.024	1.419	1.012	1.286	1.057	0.758	1.074	0.885	0.959
	(0.027)	(0.030)	(0.069)	(0.029)	(0.013)	(0.011)	(0.076)	(0.029)	(0.057)	(0.014)	(0.024)	(0.012)	(0.027)	(0.008)
1995–96	1.027	1.099	0.697	1.103	1.675	0.998	0.953	1.077	0.798	1.018	1.214	1.012	1.470	0.988
	(0.038)	(0.049)	(0.032)	(0.050)	(0.067)	(0.004)	(0.039)	(0.041)	(0.034)	(0.007)	(0.050)	(0.005)	(0.068)	(0.005)
1996–97	1.310	1.003	1.313	0.948	1.046	1.071	0.981	0.955	1.487	0.990	1.331	1.078	0.801	0.990
	(0.161)	(0.040)	(0.079)	(0.019)	(0.085)	(0.038)	(0.047)	(0.014)	(0.090)	(0.011)	(0.055)	(0.032)	(0.029)	(0.009)
1997–98	1.289	0.926	2.090	0.770	0.669	1.210	1.888	0.852	1.124	0.890	0.758	1.142	0.911	1.066
	(0.047)	(0.065)	(0.096)	(0.044)	(0.018)	(0.029)	(0.089)	(0.036)	(0.027)	(0.024)	(0.020)	(0.026)	(0.018)	(0.021)
1998–99	1.157	1.408	0.714	1.103	1.759	1.242	1.012	0.955	0.746	1.151	1.154	1.287	1.712	1.002
	(0.054)	(0.139)	(0.037)	(0.076)	(0.059)	(0.049)	(0.048)	(0.049)	(0.031)	(0.048)	(0.044)	(0.055)	(0.110)	(0.021)
1999–00	0.964	1.452	0.977	1.674	1.008	0.879	1.196	1.545	0.874	1.102	0.903	0.827	1.264	1.082
	(0.049)	(0.134)	(0.050)	(0.165)	(0.017)	(0.012)	(0.053)	(0.117)	(0.048)	(0.069)	(0.044)	(0.018)	(0.050)	(0.017)
2000–01	1.002	1.118	1.020	1.099	1.013	1.028	0.968	1.003	1.064	1.098	1.063	1.111	0.974	0.934
	(0.031)	(0.026)	(0.036)	(0.026)	(0.020)	(0.014)	(0.026)	(0.020)	(0.029)	(0.017)	(0.019)	(0.016)	(0.023)	(0.014)
2001–02	0.984	1.481	1.131	1.029	0.872	1.377	1.151	0.976	0.993	1.058	0.875	1.112	1.008	0.952
	(0.026)	(0.458)	(0.031)	(0.023)	(0.005)	(0.335)	(0.021)	(0.021)	(0.025)	(0.012)	(0.011)	(0.067)	(0.011)	(0.010)
2002–03	0.933	1.070	0.905	0.534	1.033	2.500	1.077	0.644	0.853	0.840	0.921	2.126	1.140	1.242
	(0.019)	(0.122)	(0.018)	(0.046)	(0.007)	(0.103)	(0.020)	(0.046)	(0.016)	(0.021)	(0.012)	(0.099)	(0.017)	(0.039)
2003–04	0.999	0.951	1.518	0.590	0.783	1.627	1.249	0.839	1.259	0.763	0.876	1.266	0.910	1.392
	(0.024)	(0.027)	(0.076)	(0.019)	(0.036)	(0.011)	(0.050)	(0.028)	(0.061)	(0.027)	(0.022)	(0.036)	(0.040)	(0.041)
2004–05	1..006	0.937	1.590	4.333	0.694	0.248	1.060	2.852	1.499	1.842	0.962	0.444	0.727	0.672
	(0.015)	(0.030)	(0.062)	(0.203)	(0.021)	(0.010)	(0.019)	(0.174)	(0.049)	(0.109)	(0.016)	(0.024)	(0.018)	(0.029)
2005–06	1.059	1.059	0.825	0.825	1.292	1.292	0.929	0.929	0.897	0.897	1.163	1.163	1.125	1.125
	(0.014)	(0.014)	(0.012)	(0.012)	(0.011)	(0.011)	(0.015)	(0.015)	(0.011)	(0.011)	(0.014)	(0.014)	(0.014)	(0.014)
2006–07	1.039	0.988	0.957	0.980	1.101	1.007	1.028	0.986	0.934	0.995	0.987	0.992	1.091	1.019
	(0.033)	(0.009)	(0.017)	(0.008)	(0.034)	(0.004)	(0.015)	(0.008)	(0.014)	(0.005)	(0.008)	(0.007)	(0.020)	(0.008)
2007–08	0.988	1.014	0.712	1.097	1.397	0.930	0.836	1.045	0.873	1.056	1.183	0.952	1.204	0.979
	(0.018)	(0.029)	(0..014)	(0.029)	(0.014)	(0.015)	(0.018)	(0.015)	(0.017)	(0.026)	(0.020)	(0.014)	(0.017)	(0.007)
2008–09	1.005	1.036	0.922	0.783	1.099	1.338	0.935	0.965	1.003	0.823	1.144	1.101	0.978	1.245
	(0.023)	(0.015)	(0.020)	(0.012)	(0.013)	(0.019)	(0.020)	(0.016)	(0.019)	(0.013)	(0.022)	(0.021)	(0.013)	(0.020)
2009–10	1.075	0.968	1.118	1.014	0.962	0.973	1.159	1.021	0.982	0.991	0.943	0.954	1.045	1.032
	(0.019)	(0.017)	(0.019)	(0.027)	(0.006)	(0.015)	(0.020)	(0.017)	(0.019)	(0.013)	(0.016)	(0.017)	(0.014)	(0.011)
2010–11	1.040	0.986	1.170	1.349	0.924	0.747	1.018	1.161	1.149	1.177	1.056	0.882	0.878	0.859
	(0.020)	(0.016)	(0.035)	(0.031)	(0.020)	(0.010)	(0.025)	(0.028)	(0.018)	(0.021)	(0.015)	(0.012)	(0.011)	(0.015)
2011–12	0.952	1.036	1.193	1.168	0.807	0.902	1.036	1.065	1.165	1.101	0.942	0.979	0.869	0.928
	(0.020)	(0.016)	(0.022)	(0.022)	(0.014)	(0.014)	(0.022)	(0.017)	(0.018)	(0.016)	(0.013)	(0.012)	(0.025)	(0.012)
2012–13	1.033	1.020	0.823	1.005	1.263	1.022	0.829	0.983	1.013	1.026	1.293	1.035	0.997	0.984
	(0.032)	(0.012)	(0.023)	(0.013)	(0.013)	(0.012)	(0.025)	(0.012)	(0.016)	(0.011)	(0.017)	(0.008)	(0.017)	(0.008)
2013–14	1.016	1.041	1.011	0.925	1.006	1.128	1.055	0.963	0.974	0.959	0.977	1.083	1.034	1.041
	(0.016)	(0.015)	(0.016)	(0.013)	(0.005)	(0.007)	(0.020)	(0.010)	(0.019)	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)
2014–15	1.009	0.961	1.003	1.116	1.009	0.868	0.947	1.058	1.088	1.057	1.088	0.934	0.931	0.940
	(0.024)	(0.015)	(0.017)	(0.016)	(0.013)	(0.013)	(0.020)	(0.014)	(0.025)	(0.010)	(0.015)	(0.015)	(0.009)	(0.010)
Mean	**1.038**	**1.075**	**1.119**	**1.160**	**1.039**	**1.110**	**1.081**	**1.086**	**1.059**	**1.040**	**1.028**	**1.071**	**1.037**	**1.020**

Sources: Results based on MPI calculation. Note: TFP denotes total factor productivity. The standard errors are in the parentheses.

These results suggest that productivity growth largely results from the improvement of best practice in management (or so-called catching-up effect) rather than frontier shift. This outcome is even more evident in the intermediation function (Model A) of the banking industry. These results contradict to the findings of Omar et al. (2007) of a larger positive contribution of technological change to TFP growth in the Indonesian banking industry. By contrast, Hadad et al. (2008), employing the DEA based conventional Malmquist index, discover that technological change drives TFP downward.

Improvement in efficiency is particularly important during the recent period (2009/10–2014/15). Prior to this period, technological change is the main source productivity growth. This is probably because during the 1990s and the early 2000s, the use of technology was reasonably dominant in banking operation. Subsequently, continuous efforts to improve banking practices and management through the implementation of a series of regulations have contributed to the efficiency improvement in the industry.

A further decomposition of efficiency change and technological change reveals that in Model A, pure efficiency and scale efficiency improve by an average of 8.09% and 5.88%, respectively, which fully boosts the growth in efficiency change. For technological change in Model A, pure technology and the scale of technology improve by 2.77% and 3.66%, respectively. In Model B, all subcomponents contribute positively to the improvement of efficiency, particularly, scale efficiency and pure technology are major drivers.

In Table 4, we present the bootstrap results by number of banks that have productivity growth (above unity), no change or stagnation (unity) and decline (below unity) in each year at 95% and 99% confidence intervals.[1] The table shows most of the results are significant at 5%, which suggests that the changes in each component are relatively statistically reliable. As emphasized by Wheelock and Wilson (1999, 471) 'as with any estimator, it is not enough to know whether the Malmquist index estimator indicates increases or decreases in productivity, but whether the indicated changes are significant in a statistical sense'. On average, 94% (Model A) and 96% (Model B) of the individual bank results for TFP change are statistically significant, ranging from 82.2% to 100% and from 91% to 99%, for Model A and Model B, respectively.

Next, we analyse productivity growth for Indonesian bank by group and size category as presented in Tables 5 and 6, respectively. The investigation by bank group is done by averaging the TFP score within each of the five bank groups mentioned earlier. Likewise, for each of the three size categories. Also for simplicity, the annual results are averaged into five main periods; the period before the crisis (1993/94–1995/96), the crisis period (1996/97–1999/00), the recovery period (2000/01–2004/05), the consolidation period (2005/06–2010/11), and the recent or development period (2010/11–2014–15).

All groups of banks are shown to have a positive productivity change over the period of study, except state banks (−1.96%) in Model A, whereas under Model B a positive improvement is shown for all groups. The decline in state banks derives mainly from the lower of efficiency change, which seems to be dissimilar to the rest of the groups where efficiency change is the major source of the TFP growth. Comparison of the overall means in Model A indicates that the foreign banks show the highest growth of TFP growth under both models, 15.95% and 32.55% for Model A and Model B, respectively.

Efficiency change contributes most to the growth in the overall mean TFP index across the groups in both models. In Model B, remarkable technology improvement is recorded for foreign banks (23.43%). These results may be observed because most of the banks in this groups commonly utilize the advanced technology from their parent banks in developed countries.

The results, based on bank size (Table 6), reveal that all size categories have positive productivity growth. However, unlike Rebelo and Mendes (2000), who find small banks have higher productivity growth, this study, under both models, finds large banks on average have achieved higher productivity growth than the two other categories (medium and small).

We observe that for all sizes the growth in TFP index is slightly higher under Model B than Model A during the study period, which indicates that banks are more productive in terms of generating revenue than intermediating funds. Particularly, if the analysis is directed to sub-periods, for instance, in the

[1]The individual bank result of TFP and its components cannot be presented due to limited space.

Table 4. Summary of bootstrap results for TFP, efficiency and technological change.

		TFP change						Efficiency change (EC)						Technological hange (TC)					
		Modal A			Modal B			Modal A			Modal B			Modal A			Modal B		
Year		#	5%	1%	#	5%	1%	#	5%	1%	#	5%	1%	#	5%	1%	#	5%	1%
1993–94	Growth	57	51	4	47	46	-	75	75	-	48	48	-	20	20	-	62	62	-
	Stagnation	-	-	-	-	-	-	1	-	-	5	-	-	-	-	-	-	-	-
	Decline	41	36	5	51	50	1	22	22	-	45	45	-	78	78	-	36	36	-
1994–95	Growth	33	31	-	68	66	1	91	91	-	68	68	-	0	0	-	52	52	-
	Stagnation	-	-	-	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-
	Decline	65	50	4	30	29	-	6	6	-	26	26	-	98	98	-	46	46	-
1995–96	Growth	46	44	1	57	54	-	15	15	-	53	53	-	83	83	-	47	47	-
	Stagnation	-	-	-	-	-	-	1	-	-	6	-	-	-	-	-	-	-	-
	Decline	52	51	-	41	39	-	82	76	-	39	39	-	15	15	-	51	51	-
1996–97	Growth	50	49	-	31	25	3	59	58	-	38	38	-	44	44	-	37	37	-
	Stagnation	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-
	Decline	48	48	-	67	60	3	38	38	-	58	57	-	54	54	-	61	61	-
1997–98	Growth	71	69	-	41	30	7	82	80	-	18	14	1	6	6	-	75	75	-
	Stagnation	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-
	Decline	27	27	-	57	47	5	14	14	-	79	39	21	92	52	23	23	23	-
1998–99	Growth	63	60	1	55	51	1	15	15	-	47	46	1	90	90	-	75	75	-
	Stagnation	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-
	Decline	35	31	1	43	43	-	81	72	-	49	49	-	8	8	-	23	23	-
1999–00	Growth	33	28	2	55	52	-	35	35	-	64	64	-	48	48	-	10	10	-
	Stagnation	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-
	Decline	65	48	14	43	42	-	62	62	-	33	33	-	50	50	-	88	88	-
2000–01	Growth	43	39	2	68	68	-	55	55	-	62	62	-	29	29	-	48	48	-
	Stagnation	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-
	Decline	55	25	28	30	30	-	41	41	-	34	34	-	69	69	-	50	50	-
2001–02	Growth	35	27	2	47	41	1	66	66	-	66	66	-	0	0	-	15	15	-
	Stagnation	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-
	Decline	63	39	18	51	50	1	30	30	-	30	30	-	98	98	-	83	83	-
2002–03	Growth	33	29	4	25	24	1	22	22	-	11	9	1	78	78	-	88	88	-
	Stagnation	-	-	-	-	-	-	3	-	-	1	-	-	-	-	-	-	-	-
	Decline	65	47	17	73	66	3	73	73	-	86	61	10	20	20	-	10	10	-
2003–04	Growth	34	34	-	26	23	2	73	73	-	3	3	-	20	20	-	98	98	-
	Stagnation	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-
	Decline	64	62	2	72	53	10	23	23	-	93	92	1	78	78	-	-	-	-
2004–05	Growth	47	47	-	34	30	1	87	87	-	95	84	-	8	8	-	-	-	-
	Stagnation	-	-	-	-	-	-	4	-	-	0	-	-	-	-	-	-	-	-
	Decline	51	51	-	64	60	1	7	7	-	3	3	-	90	42	14	98	45	39
2005–06	Growth	71	66	-	71	66	-	9	9	-	9	9	-	97	97	-	97	97	-
	Stagnation	-	-	-	-	-	-	5	-	-	5	-	-	-	-	-	-	-	-
	Decline	27	25	1	27	25	1	84	82	-	84	82	-	1	1	-	1	1	-
2006–07	Growth	51	51	-	37	31	2	34	33	-	27	25	-	63	63	-	74	74	-
	Stagnation	-	-	-	-	-	-	5	-	-	5	-	-	-	-	-	-	-	-
	Decline	47	47	-	61	56	2	59	59	-	66	66	-	35	35	-	24	24	-
2007–08	Growth	41	41	-	43	36	4	5	5	-	74	74	-	97	97	-	8	8	-
	Stagnation	-	-	-	-	-	-	2	-	-	3	-	-	-	-	-	-	-	-
	Decline	57	56	-	55	48	1	91	91	-	21	21	-	1	1	-	90	90	-
2008–09	Growth	50	50	-	62	59	1	26	26	-	5	5	-	76	76	-	93	93	-
	Stagnation	-	-	-	-	-	-	4	-	-	4	-	-	-	-	-	-	-	-
	Decline	48	40	5	36	33	1	68	68	-	89	89	-	22	22	-	5	5	-
2009–10	Growth	63	59	4	33	33	-	73	73	-	43	43	-	19	19	-	53	53	-
	Stagnation	-	-	-	-	-	-	5	-	-	4	-	-	-	-	-	-	-	-
	Decline	35	28	4	65	64	1	20	20	-	51	51	-	79	79	-	45	45	-
2010–11	Growth	61	61	-	45	45	-	68	68	-	87	87	-	30	30	-	-	-	-
	Stagnation	-	-	-	-	-	-	4	-	-	4	-	-	-	-	-	-	-	-
	Decline	37	33	-	53	53	-	26	26	-	7	7	-	68	68	-	98	98	-
2011–12	Growth	34	34	-	57	57	-	79	79	-	76	76	-	10	10	-	28	28	-
	Stagnation	-	-	-	-	-	-	2	-	-	3	-	-	-	-	-	-	-	-
	Decline	64	63	-	41	41	-	17	17	-	19	19	-	88	81	-	70	63	1
2012–13	Growth	43	41	1	58	57	-	9	9	-	48	48	-	94	94	-	52	52	-
	Stagnation	-	-	-	-	-	-	4	-	-	8	-	-	-	-	-	-	-	-
	Decline	55	53	1	40	40	-	85	85	-	42	41	-	4	4	-	46	46	-
2013–14	Growth	45	44	-	59	54	1	44	44	-	17	17	-	59	59	-	94	94	-
	Stagnation	-	-	-	-	-	-	5	-	-	5	-	-	-	-	-	-	-	-
	Decline	53	53	-	39	38	-	49	49	-	76	76	-	39	39	-	4	4	-
2014–15	Growth	46	43	1	32	32	-	54	54	-	72	72	-	39	39	-	10	10	-
	Stagnation	-	-	-	-	-	-	4	-	-	5	-	-	-	-	-	-	-	-
	Decline	52	51	-	66	59	4	40	40	-	21	21	-	59	59	-	88	88	-

#, 5%, and 1% denote number of estimates, number significant at 5% and at 1 %, respectively.

Table 5. TFP, efficiency and technological change by bank group.

	Model A					Model B				
Year	SOB	PNB	RDB	JVB	FB	SOB	PNB	RDB	JVB	FB
TFP change										
1993/94–1995/96	0.9478	1.0063	0.9966	1.0032	0.9351	1.0289	1.0754	1.0581	1.0440	1.0492
1996/97–1999/00	0.8028	1.1611	1.1310	1.1637	1.6668	1.9026	1.1331	1.0762	1.3474	1.4204
2000/01–2004/05	1.0923	0.9632	1.0124	0.9577	1.0144	0.9962	0.9856	1.0280	1.2510	2,0842
2005/06–2010/11	1.0909	1.0428	0.9809	1.0453	1.0882	1.0096	1.0024	1.0192	1.0164	1.0532
2010/11–2014/15	0.9681	1.0085	0.9782	1.0549	1.0929	1.0086	1.0191	0.9874	1.0014	1.0205
Overall mean	**0.9804**	**1.0364**	**1.0198**	**1.0449**	**1.1595**	**1.1892**	**1.0431**	**1.0338**	**1.1320**	**1.3255**
Efficiency Change (EC)										
1993/94–1995/96	1.0804	1.1671	1.3372	1.1912	1.1921	1.0193	1.0721	1.0696	1.0059	1.0200
1996/97–1999/00	0.7312	1.3368	1.3222	1.0790	1.2380	1.9644	1.0514	1.0360	1.2722	1.2210
2000/01–2004/05	1.4096	1.2428	1.2303	1.1961	1.1138	1.3044	1.4780	1.7946	1.3467	1.1950
2005/06–2010/11	0.9514	0.8999	0.8711	0.9526	0.9885	0.9331	0.9319	0.9483	0.9488	0.9841
2010/11–2014/15	1.0158	1.0447	1.0346	1.0340	1.0522	1.1149	1.1362	1.0956	1.0585	1.0624
Overall mean	**1.0377**	**1.1383**	**1.1591**	**1.0906**	**1.1169**	**1.2672**	**1.1339**	**1.1888**	**1.1264**	**1.0965**
Technological change (TC)										
1993/94–1995/96	1.0235	1.0795	1.0411	0.9521	0.9091	1.0132	1.0076	0.9887	1.0409	1.0274
1996/97–1999/00	1.1893	1.1067	1.0940	1.1076	1.2694	1.0986	1.0870	1.0959	1.0675	1.2473
2000/01–2004/05	0.8499	0.8733	0.8710	0.9010	0.9410	1.1050	1.2772	1.4475	1.2674	1.8233
2005/06–2010/11	1.1891	1.1943	1.1564	1.1164	1.1090	1.1184	1.1122	1.0968	1.0995	1.1072
2010/11–2014/15	0.9954	0.9945	0.9871	1.0441	1.0490	0.9365	0.9258	0.9307	0.9618	0.9661
Overall mean	**1.0494**	**1.0497**	**1.0299**	**1.0243**	**1.0555**	**1.0543**	**1.0820**	**1.1119**	**1.0874**	**1.2343**

Sources: Author's calculations. Note: SOB refers to a state-owned bank, PNB refers to a private national bank, RDB refers to a regional development bank, JVB refers to a joint venture bank and FB refers to a foreign bank.

Table 6. TFP index and its decomposition by bank size category.

	Model A			Model B		
Year	Large	Medium	Small	Large	Medium	Small
TFP change						
1993/94–1995/96	0.9740	0.9794	1.0050	1.0479	1.0475	1.0751
1996/97–1999/00	1.1197	1.1970	1.1720	1.4983	1.2761	1.0845
2000/01–2004/05	1.0506	0.9836	0.9624	1.4719	1.0367	1.0326
2005/06–2010/11	1.0570	1.0118	1.0382	1.0106	1.0069	1.0182
2010/11–2014/15	1.0158	0.9940	1.0285	1.0069	1.0111	1.0128
Overall mean	**1.0434**	**1.0332**	**1.0412**	**1.2071**	**1.0757**	**1.0446**
Efficiency Change (EC)						
1993/94–1995/96	1.1984	1.2222	1.2022	1.0380	1.0256	1.0775
1996/97–1999/00	1.1311	1.1395	1.3635	1.3583	1.1993	1.0344
2000/01–2004/05	1.2899	1.2188	1.2230	1.2836	1.4971	1.6375
2005/06–2010/11	0.9338	0.9103	0.8909	0.9332	0.9386	0.9431
2010/11–2014/15	1.0316	1.0229	1.0602	1.1019	1.1156	1.1211
Overall mean	**1.1170**	**1.1027**	**1.1479**	**1.1430**	**1.1552**	**1.1627**
Technological change (TC)						
1993/94–1995/96	0.9448	0.9760	1.0968	1.0116	1.0231	1.0010
1996/97–1999/00	1.1124	1.1562	1.0940	1.1385	1.1033	1.0815
2000/01–2004/05	0.8783	0.8774	0.8808	1.4387	1.2666	1.3883
2005/06–2010/11	1.1653	1.1392	1.1968	1.1111	1.1031	1.1106
2010/11–2014/15	1.0136	0.9997	1.0020	0.9389	0.9338	0.9289
Overall mean	**1.0229**	**1.0297**	**1.0541**	**1.1278**	**1.0860**	**1.1021**

Sources: Author's calculations. Note: TFP denotes total factor productivity.

pre-crisis and crisis period most categories have more productivity growth in a Model B than Model A. Presumably, the industry was in its rapid expansion period, where banks were aggressively performed their lending activities and collecting deposits. For Model A, the productivity of medium banks is shown to have deteriorated in the pre-crisis period, after the crisis and in the last period, which decreases the average productivity growth for medium banks below that of large and small banks.

In terms of the decomposition, efficiency change contributes to TFP growth throughout the entire study period in all bank size categories. Similar to the result for the industry overall, technological change also contributes positively in all size categories although the magnitude is relatively small, which suggests that adopting technology, such as ATMs, mobile banking and internet banking, has a continuing positive impact on the productivity growth. A comprehensive explanation as to why some banks or a group of

Table 7. Second stage variables, hypothesis and definitions.

Variable		Symbol	Expected sign	Description
Dependent variable				
Bank productivity		TFP (A) TFP (B)		Total factor productivity index of the bank for Model A or Model B
Independent variable				
Macroeconomic condition	Economic growth	GDP	+	Annual GDP growth
	Inflation	Infl	–	Inflation, consumer price (annual %)
	Broad money	Bmoney	±	Broad money is the sum of the currency outside the bank measured as a percentage of GDP
Market concentration	Concentration ratio	HHI	–	Herfindahl index (HHI) measured by sum of squared share of individual bank loans to total bank loans.
Bank characteristic factor	Size	Size	+	Bank size measured by the natural log of total assets
Restructuring	Bank restructuring	Dmerger	+	Represented by a dummy variable that takes a value of 1 for a merged bank and 0 for a bank that did not merge
Bank status	Listing bank	dlisting	+	Dummy variable that takes a value of 1 for a listing bank and 0 for non-listing
	Foreign exchange operation	dforex	+	Dummy variable that takes a value of 1 for a foreign exchange bank and 0 otherwise
Regulatory change	Year 2004	DregCh	+/–	Dummy variable that takes a value of 1 for all observations during the period from 2005–2011 and 0 for the prior period
Ownership structure/ group	State bank	d_state	+/–	Dummy variable equal to 1 for state bank and 0 otherwise
	Private bank	d_private	+/–	Dummy variable equal to 1 for domestic private bank and 0 otherwise
	Joint venture bank	d_jvb	+/–	Dummy variable equal to 1 for foreign joint venture bank and 0 otherwise
	Foreign bank	d_purefb	+/–	Dummy variable equal to 1 for foreign bank and 0 otherwise

bank have more productivity growth than others require further in-depth investigation, so we turn to regression analysis for estimating the impact of various factors on productivity growth.

The determinants of Indonesian banks' productivity growth

Variation in the TFP scores among banks suggests that banks show varying responses to changes in regulations, policies and other external factors. This section examines potential drivers of bank productivity growth, including bank characteristics, macroeconomic conditions, mergers, regulatory changes, ownership structures and market concentration. The ability of banks to cope with these factors determines their relative performance and the performance of the industry as a whole.

To estimate the effect of the explanatory variables on bank productivity, Equation (3) is specified as a linear function of explanatory variables as follows:

$$\begin{aligned} TFP_{it} = {} & \alpha + \beta_1 size_{it} + \beta_2 HHI_t + \beta_3 GDP_t + \beta_4 \inf l_t \\ & + \beta_5 BMoney_t + \beta_6 Dforex_{it} + \beta_7 Dlisting_{it} \\ & + \beta_8 Dmerger_{it} + \beta_9 DregCh_t + \beta_{10} D\_state_i \\ & + \beta_{11} D\_PureFB_i + \beta_{12} D - \Pr ivate_i \\ & + \beta_{13} JVB_i + \varepsilon_{it}, \end{aligned} \tag{4}$$

where TFP_{it} is the TFP index of bank i in year t as calculated using the bootstrapping MPI estimation. $size_{it}$ is the size of bank measured by the natural log of total assets bank i in year t. HHI_t is the Herfindahl index of market concentration in year t, measured as the sum of squared share for each bank of its loans to total loans. GDP_t, $infl_t$ and $BMoney_t$ capture the macroeconomics conditions, which are annual gross national product growth, inflation measured by the annual percentage of consumer price and broad money measured by the sum of the currency outside the bank as a percentage of gross domestic product (GDP), respectively. Bank status is represented by $Dforex_{it}$ = 1 if bank i in year t is a foreign exchange bank, otherwise zero, and $Dlisting_{it}$ = 1 if bank i in year t is listed in Indonesian stock exchange, otherwise zero. To capture restructuring $Dmerger_{it}$ = 1 if bank i in year t *is* a merged bank, otherwise zero. Change in regulation is captured by $DregCh_t$ = 1 for all observations after 2004, otherwise zero. The 2004 is chosen as the dividing year because of important changes in that year, such as the end of the role of the Indonesian Bank Restructuring Agency (IBRA) and the Blanket guarantee (BG) system, and the establishment of the deposit insurance agency, the IDIC. Ownership structure variables are D_state_i, D_PureFB_i, $D\_private_i$ and D_JVB_i, with each, respectively, represented by a dummy = 1 if the bank i is a state bank, pure foreign bank, private

national bank, joint venture bank or regional development bank, otherwise zero. The expected signs of these variables are given in Table 7. ε_{it} is a random error term, i = 1,. . ., 98, and t = 1,. . ., 23.

We conduct the Wald chi^2 tests in order to check the specifications of our empirical models. All chi^2 tests results are statistically significant at conventional 1% level of significance implying that all models are correctly specified and have good explanatory power. Confirming correct specification of these models we then estimate these models and the results are presented in Table 8 for Model A and B. Results in Table 8 show the estimated impact of the variables on TFP. The variable, size does not seem to support the argument that the larger banks are often more productive than smaller ones. Size has a positive impact on productivity when there are scale economies, but this may not be realized due to complexity of business, bureaucratic procedure and others (Ataullah and Hang 2006; Delis, Molyneux, and Pasiouras 2011). The weak impact and statistically insignificant of the size variable is consistent with the results in Table 6, where bank productivity is not linearly related to bank size.

The coefficient of market concentration variable, HHI is positive and strongly statistically significant under Model A. This positive coefficient suggests that banks tend to experience higher productivity growth in less competitive market condition. However, the sign is reversed in Model B, although the coefficient is not statistically significant.

Table 8. Determinants of TFP growth – tobit regression model.

	Model A		Model B	
Variable	Coefficient	SE	Coefficient	SE
Size	−0.0063	0.0061	−0.0041	0.0062
HHI	0.3087***	0.0951	−0.0714	0.0958
GDP	−0.0103**	0.0049	0.0049	0.0049
Infl	−0.0005	0.0019	−0.0033*	0.0019
BMoney	0.0045**	0.0023	0.0127***	0.0023
Dforex	−0.0015	0.0189	−0.003	0.0190
Dlisting	0.0031	0.0216	0.0302	0.0217
Dmerger	0.0389	0.0286	0.0417	0.0288
DRegCh	0.1175***	0.0287	0.0559*	0.0289
D_state	−0.0117	0.0385	0.0392	0.0388
D_PureFB	0.0806***	0.0277	0.0218	0.0278
D_Private	0.0042	0.0181	−0.0171	0.0182
D_JVB	−0.0082	0.027	0.0211	0.0272
Intercept	0.6712***	0.1526	0.5483***	0.1537
/sigma_u	0.0001	0.0083	0.0000	0.0076
/sigma_e	0.3005***	0.0046	0.3028***	0.0046
Log likelihood	−466.83		−483.39	
Wald chi^2	127.70***		68.85***	
Observation	2156		2156	

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

The macroeconomics variables also varies across models. The GDP growth variable has a mixed effect on productivity. The coefficient of this GDP growth variable appears to be surprisingly negative and significant under the intermediation-based productivity model (Model A), indicating that higher economic growth lowers the bank productivity growth. However, more consistent results appear in Model B, where GDP growth positively influences productivity growth although the result is statistically insignificant. This result is similar to the findings of Sufian (2011) for Malaysian banks. The effect of inflation is generally weak, however, in line with the expected hypothesis that a higher inflationary environment is unfavourable to productivity growth. This result is statistically significant only in Model B. The coefficient of broad money is positive and statistically significant for both models, which indicates that a higher amount of currency outside the banks is associated with higher productivity growth of banks.

Operating as a foreign exchange bank and/or a listing bank has no significant effect on bank productivity, although the coefficients of *Dforex* and *Dlisting* are consistently negative and positive, respectively. To some extent, this is surprising given that such banks in Indonesia are constitute to be able to engage in an extended operation, offer more diversified financial products, and have more options to finance their operation.

The coefficient of the economic liberalization variable represented by the regulatory changes is our main interest and is found to have the expected sign (positive) and statistically significance at conventional levels. This suggests that the change in regulations enables banks to increase productivity in both intermediating funds and generating revenues. Delis, Molyneux, and Pasiouras (2011) report varying effects of changes in regulation upon productivity growth in European transition countries.

Ownership types show various effects on productivity growth. The coefficient of state ownership is found to be negative and positive in Model A and Model B, respectively, indicating that state ownership negatively influence banks' productivity in the intermediation while positively affect productivity in the revenue generation, although the results are not statistically significant. Among others, pure foreign banks indicate have a positive and highly significant

coefficient in Model A, indicating more productivity growth in intermediating fund from depositors to borrowers. This result supports the typical findings in developing country studies, namely that foreign banks outperform their domestic counterparts. Private national and joint venture banks have an inconsistent effect across models and both are not statistically.

VI. Conclusions and policy implications

This article investigates the productivity growth of Indonesian banks by using the bootstrap MPI approach and data for the period 1993–2015. Panel data models are constructed for Indonesian commercial banks and the investigation is conducted using both the intermediation (Modell A) and revenue (Model B) approaches. The empirical findings show that, overall, productivity growth of the Indonesian banking industry is positive under both approaches. However, Model B yields a higher productivity growth (7.48% per annum) than Model A (3.85% per annum), with growth appearing to be less volatile towards the end of the period. The main source of productivity growth under both approaches is primarily through the efficiency improvement.

The estimates of MPI for five groups of banks reveal that positive growth is experienced by most of these groups. Annual performance of all groups fluctuates widely from 1993/94 until 2000/2001, with especially unstable economic performances surrounding the 1997 Asian Financial Crisis. The size category results show that all size categories experience an improvement in productivity over the full period of analysis under both models. Interestingly, large banks consistently achieve higher productivity growth compared with small and medium size banks under both models.

The investigation is continued by using regression analysis to estimate the impact of factors driving bank productivity growth. The empirical results show that broad money and regulatory changes in 2004 positively and significantly influence productivity growth. There is no strong evidence that bank size, restructuring (merger), foreign exchange activity and listing bank are related to productivity growth. Finally, foreign ownership shows an important positive effect on bank productivity under the intermediation-based model, while the other ownership variables have no statistically significant effect on productivity in either model.

These findings have several policy implications. First, although Indonesian banks achieved productivity improvement over the past two decades, technological change did not contribute much. Heavy regulation hinders innovation, so policymakers should continue to deregulate institutional barriers in such a way that banks can strengthen their capacity to achieve the medium- and long-term productivity growth. Further, increases in bank size through merger or acquisition would take advantage of scale economies according to the results that the large banks on average achieved higher productivity growth than the two other categories (medium and small). However, steps must be taken to prevent a declining competition culture in the industry. Since foreign banks are more productive than their local counterparts, government should initiate policies and provide incentives to strengthen local banks' capacity to reap the benefits from advanced technology, managerial knowledge and skill transfers from foreign banks. Finally, policies should be pursued that benefit the competitive environment for all banks, such as modernizing legal and political institutions, compliance with the international banking regulations (e.g. Basel accords) and maintaining macroeconomic stability.

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