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Impact of Banking Deregulation on Bank Efficiency and Productivity Growth: *Evidence from Indonesia*

Felisitas Defung

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material, which has been accepted for the award of any other degree or diploma in any university.

Signature : ____________

Date : 6 October 2014

Dedication

Dedicated to my loving

parents

and

children

Acknowledgements

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List of Abbreviations and Acronyms

AE	Allocative efficiency
AFC	Asian financial crisis
API	*Arsitektur perbankan Indonesia* (Indonesia banking architecture)
ASEAN	Association of South East Asian Nations
BCC	Banker, Charnes, and Cooper
BI	*Bank Indonesia* (The central bank of Indonesia)
BPS	*Badan Pusat Statistik* (Indonesian central bureau of statistic)
CAR	Capital adequacy ratio
CCR	Charnes, Cooper and Rhodes
CEE	Central and Eastern Europe
CIMB	Commerce International Merchant Bankers
Coef.	Coefficient
COLS	Corrected ordinary least squares
CRS	Constant returns to scale
DEA	Data envelopment analysis
DFA	Distributional free approach
DGP	Data generating process
DMU	Decision making unit
DPR	*Dewan Perwakilan Rakyat* (Indoneisan house of representative)
DRS	Decreasing returns to scale
EC	Efficiency change
EE	Economic efficiency
FB	Foreign bank
FE	Fixed effect
FSA	Financial Service Authority
GDP	Gross Domestic Product
GFC	Global financial crisis
HHI	Hirchman-Herfindahl Index
IBRA	Indonesian Bank Restructuring Agency
IDIC	Indonesian Deposit Insurance Corporation
IDR	Indonesian rupiah

IMF	International Monetary Fund
IRS	Increasing returns to scale
JVB	Joint-venture bank
LDR	Loan to deposit ratio
LOI	Letter of Intents
LP	Linear programming
LPS	*Lembaga Penjamin Simpanan* (see IDIC)
M2	Broad money
ML	Maximum likelihood
MPI	Malmquist productivity index
MSBM	Modified slack-based model
NIM	Net interest margin
NIRS	Non-increasing returns to scale
NPL	Non-performing loan
NTB	*Nusa Tenggara Barat* (West Nusa Tenggara)
NTT	*Nusa Tenggara Timur* (East Nusa Tenggara)
OECD	Organization for Economic Co-operation Development
OJK	*Otoritas Jasa Keuangan (*Financial service authority)
OLS	Ordinary least square
PAKDES	*Paket Desember* (Deregulation package launched in December 1988)
PAKJUN	*Paket Juni* (Deregulations package launched in June 1983)
PAKTO	*Paket Oktober* (Deregulations package launched in October 1988)
PEC	Pure efficiency change
PNB	Private national bank
PTE	Pure technical efficiency
PTE	Pure technological change
RDB	Regional development bank
RE	Random effect
ROA	Return on assets
SBI	*Sertifikat Bank Indonesia* (Certificate of Bank Indonesia)
SBM	Slacks-based model
SBPU	*Surat Berharga Pasar Uang* (Money market securities)
SE	Scale efficiency

SEC	Scale efficiency change
SFA	Stochastic frontier approach
SOB	State owned bank
SORM	Semi-oriented radial measure
SPF	Stochastic Production Frontier
STC	Scale of technology change
TC	Technological change
TE	Technical efficiency
TEC	Technical efficiency change
TFA	Thick frontier approach
TFP	Total factor productivity
US$	United State dollar
UU	*Undang-Undang* (law or Act)
VRS	Variable returns to scale
WB	World Bank

Abstract

Since the Asian financial crisis in 1997 the banking industry in Indonesia has undergone a series of major changes including regulatory reform, restructuring, and the use of technologies. Such changes are likely to substantially affect banking sector performance. This research seeks to empirically investigate the impact of such changes by using panel data from 1993 to 2011 to examine the effects of regulatory reforms on bank efficiency and productivity growth in Indonesia.

Here, the data envelopment analysis (DEA) method is used to assess the impact of regulatory reforms on the technical efficiency of the Indonesian banks. In addition, the Malmquist productivity index (MPI) method is used to examine the banking productivity growth and its decomposition. The DEA and MPI are used in conjunction with bootstrapped methods developed by Simar and Wilson (1998b, 1999a) to determine statistical inference. Lastly, a Tobit regression model is utilised to identify the determinants of efficiency change and productivity growth.

Empirical results from this research show that the Indonesian banking industry is inefficient in both intermediation and revenue based models with the mean technical efficiency being 59.4% and 69.2%, respectively. Although there are fluctuations in the efficiency score year to year and the overall efficiency is higher under the revenue approach model, the intermediation approach model shows an improvement trend over the study period. Further analysis by bank group shows that the best performers are state owned banks, followed by foreign and joint venture banks. Findings indicate that the private and regional development banks are the least efficient, but exhibit an improvement trend. Estimation on bank size suggests larger banks are the most efficient.

Results from the MPI show that bank productivity improves under both models. In particular, productivity growth is mainly driven by technological change, rather than efficiency change. Although, under the revenue based model both components contribute positively, technological change emerges as being superior. Further analysis shows that most of the bank groups experience productivity growth, except for foreign banks in intermediation model, and regional development banks in the revenue based model. Unlike the efficiency result, there is no evidence that bank productivity is associated with bank size. The medium size bank is found to be the most successful in gaining productivity growth under both models.

Analysis using the Tobit regression model focuses on identifying the determinants of bank efficiency and productivity growth. Results show a stable macro economy, ownership structure and bank size are important in achieving technical efficiency. Private and regional development banks are shown to have no significant effect on the efficiency and productivity growth of the Indonesian banking industry. This result is generally consistent with bank efficiency and productivity results as determined in the first and second analysis.

This study finds that regulatory change contributes positively to bank efficiency and productivity growth in Indonesia through the period studied, although it is only statistically significant in the revenue based approach. The findings suggest that government can provide supportive regulations to promote bank efficiency and productivity growth. Similarly, the positive and significant effect of bank restructuring on private banks imply that the Indonesian government has been successful in formulating policies that improve efficiency and productivity growth for these banks.

Key Words: Bank efficiency, productivity growth, data envelopment analysis, panel data, technological progress, Indonesia

JEL Classifications: G21, G28, G34, C14.

Chapter 1
Introduction

1.1 Background of the Study

As a key part of the financial system, banks are widely recognised as the engine of economic development. Several theories support the fundamental role of financial intermediaries in channelling scarce financial resources into the economy to sustain economic growth (King and Levine 1993; Levine 1997). Therefore, an efficient financial system is essential for a bank to perform its function of intermediating funds between savers and borrowers.

Following the severe economic crisis of 1997, the Indonesian financial authorities sought to rebuild and restore the banking industry to enable it to perform its intermediation role properly. To this end, a series of regulatory reforms were enacted, including revision of two key regulations of the Indonesian banking sector: the Banking Act (*UU Perbankan No. 10/1998*) and the Central Bank Act (*UU Bank Indonesia No. 23/1999*)[1]. Subsequently, reforms have been accompanied by various policies, including restructuring, privatisation, and establishment of several institutions. One of the observable consequences of such policies -some of which were implemented not only because they were urgently needed but because they were mandated by the International Monetary Fund (IMF) (Sato 2005)- is a dramatic decrease in the number of banks.[2] A crucial period for the Indonesian banking sector occurred when the IMF ended its role in 2004 and the Indonesian Deposit Insurance Corporation (IDIC) was established. The establishment of IDIC is to replace the blanket guarantee system adopted during the crisis recovery period. These new circumstances, together with advances in information and communication technologies and the increasingly global nature of the banking business, have transitioned the Indonesian banking industry into a new phase.

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[1] The Central Bank Act was later amended by Law No. 6/2009.

[2] The number of bank before the crisis (1996) was 239 banks then down to 149 banks in 2000 and to 139 banks in 2002.

As the banking system is a primary component of the Indonesian financial system, the banking sector performance should have been substantially affected by these changes. Berger and Humphrey (1997) observe that deregulation is typically intended to increase market competition by reducing barriers to competition, reducing subsidies to protected sectors and improving the regulatory and contracting environment. As a result, deposits and credits should be intermediated more effectively, reducing inefficiency in the system, boosting productivity and enhancing economic growth.

Several empirical studies have examined the impact of deregulation on bank efficiency and productivity growth, with mixed results. While some studies (Berg, Førsund, and Jansen 1992; Gilbert and Wilson 1998; Leightner and Lovell 1998; Canhoto and Dermine 2003; Chen, Skully, and Brown 2005; Isik and Hassan 2003b) find that bank efficiency and productivity have improved, others observe no significant impact (Hao, Hunter, and Yang 2001; Elyasiani and Mehdian 1995; Havrylchyk 2006). Furthermore, some studies find a negative effect of deregulation on bank efficiency and productivity growth (Grabowski, Rangan, and Rezvanian 1994; Humphrey and Pulley 1997; Lozano-Vivas 1998; Kumbhakar et al. 2001; Fu and Heffernan 2007). In some cases, the effect of deregulation is found to depend on bank characteristics such as size and ownership structure. The mixed findings, some researchers argue, may be related to the variables, country and time period, the methodological frameworks employed, and the changing nature of the banking industry. These inconclusive findings indicate that the relationship between deregulation, bank efficiency and productivity growth remains unsettled.

Over the last decade, research interest has expanded from developed countries to developing and emerging economies, including Asian countries. However, only a limited number of published studies have focused on Indonesia. Thus, studies of Indonesian banking efficiency and productivity growth have not been comprehensive in nature. Some studies of the Indonesian case include Margono, Sharma, and Melvin (2010), Hadad et al. (2011) and Zhang and Matthews (2012). Although important results have emerged from these researches, none have investigated the effects of post-crisis reforms on the Indonesian banks efficiency and productivity growth. Moreover, the data used in these studies do not go beyond 2008; hence, the literature has fallen out of date. Therefore, comprehensive information on the nature of the effects of the financial reforms on the banking industry is lacking in the case of Indonesia.

Additionally, in the substantial amount of empirical research conducted to date, assessments have primarily focused on the impact of deregulation on the banking industry in general, while less attention has been given to the effects of reforms on particular types of banks (bank groups) and on banks of differing sizes. The investigation of sub-aggregates of the banking industry is valuable, particularly in the Indonesian case, where large disparities between bank groups could affect the efficiency and productivity growth at the industry level. Moreover, the dominance of one bank group in terms of numbers of banks will clearly be reflected at the industry level, although other groups may have fully adapted to given regulatory changes.

This thesis attempts to fill this void in the literature, particularly in the Indonesian case. The study presents an analysis of a long series of panel data of 101 banks, covering the period from 1993 to 2011. Three approaches are employed in examining the impact of change in regulation on bank efficiency and productivity growth among Indonesian banks. First, a data envelopment analysis (DEA) is employed to assess the impact of regulatory reforms on banks' technical efficiency. Second, the Malmquist productivity index (MPI) method is used to examine productivity growth and decompose it into its sub-components. Both measures, DEA and MPI, are calculated using a bootstrapping method to derive statistical inferences of the results. Finally, a Tobit regression model is applied to identify the determinants of efficiency and productivity at both the aggregate industry and the individual bank group levels.

1.2 Research Objectives

The objective of this study is to examine how changes in financial regulations have affected the technical efficiency and productivity growth of the Indonesian banking industry. The specific objectives are as follows:

1. To investigate the technical efficiency and productivity growth of Indonesian banks at the industry level and by bank group and bank size.[3]
2. To examine the sources of productivity gains based on a decomposition of productivity growth into two components: technical efficiency changes and technological changes.
3. To identify the determinants of efficiency and productivity in Indonesia, both at the aggregate industry level and at the bank group level.
4. To examine the impact of regulatory changes on bank efficiency and productivity growth.

1.3 Method of Research

To achieve these research objectives, this thesis employs an analytical framework comprised of three phases. Non-parametric data envelopment analysis is used in the first stage to estimate banks' technical efficiency. Subsequently, the Malmquist productivity index method is used to examine productivity growth and decompose it into its sub-components; efficiency change and technological change. Both approaches are employed in conjunction with bootstrapping methods, proposed by Simar and Wilson (1998b, 1999a), to draw statistical inferences. At the second stage, a Tobit regression model is utilised to identify the determinants of efficiency changes and productivity growth.

Under the DEA, a set of input and output variables is used to estimate the technical efficiency of individual banks for each year during study period. Variables are specified under both the intermediation-based and revenue-based approaches to provide contrasting modes of efficiency analysis. To overcome the absence of statistical inferences in non-parametric DEA, a complementary technique, the bootstrap DEA method proposed by Simar and Wilson (1998b), is employed. The analysis is conducted on the full sample of banks by taking the mean efficiency of all banks in each year to capture the industry efficiency level. The result is then divided into five groups of banks to examine the efficiency levels of different bank groups within the industry. Similarly, the results are also classified by size of banks (large, medium and small) to investigate the efficiency in different bank size.

[3] Allocative efficiency is not considered in this research due to lack of data.

Under the MPI method, total factor productivity (TFP) growth of banks is decomposed into two basic components: efficiency changes and technological changes. Similarly to the analysis of efficiency, the bootstrap MPI method, proposed by (Simar and Wilson 1999a), is adopted to enable statistical inferences. The analysis is performed on the growth and pattern of TFP and its components at the aggregate banking industry level as well as the bank group and bank size levels.

In the final phase of the study, a Tobit regression model is run to identify the determinants of efficiency and productivity. Technical efficiency and TFP growth, estimated via the methods described above are regressed on various independent variables. The estimations are conducted both at the aggregate industry level and the bank group level.

1.4 Significance of the Research

The topics of bank efficiency and productivity growth have been investigated in numerous international studies. However, only a few studies, each with various limitations, have examined the Indonesian banking industry. Hence, the present study seeks to contribute to the literature in several significant ways.

First, the study is one of the first to employ the method of non-parametric bootstrapping (bootstrap DEA) to measure bank efficiency and productivity growth in an inclusive way, with both measures presented and analysed. Although previous studies have used the bootstrap DEA method, they tended to exclusively focus on specific measures, such as cost efficiency, technical efficiency and productivity growth. Moreover, in the case of Indonesia, this is the first study to examine banks' technical efficiency using the bootstrap DEA approach.

Second, this study represents the first attempt to use the bootstrapped Malmquist productivity index (MPI) to measure productivity growth and its decomposition in the Indonesian context. Previous studies have used the conventional MPI to examine and decompose productivity growth in its sub-components. The bootstrapped MPI enables the derivation of statistical inference from the results, hence provides more reliable findings to be analysed. In addition, this method allows further decomposition of efficiency changes and technological changes into sub-components, allowing a more in-depth analysis.

Third, this study is the first to investigate the impact of regulatory reforms implemented following the 1997 Asian financial crisis on Indonesian banks' efficiency and productivity growth. To conduct the analysis, a two-stage procedure, combining non-parametric and econometric aspects, is employed, enabling a more comprehensive investigation. In the first stage, the impact of the reforms on relative efficiency levels and productivity growth is analysed. Then, the measures of efficiency and productivity are regressed on bank characteristics and reform variables.

Fourth, this study examines the impact of regulatory reforms on bank efficiency and productivity at the aggregate industry level, by bank group and by bank size. A regression involving the determinants of efficiency and productivity at the bank group level, to the best of the author's knowledge, has not previously been done in a single country study. This feature of the study allows for an extensive analysis, as different bank groups and banks of different sizes differ in their business features. Previous studies of efficiency and productivity have largely focused on the banking industry level, paying less attention to individual bank groups. Hence, this study provides new empirical evidence regarding the impact of financial reform on the Indonesian banking sector.

Fifth, the present study covers a long series of panel data encompassing the period from 1993 to 2011; thus, it includes the period preceding the crisis. Although the analysis focuses on the impact of regulatory changes after the crisis, inclusion of the pre-crisis period provides a more comprehensive picture of the evolution of Indonesian banking performance. A long series of data enables the analysis to include measures of efficiency and productivity before the 1997 crisis. In addition, this research updates existing studies on Indonesian banking efficiency and productivity growth, using data through 2011. To the best of the author's knowledge, no previous Indonesian studies include data beyond 2008.

1.5 Structure of the Thesis

This thesis consists of eight chapters. This first chapter provides an introduction to the study and presents the background, the research questions examined and the objectives and significance of the study. Chapter 2 provides an overview of Indonesia's banking system, including its history and evolution since the 1980s. Changes in regulations, policies and reforms from both the pre- and post-crisis period are highlighted, including problems and challenges faced by the industry. General developments of the banking sector in relation to the effect of reforms on banking structure, the role of central bank and bank performances are discussed.

Chapter 3 contains a review of the literature on efficiency and productivity growth and the application of these concepts to the banking industry. The theoretical and empirical research on efficiency and productivity are discussed, along with methods used to estimate the measures. Empirical studies, both international and Indonesian-focused, are reviewed and summarised to highlight the mixed evidence that exists regarding the effects of financial reforms on bank performance. As empirical studies of bank efficiency and productivity are few, this thesis emphasises the need to update the literature in the Indonesian case. Two measurement methods, stochastic frontier approach (parametric) and data envelopment analysis (non-parametric), are identified as the dominant analytical tools used for this purpose.

Chapter 4 describes the analytical framework used to measure the efficiency and productivity of the Indonesian banking system. The chapter begins with the discussion of two frontier approaches used to estimate bank efficiency and productivity growth. In particular, the chapter explains the use of data envelopment analysis and the Malmquist productivity index, featuring the bootstrap method, to obtain measures of technical efficiency and total factor productivity and its components. A discussion of the inputs-outputs specification is also presented. Finally, it explains a regression model that is used to estimate the determinants of bank efficiency and productivity.

The empirical analysis of this thesis is presented in the three chapters that follow. Chapter 5 reports on the efficiency level of Indonesian banks. In particular, the technical efficiency of Indonesian banks is estimated using the bootstrap DEA method, to statistically infer the efficiency scores. The estimations are obtained at the industry and bank group levels. Estimations are also conducted for different sizes of banks (large, medium and small).

Chapter 6 presents an empirical analysis of the productivity growth of Indonesian banks, with the bootstrap Malmquist productivity index employed to decompose productivity growth into technical efficiency change and technological change. Additionally, further decompositions are presented for each of these components. The chapter analyses the trends and possible reasons for changes in productivity growth. Similarly, the results are analysed at the aggregate banking industry as well as at bank group and bank size levels.

Chapter 7 investigates the determinants of bank efficiency and productivity. Using a Tobit regression model, the relationships of bank efficiency and productivity with various variables representing macroeconomic factors, restructuring, regulatory change, bank status, bank characteristics and ownership structure are examined. The aim of this chapter is to further analyse possible sources of efficiency and productivity differences. The determinants are then separately tested across bank groups to provide more specific analysis of the effects of the variables.

Chapter 8 summarises the main findings and presents policy implications, discusses limitations of the study and provides recommendations for future research.

Chapter 2
Overview of Indonesian Banking Industry and the Sequence of Financial Reforms

2.1 Introduction

The banking sector is well-known as an industry that operates in a heavily regulated atmosphere. The role of deregulation in banking works to improve overall performance. Indonesia has undergone a substantial transformation of its banking sector since the 1980s until the 2000s. Series of financial reforms introduced by the government have resulted in changes of structure, supervisory policy, risk management and business performance in the banking industry. This chapter seeks to present an overview of the Indonesian banking industry and its evolution as an impact on the sequencing of financial reforms in Indonesia.

The rest of this chapter is organised as follows. Section 2.2 introduces the overview of the Indonesian banking system, followed by the sequence of financial reforms in Indonesia in Section 2.3. This section includes the four main periods of reform; the 1980s reforms, the 1990s reforms, the period of crisis (1997-1999) and the post-crisis banking reforms. Section 2.4 discusses the impact of financial reforms on the commercial banks' performance in term of various indicators. Section 2.5 concludes the chapter.

2.2 Indonesian Banking System: An Overview

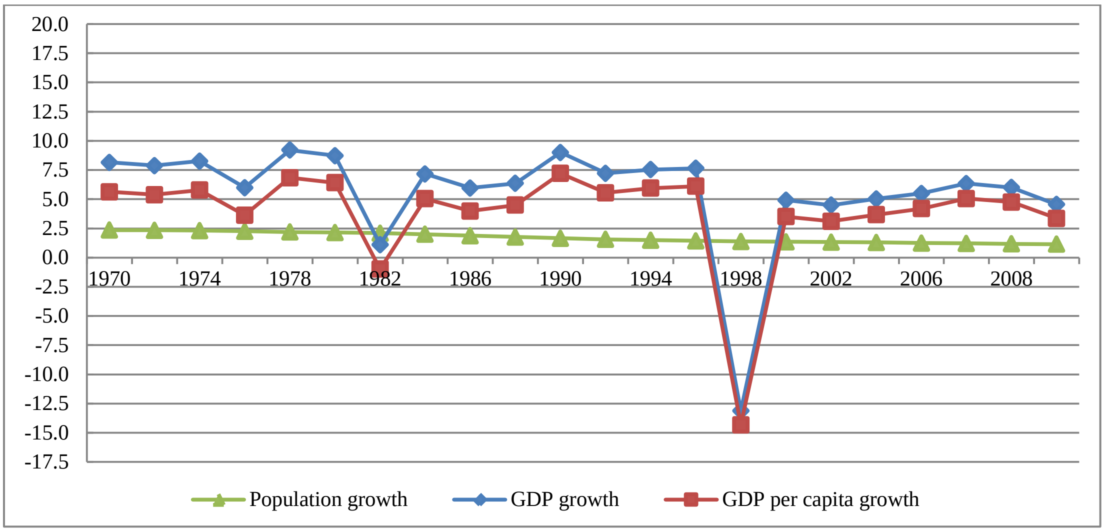
As in many other countries, the banking industry plays a crucial role in Indonesian economic development. Categorised as a lower middle income level country by The World Bank, the Indonesian economy has grown steadily since the 1997 financial crisis.[4] Figure 2.1 and

Figure 2.2 show the economic profile of Indonesia from 1970 to 2008. As can be seen in Figure 2.1, population growth is the only measure that moves steadily down. While the other macroeconomic factors, such as the Gross Domestic Product (GDP)

[4] The categorisation is found in The World Bank website http://data.worldbank.org/country/indonesia, accessed 24 February 2015.

growth, GDP per capita growth, inflation and money and quasi money (M2) have fluctuated since early 1970 with their worst performance during 1997 to 1999.[5] The Indonesian economy began to recover after that period, but slowed down in 2008 when the global financial crisis occurred. The GDP growth declined to 4.55% in 2009 after achieving the highest rate of growth in 2006 of 6.35%.

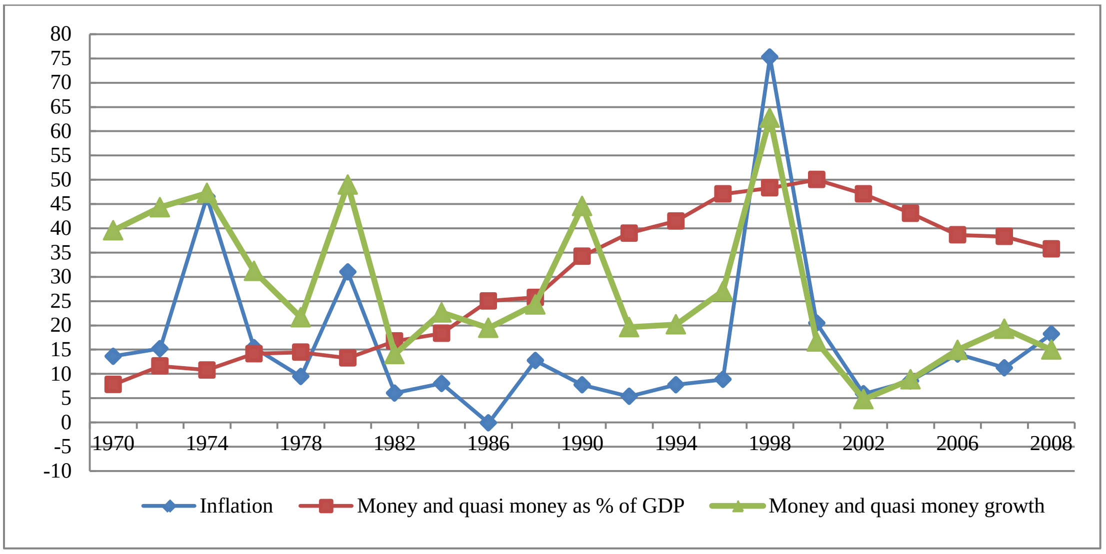
Figure 2.1: Population and GDP Growth in Indonesia (%)



Source: The World Bank (2012)

Note: GDP growth and GDP per capita growth is the annual growth rate of GDP and GDP per capita, respectively, at market prices based on constant local currency, aggregated on constant 2005 US$.

Figure 2.2: Inflation and Money and Money Quasi (M2) in Indonesia (%)



Source: The World Bank (2012)

[5] GDP growth and GDP per capita growth refer to GDP at market prices based on constant local currency and aggregated on constant 2005 US$.

During the 1970s, and before the crisis, the Indonesian banking sector was characterised by a common problem found in developing economies. State owned banks dominated the markets and channelled funds to subsidised sectors, whilst major private banks poured most of their funds to their group companies (Hamada and Konishi 2010).

Table 2.1: Contribution of Financial Sector to the GDP

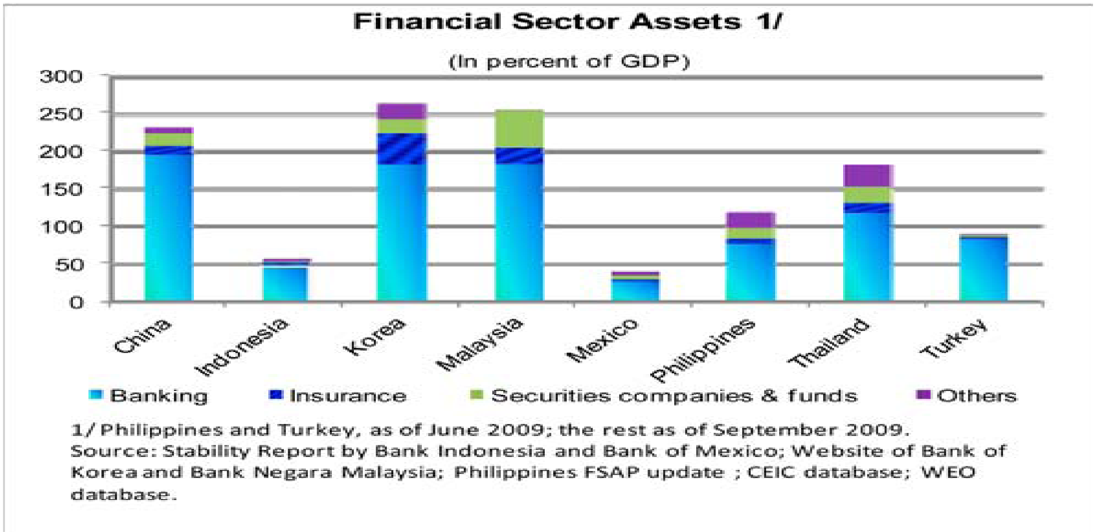
GDP	2004	2005	2006	2007	2008	2009	2010
GDP (current, in million US$)	256,836.88	285,868.61	364,570.53	432,216.74	510,244.55	539,355.49	706,558.24
Finance, Real Estate and Business Services :	8.47%	8.31%	8.06%	7.73%	7.43%	7.20%	7.21%
a. Bank	**3.42%**	**3.18%**	**2.87%**	**2.67%**	**2.53%**	**2.35%**	**2.29%**
b. Non-Bank Financial Institutions	0.73%	0.75%	0.80%	0.82%	0.84%	0.85%	0.86%
c. Services Allied to Finance	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.75%
d. Real Estate	2.88%	2.94%	2.92%	2.79%	2.67%	2.59%	2.62%
e. Business Services	1.39%	1.38%	1.41%	1.38%	1.33%	1.34%	1.38%

Sources: The World Bank (2012) and BPS (2012).

Up to now, like most emerging economies the Indonesian financial sector has been dominated by the banking industry as can be seen in Table 2.1 and Table 2.2. Among main sectors of Indonesian GDP, manufacturing constitutes as the largest contributor by 25%. Finance, real estate and business services, are classified as one sector, and contributing about 7.7% on average to Indonesian GDP. This sector is made up of five subsectors as depicted in Table 2.1. Among this subsector, the banking industry leads the portion of the share GDP either directly as a percentage of GDP and as a percentage to the sector itself.

However, in terms of total financial sector assets, the percentage of Indonesian financial sector assets to GDP is below 60%.This is relatively small, when compared to similar countries such as China, Korea, Malaysia and Thailand, as reported by the International Monetary Fund (IMF) (2010). Figure 2.3 shows that Indonesia is in second place as the smallest share of its financial sector assets to GDP after Mexico, whilst other peer countries like Korea, Malaysia and China remain at the top.

Figure 2.3: Financial Sector Assets of Comparable Countries Financial Sector



Source: IMF (2010, 15)

The domination of the banking industry can also be seen in its asset share of the financial institution sector. Table 2.2 shows that the banking industry not only dominates the asset share of financial institutions' assets, with an average share of 80% but also remains in the lead, in relation to the number of institutions. Even though the asset share decreased during 2011, the gap with the non-bank institutions is still significant. Other financial institutions that have a key role regarding assets share include insurance companies, finance companies and pension funds with the share of 16.5% (2010).

Table 2.2: The Composition of Financial Institutions' Assets

Financial Institutions	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**		**Jun-11**	
						*)		*)	
Commercial Banks	81.50%	79.00%	79.00%	79.00%	79.50%	122	81.70%	121	77.00%
Rural Banks	1.10%	1.10%	1.00%	1.10%	1.10%	1,706	1.20%	1,682	1.20%
Insurance	7.30%	8.20%	9.00%	8.00%	8.80%	142	5.80%	142	9.70%
Pension Funds	3.50%	3.20%	3.00%	3.20%	3.10%	272	3.30%	282	2.50%
Finance Companies	5.30%	4.60%	5.00%	5.70%	4.40%	142	6.20%	192	5.50%
Venture Capital	-	-	-	-	-	-	-	71	0.10%
Securities	1.00%	3.70%	3.00%	2.70%	2.70%	119	1.10%	113	0.70%
Mutual Funds **)	-	-	-	-	-	-	-	642	2.80%
Credit Guarantee Companies	-	-	-	-	-	-	-	4	0.10%
Pawn Broker	0.30%	0.30%	0.00%	0.30%	0.40%	1	0.50%	1	0.40%
Total	**100%**	**100%**	**100%**	**100%**	**100%**		**100%**		**100%**

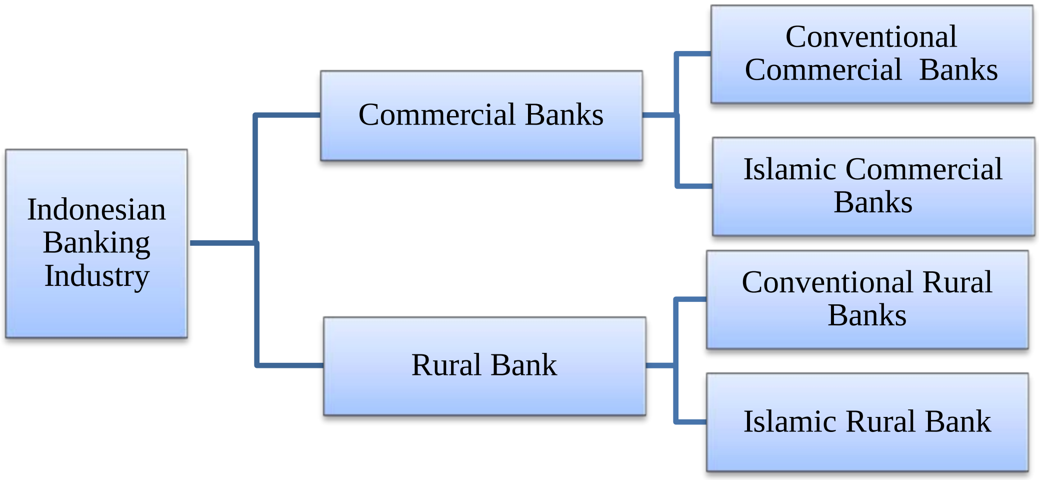
Source: Author's compilation from various editions of Financial Stability Review, Bank Indonesia.
Note: *) Numbers of financial institution. The data is only available after the last two years of Financial Stability Report. **) Investment collective, not the institutions; All other years' data are per December except for 2011.

The Bank Indonesia (BI) is the Indonesian central bank and it is authorised by the 1945 Indonesian Constitution. Act no 13 of 1968 governs and regulates the banking sector and monetary authorities in Indonesia. This act was subsequently amended by Act no. 6 in 2009. As a central bank, BI issues regulations and policies of the Indonesian banking industry and also supervises banking operations. The main regulatory framework for the banking sector itself is the Act no. 7 of 1992 as amended by Act no. 10 of 1998 and is known as The Banking Act.

Based on the current banking act, the Indonesian banking industry is classified into commercial banks and rural banks. The most significant factors that differentiate commercial banks from rural banks are their activities and ownership types. Based on the activities, a rural bank does not involve itself directly in payment systems, in view of their limited operational coverage. This means that they do not issue cheques and involve in foreign currency transactions. Instead, these activities are performed by commercial banks. With regard to ownership, rural banks can be owned by Indonesia citizens (either individual and/or legal entities owned by Indonesian citizens), and regional governments. In contrast, commercial banks have multiple types of ownership choices. They can be owned by the state government, regional government, national private, joint-ventures and wholly foreign-owned. Although the number of rural banks is remarkably big and far bigger the commercial banks, their share of banking business, in fact, is low as is the number of branches (see Table 2.3). Rural banks function mostly as community banks and so have limited operation coverage.

Each of the above classifications (commercial and rural banks) subdivides further into two operation systems: regular commercial banks, which are run by conventional laws and systems, and Islamic banks run by Sharia law. Figure 2.4 illustrates the Indonesian banking industry classification and sub-classification.

Figure 2.4: Classification of the Indonesian Banking Industry



Source: Adopted from Banking Act no. 10 of 2008

A remarkable development of Islamic banking increases after the Act no 21 of 2008 about Sharia banking released. However, the share of this group of banks to the Indonesian banking industry is still far below than those of conventional commercial banks. The share of each group in the banking industry can be seen in the Table 2.3.

Table 2.3 also reveals that conventional commercial banks are the main contributors to the industry's total asset to the maximum above 90% with an average of 70%. The domination of conventional commercial banks still seems to be continuing onward. However, unlike sharia (Islamic) commercial banks, rural banks and rural sharia banks, the share of conventional commercial bank's assets shows a decline to the industry. In terms of branches, the rural banks group has gained the greater number followed by conventional commercial banks and Sharia rural banks. The number of both conventional banks, - rural or commercial- , has decreased in the past few years which contributed to the decreasing trend in the total banking industry.

Table 2.3: Distribution of Total Assets, Total Banks and Total Banks 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	1,721	2,500	3,571	6,579	12,527	17,111	21,151	27,286	34,036	48,014	79,186	116,930
Rural Banks	4,731	6,474	9,080	12,635	16,707	20,393	23,045	27,741	32,533	37,554	45,742	55,799
Sharia Rural Banks	-	-	-	-	-	585	896	1,215	1,693	2,123	2,739	3,520
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	4,731	2,355	2,141	2,141	2,158	2,009	1,880	1,817	1,772	1,733	1,706	1,669
Sharia Rural Banks	-	-	-	-	-	92	105	114	131	139	150	155
Total	4,882	2,500	2,282	2,279	2,291	2,232	2,115	2,061	2,027	1,993	1,978	1,944
Total Banks Offices :												
Conventional Commercial Banks	6,492	6,681	6,888	7,541	7,676	7,935	8,764	9,282	10,157	12,017	12,622	13,407
Sharia Comercial Banks	55	84	113	189	263	301	346	398	711	820	1,215	1,390
Rural Banks	1,482	2,432	2,747	3,299	3,472	3,110	3,173	3,250	3,367	3,644	3,910	4,172
Sharia Rural Banks	-	-	-	-	-	92	105	185	202	225	286	364
Total	8,029	9,197	9,748	11,029	11,411	11,438	12,388	13,115	14,437	16,706	18,033	19,333

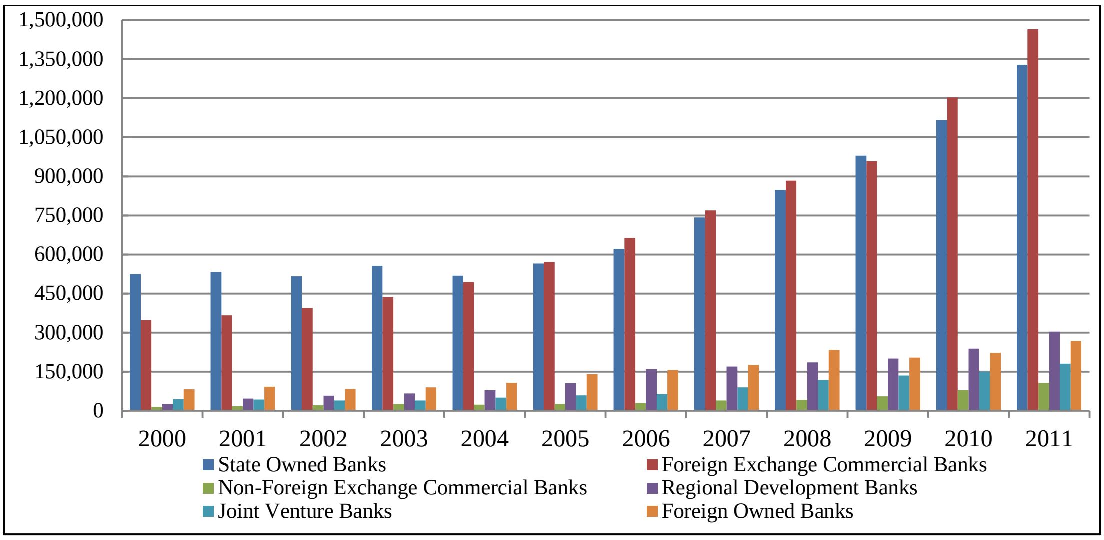
Source: Indonesian Banking Statistics, Bank Indonesia (2005c, 2011c)

The falling number of banks, partly, is the effect of bank restructuring policy after the Asian financial crisis in 1997. In spite of this, the total bank branches are moving in a positive direction, followed by the upward trend of the total assets. In contrast, the number of branches of rural banks falls below the conventional commercial banks, which might due to its restricted operational area.

Thus, it is documented that the commercial bank is the main engine for the development of the Indonesian banking industry. 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. Based on the type of ownership, banks are classified as state banks, private banks, foreign banks, joint venture banks, and regional development banks. Based on the type of authorization (or bank status), banks are distinguished as foreign exchange and non-foreign exchange banks.

Even though the role of Sharia commercial banks has constantly increased year on year, their overall contribution in Indonesian commercial banks is relatively minor (below 10 %). For example, in 2000 their share in total assets, total bank and total branches were, consecutively, 0,17%, 1,32% and 0,84%, then consistently increased each year to 2,32%, 9,17% and 9,3% in 2011, respectively. Hence, the illustration of commercial banks in Figure 2.5, Figure 2.6 and Figure 2.7 are mostly representing conventional commercial banks.

Figure 2.5: Total Assets of Groups of Banks (Billion IDR)

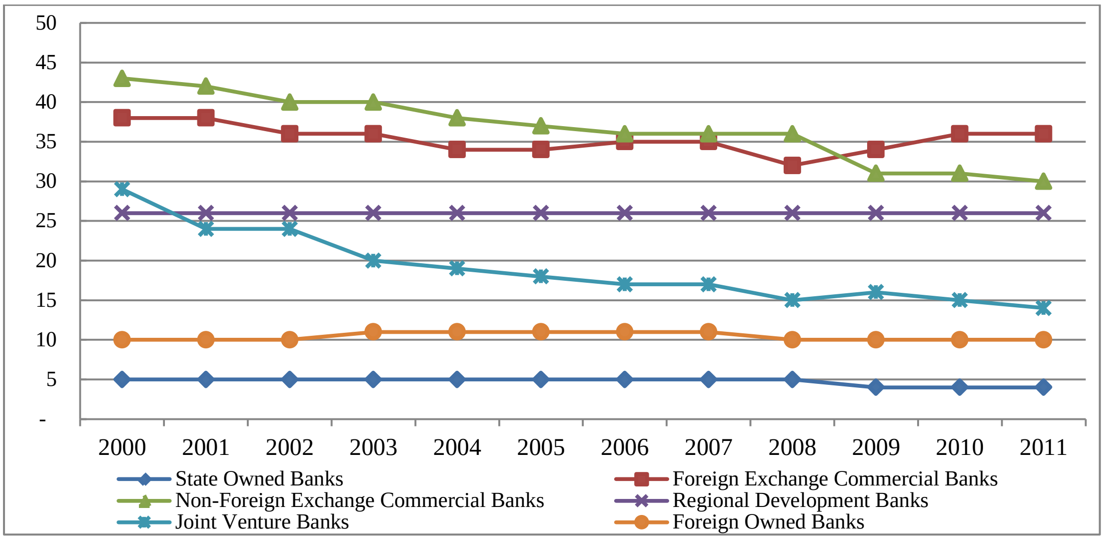


Source: Indonesia Banking Statistics, Bank Indonesia (2005c, 2011c)

It implies in the previous table (Table 2.3), that the growth of total assets across all groups of banks is not surprising. Nonetheless, Figure 2.5 exhibits the fact that the domination of total assets of the state owned bank has shifted to the foreign exchange commercial banks from 2005 onward. Before that period, the state owned banks were well known as the group of banks that had the biggest assets compared to other groups.

Similar to the pattern of the industry as a whole, the positive growth of total assets and total branches is followed by the negative growth of total banks (see Figure 2.6). The decreasing in the number of banks is an effect of a continuing process in Indonesian bank restructuring following the Asian financial crises in 1997 and up to the present day. Before the crisis, in 1996, the total number of commercial banks was 239 and it then gradually declined until it reached 120 banks in 2011. The reduction of banks during the period of 1997-1999 was mainly due to bank liquidation or closure and policy to freeze the bank's operation by the government. However, for the period of 2000 onward, mergers and acquisitions have been the most frequent action policy taken, that caused the number of banks to decline.

Figure 2.6: Number of Commercial Banks per Groups

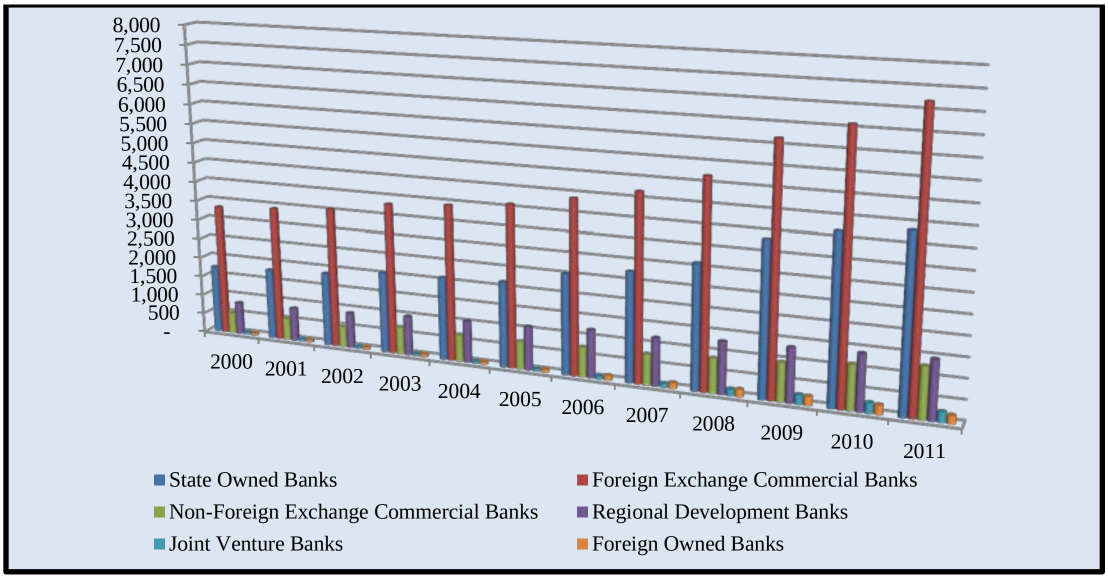


Source: Indonesia Banking Statistics, Bank Indonesia (2005c, 2011c)

Among the group, non-foreign exchange commercial banks were the highest in total banks until 2008 then it gradually declined. Afterward the lead shifted to the foreign exchange commercial banks. This is because most of the banks undertaking a merger during that period were non-foreign exchange banks and the new merged banks become foreign exchange banks. The rest of the groups moved just slightly down or remain the same during the period (regional development banks), except for joint venture banks which moved down more than the other groups. In 2000, the joint venture banks numbered 29 becoming just 14 banks in 2011.

Figure 2.7 illustrates the development total bank branches. It reveals that all groups have experienced the positive growth in their total banks branches, and their growth from 2000 to 2011 is above 110 % except for regional development banks which only grew by 78 %. This growth reverses to its development in total assets where regional development banks lead the growth by more than tenfold from 2000 to 2011. It highlights foreign exchange commercial banks lead the number of branches, but that the growth is led by joint venture banks which grew by 3.4 times.

Figure 2.7: Total Number of Banks' Branches



Source: Indonesia Banking Statistics, Bank Indonesia (2005c, 2011c)

Given the dominant role of the banking industry in the Indonesian financial sector, it is noted that commercial banks have been the major part of the industry. Moreover, the industry has consistently progressed toward a stronger banking structure. The various classifications and subdivisions of the banks provide a wide range of services to respond to different needs. Similarly, the grouping reflects the variations of management and operation system conducted under different ownership types.

2.3 The Sequence of Financial Reforms

Historically, the development of the Indonesian financial sector can be differentiated into two main periods: a financial repression period and a financial liberalism period. The repression period was the period before the deregulation era in 1983. During that period; the government intervention dominated the policies in the banking sector such as setting deposit interest rates in state owned banks, setting lending rates for priority economic sectors, and limit credits expansion. The liberalism period started in the 1980s. The chronology of Indonesian financial sector reforms is presented in Appendix Table 2.1.

The early stage of the banking industry emergence in Indonesia commenced after 1966, with the inauguration of Soeharto administration (Hamada 2003). Prior to that period, the development of the financial system was sluggish due to disruptions such as prolonged of fiscal deficit and hyperinflation. The initial development was characterised by the launched of Banking Act no. 14 of 1967 and followed by the Central Bank Act no. 13 of 1968. According to this Banking act, banks were classified into three categories based on the type of credit lending and sources of fund obtained. These categories were general banks, saving banks and development banks.

In fact, the Banking Act of 1967 also marked as the formal establishment of a proper banking system in Indonesia. The main task of banks based on the Banking act was to enable the intermediation of funds and loans in order to stimulate economic growth under the direction of central bank. However, the industry was heavily regulated at that point in time, where the interest rates were managed by the government at a low level. State owned banks dominated the banking activities which accounted for about 70% - 80% of total assets of commercial banks. They operated solely as loan providers to the private sector and functioned as agents of development by channelling government subsidised loans (Zulverdi, Gunadi, and Pramono 2007).

Accordingly, the financial liberalisation that significantly transformed the Indonesian financial sector was initiated since the 1980s. Following that year, a series of financial reforms introduced and influenced the financial system development. Financial reforms, which influenced the development of the banking sector in Indonesia, can be classified into four major periods; i.e. financial deregulations in the 1980s, key reforms in 1990s, a period of crisis (1997-1999) and post-crisis banking reforms.

2.3.1 Financial Deregulations in the 1980s

The most imperative and fundamental deregulation in Indonesian banking sectors was carried out in 1983 and 1988 respectively. These two deregulations have brought many radical changes that had had tremendous implications in the banking industry.

The 1983 reform was the first deregulation package which was implemented on 1st June 1983 and became known as *PAKJUN 1983*. This radical reform was designed to promote banks competition in mobilising funds from the public and to reduce banks dependency on liquidity from the central banks. This deregulation package involved three aspects in general; first, eliminating the credit ceiling system for the banking sector; second, modifying the complex system liquidity credits; and third, relaxing the interest rate policy which was a direct purpose of monetary policy (Zulverdi, Gunadi, and Pramono 2007).

Following *PAKJUN 1983*, the government announced a second and a more ambitious financial liberalisation in October 1988 (implemented in 27 October 1988). The deregulation package, known as *PAKTO 1988*, was created mainly to support *PAKJUN 1983*. It made various changes to the regulatory banking structure by removing restrictions on entries into the banking sector. The main features of this reform were: easing of the requirements and procedures for new private banks entry, easing of the requirement for all banks to open new branches, liberalisation of foreign banks entry through a joint venture and expansion of the operation in foreign exchange transactions. Reduction in reserve requirement, the removal of limits on offshore borrowing and the removal of competition barriers were other additional features of this liberalisation package.

As a consequence, the number of banks had grown vastly followed by a sharp increase in deposit and credit expansions. As a result, many new private banks were established. The number of private banks rose 2.5 times in five years, from 63 banks in 1988 to 166 in 1993, and the number of branches increased from 550 to 2,926 or more than 5 fold during that period. The new foreign banks also increased by 3.6 times from 1989 reaching 40 banks (Hamada and Konishi 2010; Sato 2005). The increasing number of private banks consequently increased their share in the industry while the supremacy of state owned banks declined significantly.[6] Those implications, brought by the financial liberalisation, were not supported by adequate supervision. Therefore, as the number of banks and credit expansion spurred the economy, problems started to show up. The government, through the central bank, took further action in the 1990s to overcome the adverse impacts.

[6] Sato (2005) states that from 1988 to 1996, the share of private banks increased doubled from 24% to 52% and state owned banks share decreased from 63 to 38%.

2.3.2 Regulations in 1990s

In the 1990s, the government consecutively introduced further prudential regulations, which were designed to ensure banks soundness. It began with the credit reform in January 1990. This reform was in effect, an attempt to limit the various subsidised loans that channelled from BI to the banks to support the government's credit programs. Besides, this program was suspected as acting as a significant contributor to the base money growth and uncontrolled inflation during 1989 (McLeod 1999). With the rapid increase of money supply (M2) as the total amount of banks' lending and deposit increased, the bank's non-performing loans also increased. Subsequently, the government introduced prudential regulation packages for sound banking in February 1991. This package modified the two previous deregulation packages (1983 and 1988) and was part of meeting compliance with the international standard of capital adequacy ratio (CAR) to maintain the banking soundness. This regulation package was comprised:

- A requirement that all banks had to meet a CAR of 8% by the end of 1993;
- a new ratio-based standard of bank soundness and point-rating systems introduced for all banks;
- and grant the authority to the central bank to issue cease-and-desist orders to any bank defying its guidance (Sato 2005).

Consequently, in response to the development of the banking industry and to enhance the role of the banking sector in the era of globalisation, the government introduced a new banking act in 1992. This new banking act (Act no. 7 of 1992) was designed to ensure the trust worthiness of banks and to replace the previous banking act of 1967 which was inadequate to accommodate the dynamic pace of banking development. The act provided the implementation of prudential regulation, administrative sanction, a requirement on legal lending limits, and a division of role between the central bank and Ministry of Finance for supervising unsound banks. In general, the act restructured the industry by: lessening the type of the banks; detailing the banks licensing and ownership requirements; providing more exact government control over bank lending and capital adequacy policies; requiring an education and training program for bank officers and directors; and establishing a division between the two types of banks: commercial and rural (Low 1997).

That series of financial reforms since 1983 delivered better foundations for the development of the banking industry and encouraged the intermediary functions of the banking system. Overall, the industry had succeeded in supporting strong economic growth for more than a decade prior to the Asian financial crisis in 1997 and evidenced in the growth of banks and branches, deposits acquired and loans extended to the business sectors.

2.3.3 The Period of Crisis (1997 -1999)

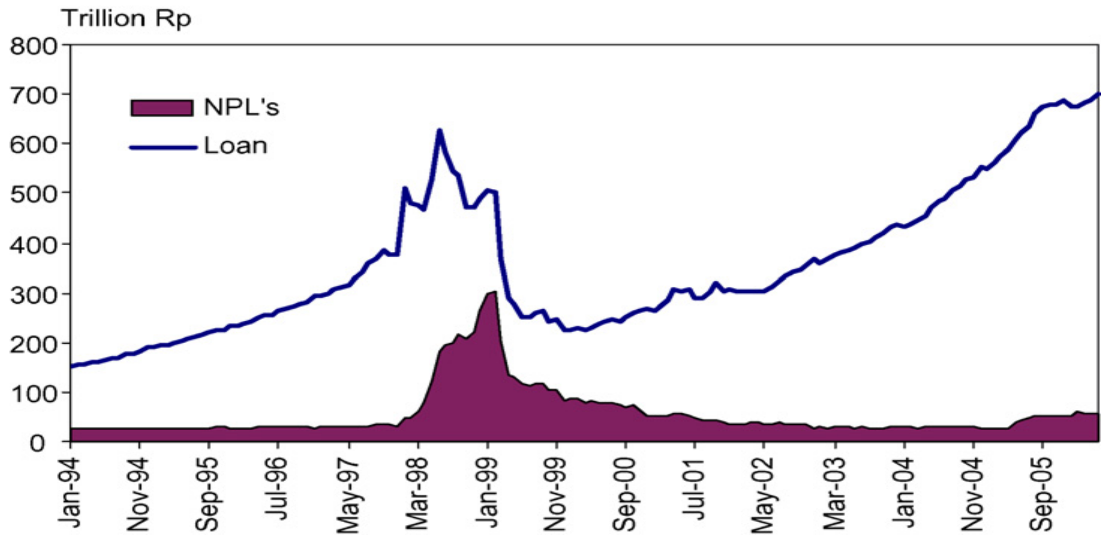
The aggressive growth of banks and credit since the 1988 deregulation was not accompanied with an adequate supervision, especially the supervision of risk taking behaviour. As a result, deterioration in the overall loan quality of the Indonesian banking was un-avoided. The Asian financial crisis spread to Indonesia in July 1997, following the mass withdrawal of international capital that led to a large depreciation of the domestic currency and the default of liabilities of many domestic firms to international and domestic banks.[7] Since most of banks credits portfolio comprised the borrowers from the corporations who had been engaged in international transactions, further effects of this circumstances were easy to predict. The quality of banks' assets deteriorated due to the increase of non-performing loans (NPLs). As reported by Zulverdi, Gunadi, and Pramono (2007), the non-performing loans in the Indonesian banking increased significantly from IDR 28 trillion on average prior the crisis period, to IDR 84 trillion subsequently, and it reached the highest point from IDR 100 to 300 trillion during the crisis as depicted in Figure 2.8.

At the same time, the crisis brought liquidity shortages to the domestic banks which arose from the increased burdens firms servicing external debts. As a result, banks faced the loss of confidence in international banking relations. An effort made by the government to seek for IMF support on October 1997 had not significantly improved the condition either. The liquidation of 16 private banks on 1st November 1997 was one policy implemented under the IMF support. The closure was taken without an

[7] Prior the crisis the Indonesian Rupiah (IDR) was 2450 per US$ (June 1997) then depreciated to IDR 10.375 per US$ in January 1998 then to approximately IDR 14.900 in June 1998 (Anwar 2002).

adequate deposit guarantee scheme, and in fact worsened public confidence. As a result, a rush on banks became unavoidable and pushed the government to introduce a blanket guarantee arrangement on 27 January 1998 (Sato 2005; Zulverdi, Gunadi, and Pramono 2007). Subsequently, the government announced the establishment of the Indonesian Bank Restructuring Agency (IBRA), a new regulatory and independent institution reporting to the Ministry of Finance.

Figure 2.8: Banks's Loan and NPLs.



Source: Zulverdi, Gunadi, and Pramono (2007, 162)

Hamada and Konishi (2010) argue that having the capital account opened in the very early stage of the process of liberalisation, even before the banking reforms in the 1980s, resulted in Indonesia suffering much more serious and acute financial problems in the wake of the Asian financial crisis compared to other Asian countries such as Thailand and Korea. In addition, Tornell (1999) indicates that the contagion of the crisis in Asia was not random, but was associated with the poor economic fundamentals including the weakness of the banking sectors.

Later, although the public's confidence was restored, the banks remained beset with problems such as increasing of NPLs, decreasing in banks capital and lending ability whilst being unable to maximise function as a financial intermediary in the economy. In collaboration with international agencies, the government took further action by introducing restructuring and recapitalisation programs to solve the insolvency issue in the banking system. However, none of the government actions ever seemed to be sufficient to heal the fundamental problems in the Indonesian banking sector. The actions taken were mostly to cope with the problems that generate a short term impact such as; liquidation, merger, restructuring and recapitalisation and it was feared, would lead to repetition of problems in the future.

Accordingly, the government took the crucial step of announcing the amendment of the banking act as an effort to provide an adequate framework for the banking sector. This new legal framework (Banking Act no. 10) launched by the end of 1998 replaced the role of the previous banking act, and provided the underpinning necessary for many notable regulatory changes to the banking system until the present. The substantial change made under this new act is the expanded authority of the central bank, which now not only supervised the banking operation, but also issuance and revocation of banking licenses alongside the imposition of administrative sanctions. Previously, such authorities had been granted to the Ministry of Finance.

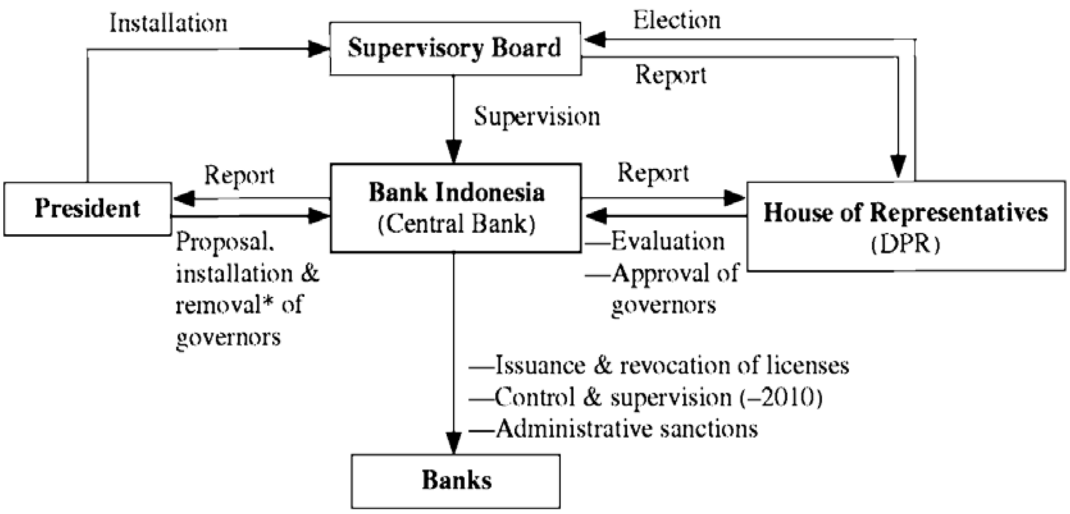
Subsequently, in the following year, the government also introduced the new Central Bank Act no. 23 of 1999 replacing the Central Bank Act of 1968. This new Act has empowered the Indonesian central bank to perform its role as an independent state institution, free from government or other party intervention. The independence of the central bank was one of the IMF programs for East Asian countries affected by the 1997 Asian financial crisis (Thailand, South Korea and Indonesia). In Indonesia, the independent status is reflected in the selection of the central bank board of governors. The president has to propose the candidates to the House of Representatives (DPR) to be selected and chosen with parliamentary consent. In the earlier act, the governor was part of the cabinet members and appointed directly by the president.

2.3.4 Post-Crisis Banking Reform

Succeeding the 1997/1998 financial crisis, Indonesian banks experienced considerable regulatory changes, including the amendment of the last two fundamental laws in the Indonesian banking sector. In the 2000s, the government tried to address several major issues, inherited from the previous administration. Those issues either had not been solved, or it required a longer time for the implementation or the government delayed the implementation. Amongst others, bank restructuring, the establishment of a proper deposit guarantee system and the establishment of adequate supervision system as required by the IMF, are the continuing works yet to be completed. Therefore, the government continued to introduce the series of regulations during the 2000s. Most of the regulations during this period were to re-regulate the previous regulation, such as regulations related to the central bank.

In January 2004, the government announced the amendment of the Central Bank Act of 1999. This new evolvement of the Act ascertained the equal role and relationship among the central bank, the house of representative (DPR) and the president. Figure 2.9 displays the new role of BI in relation to others institutions.

Figure 2.9: The Indonesian Central Bank under New Act



Source : Sato (2005, 111) .
* Only if governors commit prohbited acts and do not resign, then the president can remove them

The global financial crisis in 2007-2008 forced the government to introduce the enactment of ‘Government in Lieu of Law no. 2’ in 2008. This law contains the change in the stipulation in the short term credit from the central bank to Sharia banks. The introduction of this Law was one of the preventive efforts of the government in facing the 2008 global crisis which had been affecting the banking sector in Indonesia. Later, the government authorised this stipulation to become the new Central Bank Act no 6 in 2009 which establishes its power as the top authority to regulate the industry and is still in place up to present. Another prevention effort was the amendment of regulation regarding the requirement to return to and meet a minimum capital adequacy ratio (CAR) of 8% by the end of 2001. An additional act in the banking sector was also enacted in 2008 regarding Sharia (Islamic) banks. This new act (no. 21 -2008) was launched on July 2008. Previously, the regulation was related to Sharia banking operations and these were integrated in the same act as the conventional bank.

A proper deposit guarantee scheme is vital in maintaining public confidence and ensuring the stability of the banking industry. The blanket guarantee system, which was initiated in 1998, set to expire in 2004 (as stated in the Letter of Intent of the IMF). Therefore, the government prepared and announced the establishment of the Indonesian Deposit Insurance Corporation (IDIC) or known as *LPS* (*Lembaga Penjamin Simpanan*) in September 2004 (legalised in Act no 24 of 2004). According to the IMF (2010), the Indonesian deposit insurance regime is in line with international practice. As independence of state entity, the functions of the IDIC are to insure depositor's funds of banks and to participate in promoting the stability of the country's financial system in accordance with its authorised mandate. The introduction of this system was implemented smoothly. The replacement started by the implementation of limited guarantee, and gradually reduced the maximum amount of guaranteed funds. It started from the full amount to IDR 5 billion, lowered to IDR 1 billion and lastly IDR 100 million by 2007. This policy was mainly to promote competition and the solidity of the banking sector as depositors were encouraged to choose healthier banks.

Nevertheless, in response to the global financial crisis in 2008, the government amended IDICs act by enacting government regulation no. 3 of 2008, which stipulates an increase in deposit coverage from a maximum of IDR 100 million to a maximum of IDR 2 billion. However, a maximum interest rate is determined by the IDIC in order to prevent banks from overpaying to attract deposits from depositors. The IDIC announces the maximum insured interest rate each month that is valid for a month of that respected month. The eligibility of payment claim compliance is: if the depositor has not obtained an interest rate higher than the maximum interest rate set by IDIC; if the deposit is recorded in the banks' bookkeeping and if the depositor is not deemed responsible for the failing condition of the bank.

The BI in collaboration with the IDIC provides information on the banks under special surveillance to IDIC. Afterward, IDIC takes steps toward rescuing either a systemic failed bank or non-systemic failed bank.[8] Until the end of 2011, the IDIC had paid the insurance claims of 46 banks that had been liquidated. However, since most of the liquidated banks were rural banks there was no significant spill-over effect.

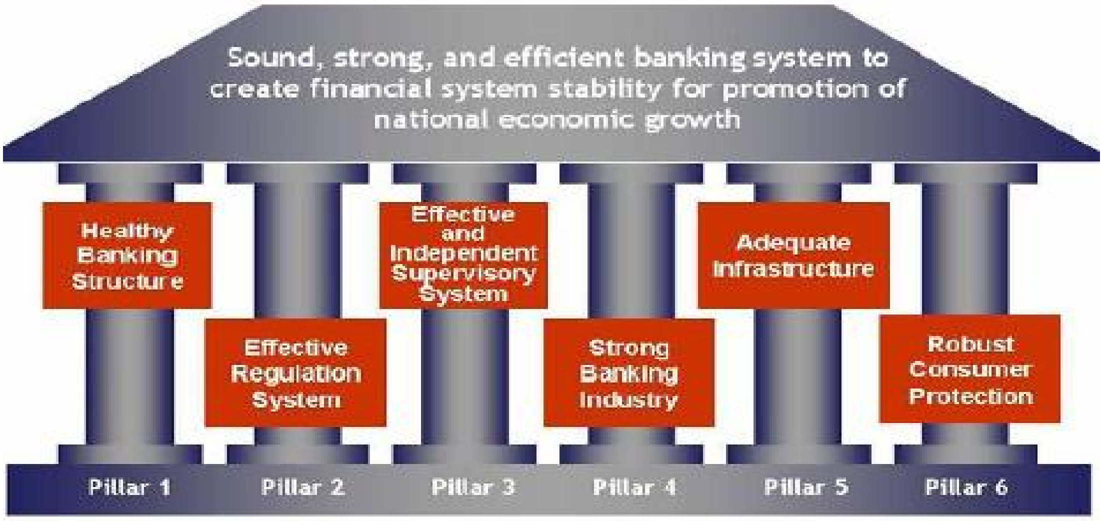
During the period of the 2000s, the consolidation of the banking sector and structural reforms continued as part of a plan to strengthen the Indonesian banking structure, and to attain a sound and efficient banking system. As part of that effort, the central bank has designed the Indonesia Banking Architecture (API) to provide a comprehensive framework for future development of the Indonesian banking industry over ten years. The API consists of six pillars as portrayed in Figure 2.10. These pillars are formulated to achieve a sound, strong and efficient banking system. Following its launching in January 2004, the API programs have been redesigned by the central bank. The purposes in doing so were to accommodate a better integration into the national economic programs and to build international competitiveness within the banking industry. Initially, the API consisted of 19 programs containing 34 activities, After the redesign it became 20 programs comprising 55 activities (Bank Indonesia 2012b).

The result of structural reforms can be seen in the number of banks that have gradually decreased every year as showed in Table 2.3. Hadad et al. (2008a) note that the reduction in the number of banks occurred in three different ways. The first was that banks were required to have a minimum Tier I capitalization of IDR 80 billion (US$ 8.81 millions) by 2007, increasing to IDR 100 billion (US$10.2 millions) by 2010; hence, many small private banks would have been priced out of the market and would have had to merge. Secondly, in June 2006, Bank Indonesia introduced the ‘single presence policy’ that prohibits investors from holding more than 25% of the shares of more than one bank. Third, in 2007, the introduction of the financial stability net, saw a reduction in the depositor guarantee level from IDR 2 billion to

[8] The scheme of bank rescue because of systemic and non-systemic failed bank is described in IDIC website http://www1.lps.go.id/web/guest/mekanisme-resolusi-bank.

IDR 100 million (US$11,000), which covers 98% of all depositors and 38% of deposits.

Figure 2.10: The Six Pillars of Indonesian Banking Architecture



Source: Bank Indonesia (2012b)

In the case of commercial banks, the decreasing number of banks during 2000s was caused mainly by the merger and acquisition of small banks or from the group non-foreign exchange banks. Table 2.4 reveals that a series of mergers occurred during the 1996 to 2011. Amidst those mergers, the merger of five state banks in 1999 (no. 2 in 1999 of Table 2.4) to become Bank Mandiri marks as the biggest merger in the Indonesian banking sector history. Accordingly, Bank Mandiri also promptly becomes the biggest bank in Indonesia until present day. The rest of the mergers were medium and small banks as shown in the table.

The merger policy was part of government strategy to guide the industry to a single presence policy as mentioned earlier. This policy was designed to restructure Indonesian bank ownership, making a party may only become a controlling shareholder in one bank.[9] However, this stipulation does not apply if the banks are managed with different business philosophies, such as a conventional bank versus an Islamic bank, or if one of it is a joint venture bank.

[9] Based on the Indonesian central bank regulation (PBI) No. 8/16/PBI/2006, controlling shareholder is a legal entity and/or an individual and/or a business group that holds bank shares 25% or above.

Table 2.4: Banks Mergers during 2000s

Year	No. of Merger	Banks Merger	Merged Bank
1996	1	Bank Delta Bank Danamon	Bank Danamon
1999	1	Bank Korea Commercial Surya Bank Hanil Tamara	Bank Woori Indonesia
	2	Bank Bumi Daya Bank Dagang Negara Bank Pembangunan Indonesia Bank Exim	Bank Mandiri
	3	Bank Danamon Bank PDFCI	Bank Danamon
2000	1	Bank Danamon Bank Tamara Jayabank International Bank Tiara Asia Bank Risjad Salim International Bank Rama Bank Nusa Nasional Bank Duta	Bank Danamon
2001	1	Bank Dai-Ichi Kanggo Bank IBJ Indonesia Fuji Bank International	Bank Mizuho Indonesia
	2	Bank Sumitomo Mitsuo Indonesia Sakura Swadarma Bank	Bank Sumitomo Mitsuo Indonesia
	3	UFJ Indonesia Bank Tokai Lippo Bank	UFJ Indonesia Bank
	4	Bank Pikko Bank CIC	Bank Mutiara
2002	1	Bank Bali Bank Artha Media Bank Universal Bank Prima Express Bank Patriot	Bank Permata
2003	1	Bank Keppel Tat Lee Buana Bank OCBC Indonesia	Bank OCBC Indonesia
2004	1	Bank Pikko Bank Danpac Bank CIC	Bank Mutiara (was known as Bank Century)
2005	1	Bank Artha Graha Bank Inter-pacific	Bank Artha Graha International
2006	1	Bank UFJ Indonesia Bank of Tokyo Mitsubishi	Bank of Tokyo Mitsubishi UFJ
2007	1	Bank Commonwealth Indonesia Artha Niaga Kencana	Bank Commonwealth Indonesia
	2	Bank Multicor, Tbk. Bank Windu Kentjana	Bank Windu Kentjana International
2008	1	Bank Niaga Bank Lippo	Bank CIMB Niaga
	2	Bank Hagakita Bank Haga Bank Rabobank Duta	Bank Rabobank International Indonesia
	3	Bank Harmoni International Bank Index Selindo	Bank Index Selindo
2009	1	Bank OCBC Bank NISP	Bank OCBC-NISP
2010	1	PT Bank OCBC-NISP Bank OCBC Indonesia	Bank OCBC-NISP
2011	1	Bank Buana Bank UOB Indonesia	Bank UOB Buana

Source: Banking Supervision Report, Bank Indonesia, various editions

Apart from that, the government's share in some nationalised banks was gradually sold to domestic and foreign investors as part of bank restructuring and re-privatisation programs, during 2000-2007. This resulted in an increasing foreign presence in the Indonesian banking industry (see Figure 2.11).

Where supervision is concerned, the central bank has continued to hold this function until 2011. Even though the IMF had requested as well as recommending the establishment of an independent and integrated supervisory framework in respond to the 1997 crisis, Indonesia was not responded promptly. Others, such as Korea countered immediately by establishing the Financial Supervisory Committee (FSC) in February 1998 (Sato 2005). In Indonesia, the realisation of the establishment has only recently taken place. After being postponed from its initial planned formation (December 2002), the government announced the establishment of *Otoritas Jasa Keuangan* (OJK) or Financial Service Authority (FSA) on November 2011. The legal formation is based on Act no. 21 of 2011. According to Sato (2005), the postponement of the FSA establishment was because of the strong opposition from the central bank. Given that the central bank has had the capabilities that are incomparable to other government entities. It was argued that since the central bank has the predominance in terms of information, experience and human resources regarding the banking industry, thus it would be deprived of supervisory if the authority is separated.

The FSA, as proposed by the IMF, not only supervises the banking sector, but consolidates the financial sector supervision in one place. The other financial institutions include: security markets, insurance companies, pension funds, finance companies and other financial services. In performing its role to supervise the banks, the FSA collaborates with the central bank and the IDIC.

The sequence of reforms from the 1980s up to the 2000s has presented the Indonesian banking sectors with a series of challenges. After obliging the industry to be in a closed environment for decades, the liberalisation reforms in the 1980s have put the industry into a golden epoch. Successively, in the last decade, the reforms have attempted to convey the industry toward international practice standards such as the independence of the central bank, a proper deposit guarantee program and an integrated supervision system. Given the dynamic pace of the banking development, these reforms may continue. Nevertheless, the reforms' impact on the industry is an essential issue. The next section discusses the impact on the commercial banks.

2.4 The Impact of Financial Reforms on the Commercial Banking Industry

The previous section briefly discussed the major financial reform implemented since 1980s until the 2000s in Indonesia. The impact of these reforms has influenced the banking sector in many ways, including but not limited to, the structure of the Indonesian banking sector, the power and role of the central bank, and the performance of the banking industry.

The purpose of regulations is to have a strong and robust banking system. These regulations have influenced the performance of the banking industry either directly or indirectly. The IMF (2010) reports four main findings regarding the financial system stability assessment during 2009. These findings include:

(1) a decisive and successful response, as well as a decade of policies and structural reforms, which helped Indonesia recover quickly from the 2008 global crisis;
(2) the Indonesian banking system is generally healthy;
(3) banking supervision and regulation have improved substantially, but gaps remain in dealing with problem banks and crisis management;
(4) Indonesia is planning a major change in the regulatory architecture by creating an integrated supervisory agency.

The overall performance and development of commercial banks during the period of financial reform can be seen in Table 2.5. The indicators in the table show that there was a general development of the commercial banks. Most of the figures suggest a consistent progress which includes: the amount of loan and deposits, returns on assets (ROA), the ratio of operations expenses to operating income, loan to deposit ratio (LDR) and net interest margin (NIM). Even though the other indicators, such as growth of assets, CAR and NPL ratio fluctuated, overall they were progressing.

The first four years of the 2000s highlights the slow progress of the industry, which was still in the recovery period. For instance, the ratio of loan to deposit (LDR) was less than 50%, which implies that the deposits generated by the banks were not expanded proportionally into credits. Furthermore, the assets growth fluctuated during that time from 5.8% in 2001 and dropped to 1.1% in 2001 then climbed to 9.1% in 2003. The inefficiency was also apparent in the high ratio of operating expenses to operating income and a low ROA ratio, especially during the first three years.

Table 2.5: General Performance of Commercial Banks

Year	Growth of Assets (%)	Loan (IDR million)	Deposit (IDR million)	CAR (%)	ROA (%)	Operations Expenses/ Operations income (%)	LDR (%)	NIM (%)	NPL (%)
2000		283,097	699,860	12.46	1.56	98.12	33.41		20.09
2001	5.8	316,059	797,360	19.93	1.45	98.41	33.01	3.6	12.23
2002	1.1	371,057	835,777	22.44	1.96	94.76	38.24	4.14	7.5
2003	9.1	440,505	885,641	19.43	2.63	88.1	43.52	4.64	6.78
2004	4.8	559,470	967,193	19.42	3.46	76.64	49.95	5.88	4.5
2005	15.5	695,649	1,127,937	19.3	2.55	89.5	59.66	5.63	7.56
2006	15.2	792,297	1,287,102	21.27	2.64	86.98	61.56	5.8	6.07
2007	17.3	1,002,012	1,510,834	19.3	2.78	84.05	66.32	5.7	4.07
2008	16.3	1,307,688	1,753,292	16.76	2.33	88.59	74.58	5.66	3.2
2009	9.7	1,437,930	1,973,042	17.42	2.6	86.63	72.88	5.56	3.31
2010	18.7	1,765,845	2,338,824	17.2	2.86	86.14	75.21	5.73	2.56
2011	21.4	2,200,094	2,784,912	16.1	3.03	85.42	78.77	5.91	2.17

Note: Growth of assets includes the Sharia Banks
Source: Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

The turbulence from the global economic crisis had slowed the progress of the industry. It is evidenced by the decline in almost all indicators in 2009. However, all indicators recovered and progressed again in the following year. This implies that because of its experience in the 1997 crisis, the government was much better prepared.

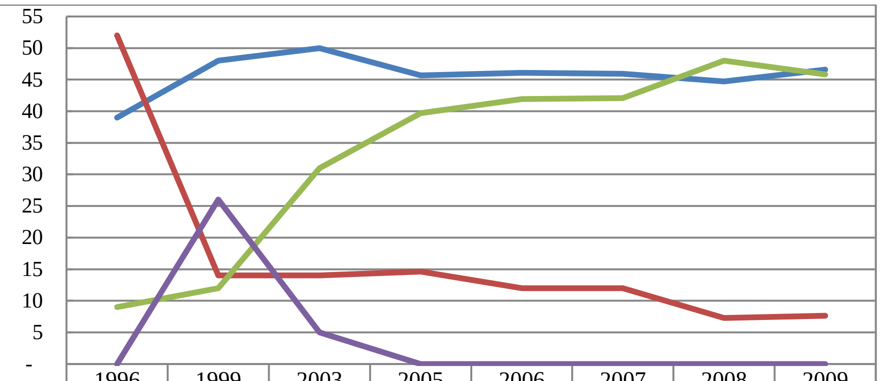
Although the indicators have presented the stable development of the commercial banks, the effect of changes in regulation has also impacted on the banking structure and ownership, assets growth of bank groups and their performances.

2.4.1 The Banking Structure and Ownership of Commercial Banks' Assets

Following the opening of market entry in 1988, the number of banks increased massively including the number of branches reaching a peak in 1996, which recorded 236 commercial banks. Afterward, the number of banks declined gradually due to liquidation during the crisis period and to the merger and acquisition during the 2000s period.

The financial reforms not only changed the number, but also changed the structure of bank ownership in the industry. The evolution of ownership since 1996 to 2009 is presented in Figure 2.11. Before the crisis (in 1996), the share of domestic private to the banking industry was more than half, followed by the share of government owned at 39%, and with the foreign share less than 10%. Afterwards, however, foreign ownership increased steadily and reached almost half of the industry assets share-based in 2008, before it slowed down in 2009. The foreign presence is not merely in the form of a sole proprietorship, but in the form various joint venture businesses. On the contrary, the share of domestic private banks dropped gradually moving to less than 10% share in the industry. Government ownership enlarged its share sharply during the recovery period before they tailed off from 2005 to 2008.

Figure 2.11: Ownership Structure of Commercial Banks (%)



	1996	1999	2003	2005	2006	2007	2008	2009
State Owned Bank*	39	48	50	46	46	46	45	47
Local / Private	52	14	14	15	12	12	7	8
Foreign**	9	12	31	40	42	42	48	46
IBRA	-	26	5	-	-	-	-	-

Note : For 1996,shares are based on shares in bank credit

* State owned commercial banks and regional development banks

** Including foreign bank branches, joint-venture banks and foreign acquisition banks

Source : IMF Country Report (2004), Banking Supervision Report, Bank Indonesia, various edition.

This phenomenon is possibly associated with policy acted upon during the crisis. For instance, during the recovery period, banks liquidation occurred largely in the private banks. A similar story happened in bank acquisition, in which many private banks were acquired either by the government or by the foreign investors. Subsequently, the program of recapitalisation and restructuring during the recovery period led to IBRA ownership from 1999 until 2003.

2.4.2 Assets Growth of Commercial Banks

Despite the positive improvement of commercial banks' total asset, nonetheless, the growth of banks' assets per groups was varied. Figure 2.5 demonstrates how the assets of groups of banks were distributed and grew during 2000s. None of the group had experienced straight growth in their assets, yet, the fluctuation was varied among the groups: four out of six groups have even suffered a negative growth in their assets. These groups are state owned banks, non-foreign exchange banks, joint venture banks and foreign exchange banks. The negative growth for those four groups ranged from -2.5% to -12.5%. It occurred up to 2004 except within foreign exchange banks that grew by -12.5% in 2009. This fact is unsurprising. Indeed, the foreign exchange banks were the most affected by the global financial crisis in 2008, while two other groups; foreign exchange commercial banks and regional development banks, fluctuated but still grew positively.

The highest growth among groups was experienced by regional development banks which grew at 80% in 2001 and 50 % in 2006. This figure followed by non-foreign exchange banks at 40.7 % in 2010 and joint venture banks at 40.5 % in 2007. The growth of commercial bank's assets, however, did not seem to have a strong and direct correlation with the growth of their branches as presented in Figure 2.7 and neither with the number of banks. For instance, the highest branch growth for regional development banks and non-foreign exchange banks occurred in 2003 (not in 2001 and 2010) at 10.3% and 32.6 %, respectively with similar patterns within other groups. Furthermore, this phenomenon offers additional data for the commercial banks as a whole. After the growth of assets slumped to 9.7% in 2009, it consistently increased from 18.7% (2010) to 21.4 % (2011). On the contrary, the growth of branches from 2007 increased, reaching its highest growth in 2009 at 18.1% before a decrease to 7.8 % (2010) and 6.9% (2011).

Table 2.6: Commercial Banks Assets Distribution and Growth

Groups		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
State Owned Banks	N	525.2	533.4	516.6	556.1	519.0	565.6	621.2	742.0	847.6	979.1	1,115.5	1,328.2
	G		1.6	-3.2	7.7	-6.7	9.0	9.8	19.4	14.2	15.5	13.9	19.1
	S	50.5	48.5	46.4	45.8	40.8	38.5	36.7	37.4	36.7	38.6	37.1	36.4
Foreign Exchange Commercial Banks	N	347.7	365.9	393.9	436.2	494.2	571.2	663.0	768.7	883.5	958.5	1,203.4	1,464.0
	G		5.3	7.7	10.7	13.3	15.6	16.1	15.9	14.9	8.5	25.5	21.7
	S	33.4	33.3	35.4	35.9	38.8	38.9	39.1	38.7	38.2	37.8	40.0	40.1
Non-Foreign Exchange Commercial Banks	N	14.7	18.0	21.0	25.5	23.3	26.3	29.7	39.0	42.5	55.8	78.5	107.1
	G		22.6	16.6	21.6	-8.6	12.8	12.8	31.5	8.9	31.3	40.7	36.4
	S	1.4	1.6	1.9	2.1	1.8	1.8	1.8	2.0	1.8	2.2	2.6	2.9
Regional Development Banks	N	26.2	47.1	58.2	66.4	78.5	106.4	159.5	170.0	185.3	200.5	239.1	304.0
	G		80.1	23.5	14.2	18.2	35.6	49.9	6.6	9.0	8.3	19.2	27.1
	S	2.5	4.3	5.2	5.5	6.2	7.2	9.4	8.6	8.0	7.9	7.9	8.3
Joint Venture Banks	N	43.8	42.7	39.3	39.3	50.0	59.6	64.4	90.5	118.1	135.7	150.0	181.1
	G		-2.5	-7.9	-0.1	27.3	19.2	8.0	40.5	30.6	14.9	10.6	20.7
	S	4.2	3.9	3.5	3.2	3.9	4.1	3.8	4.6	5.1	5.4	5.0	5.0
Foreign Owned Banks	N	82.3	92.5	83.2	90.0	107.1	140.7	156.1	176.3	233.7	204.5	222.3	268.5
	G		12.4	-10.0	8.1	19.0	31.3	10.9	12.9	32.6	-12.5	8.7	20.7
	S	7.9	8.4	7.5	7.4	8.4	9.6	9.2	8.9	10.1	8.1	7.4	7.3
Total	N	1,039.9	1,099.7	1,112.2	1,213.5	1,272.1	1,469.8	1,693.9	1,986.5	2,310.6	2,534.1	3,008.9	3,652.8
	G		5.8	1.1	9.1	4.8	15.5	15.2	17.3	16.3	9.7	18.7	21.4
	S	100	100	100	100	100	100	100	100	100	100	100	100

Note: N, G and S denote nominal (IDR trillion), growth (%) and share (%), respectively.
Source: Growth and share are author's calculation based on data from Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

In terms of the amount, all groups show improvement in their assets even though this was not proportionately distributed among the groups. The share of state owned and foreign exchange banks dominated the assets of commercial banks leaving the other groups far behind them. From the highest to the lowest share, it can be ranked (on average) as; state owned banks, foreign exchange commercial banks, foreign banks, regional development banks, joint venture banks and non-foreign exchange banks with share 41.1%, 37.5%, 8.4%, 6.8%, 4.3% and 2.0% respectively.

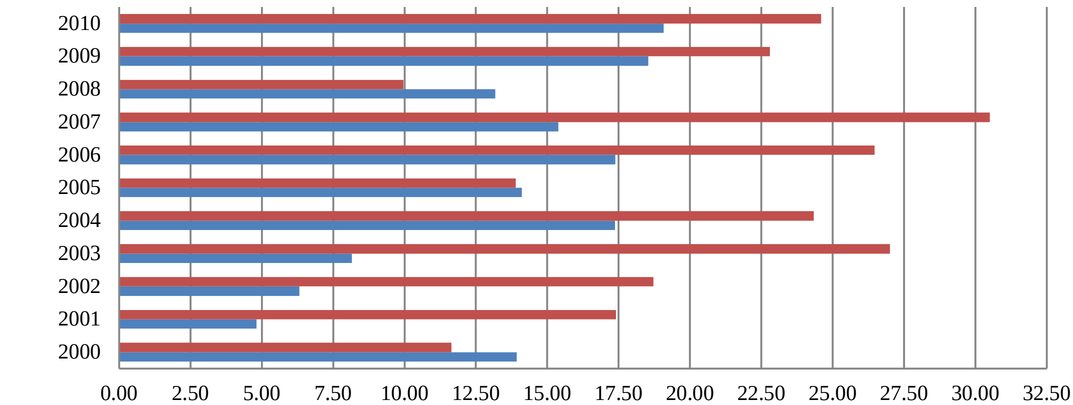
Nonetheless, the shares of two top rankings, showed the opposite trend. The share of the state owned banks has been constantly decreasing from year to year: from 50.5 % in 2000 to 36.4% in 2011 whereas foreign exchange banks have been steadily increasing (33.4 % in 2000 to 40.1% in 2011). As mentioned in Section 2.2 that since 2005 the domination in asset shares has shifted from state owned banks to foreign exchange banks up to now. This hegemony is likely to be continued onwards, since foreign exchange banks are the only groups showing increasing growth both in number of banks and branches.

2.4.3 Deposit and Credit

The fluctuation of asset growth was followed by the variability growth of bank deposit and bank credit. However, the growth of credit had been always larger than deposits as displayed in Figure 2.12. Both slowed down in 2009, but continued to show positive growth in the last two years of the data at the same pattern as before the 2009.

The effect of the transition process in the deposit guarantee scheme in 2004 is evidenced in a relatively small growth of deposits from 2000 to 2004. After that, starting from 2005 it grew more than two fold, whilst the credit growths tend to move in an opposite direction. The highest growth occurred in different years for credit and deposits. The growth of credit reached its highest rate in 2007, at 30.5%, whereas deposits experienced the highest rate in 2011 at 19.1%.

Figure 2.12: Annual Growth Deposit and Credit (%)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Credit	11.6	17.4	18.7	27.0	24.3	13.9	26.5	30.5	10.0	22.8	24.6
Deposit	13.9	4.8	6.3	8.2	17.4	14.1	17.4	15.4	13.2	18.5	19.1

Source: Author's calculation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

The role of deposits and credits is like an engine for the banks because they are the major component in a bank's assets. The composition of third party funds or deposits collected based on location, is disproportionate as well as the credit not being equally distributed. Both are concentrated in the Java and Sumatera region for 88%, (the western part of Indonesia) followed by the central part: the Kalimantan and Sulawesi region, which accounts for 8%, and lastly the eastern part, consisting of Papua, Maluku. NTB, NTT and Bali, constitute just 4%. These extensive disparities are undoubtedly associated with the variations in population density, which is concentrated on the islands of Java and Sumatera.

Table 2.7 presents the distribution of deposit and credit among groups of banks. The share groups in deposits and loans follow the pattern of the total asset sharing. On average, the state owned banks and the foreign exchange banks still dominate the share at the same level of 40% of deposits and 37% of credit, followed by, consecutively, the foreign exchange banks at 7% and 3 %, the regional development banks at 7% both and lastly the non-foreign exchange commercial banks at 2% and 3%. However, in terms of trends, these two dominators are moving in the opposite direction. The state owned bank groups managed to decrease whilst the foreign exchange commercial banks tended to increase, in keeping with regional development banks.

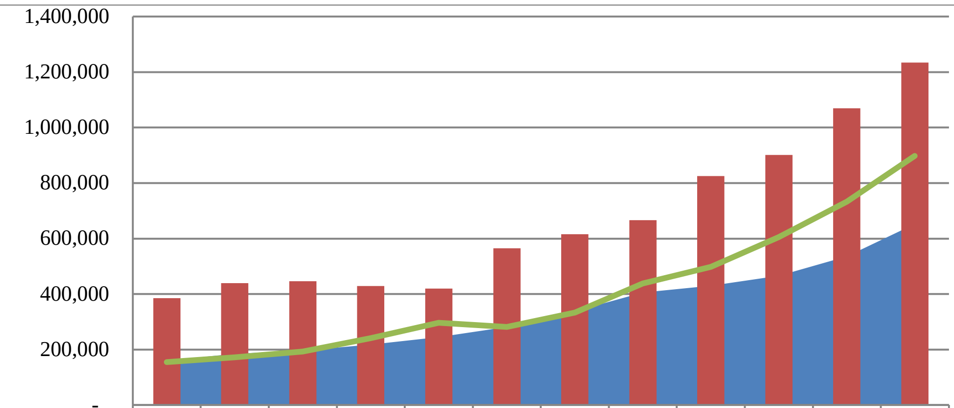
Table 2.7: The Share of Deposits and Credit to the Total Commercial Banks (%)

Year	State Owned Banks		Foreign Exchange Commercial Banks		Non-Foreign Exchange Commercial Banks		Regional Development Banks		Joint Venture Banks		Foreign Owned Banks	
	D	C	D	C	D	C	D	C	D	C	D	C
2000	45.1	38.2	38.0	27.2	1.6	3.7	2.8	3.6	3.1	10.7	9.3	16.6
2001	45.7	38.4	36.4	30.2	1.7	3.1	4.6	4.9	2.9	9.2	8.6	14.1
2002	44.3	40.6	38.4	33.9	2.0	3.1	5.5	5.8	2.6	6.8	7.2	9.8
2003	41.5	40.2	40.6	36.3	2.2	3.3	5.8	6.4	2.5	5.7	7.4	8.1
2004	39.1	39.8	42.0	37.4	2.0	2.7	6.2	6.7	2.9	5.5	7.8	7.9
2005	38.2	36.9	41.0	39.9	1.9	2.4	7.6	6.5	3.1	5.3	8.2	9.0
2006	37.3	36.3	40.8	39.8	1.9	2.4	10.0	7.1	2.8	5.2	7.2	9.2
2007	37.8	35.5	40.2	40.7	2.0	2.4	8.9	7.2	3.6	5.8	7.5	8.4
2008	38.4	36.0	40.3	40.1	1.3	2.1	8.2	7.4	4.4	5.8	7.4	8.7
2009	39.7	37.9	39.6	38.6	2.2	2.5	7.7	8.4	4.8	5.6	6.0	7.0
2010	38.4	36.4	41.7	40.7	2.5	2.8	7.9	8.1	4.2	5.6	5.3	6.4
2011	37.3	35.3	42.2	41.9	3.0	3.1	8.4	8.0	4.0	5.5	5.1	6.2

Note: D : Deposit, C : Credit
Source: Author's calculation based Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

Typically, deposits or third party funds are collected from three kinds of deposit products; saving deposits, time deposits and demand deposits. The composition of deposits in commercial banks is presented in Figure 2.13. Time deposits are the main source of bank funds in any groups then followed by saving deposits and, lastly, demand deposits. The trend towards time deposit shares was declining while the share of saving deposits shows a reversing trend. The demand deposits remained stable in terms of share, but it exhibits an increasing pattern in terms of growth. Although credit in banking has always increased more than deposits, it was not distributed proportionally among economic sectors.

Figure 2.13: Type of Deposits Composition (billion IDR)



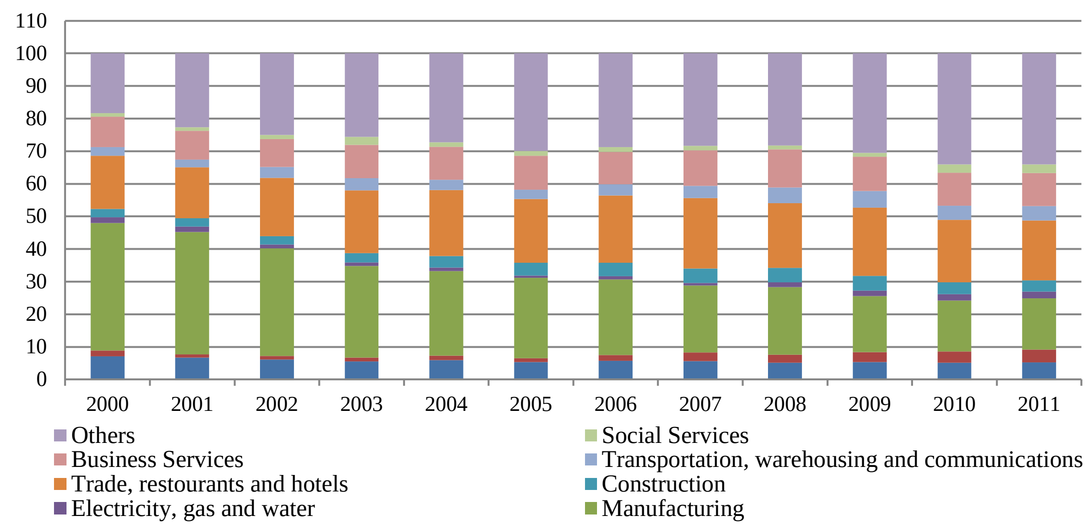
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Demand Deposits	160,21	184,86	196,22	217,99	244,96	281,41	338,01	405,55	430,00	465,88	535,85	652,64
Time Deposits	385,32	439,90	446,19	428,83	419,68	565,03	615,16	666,70	824,70	901,70	1,069,	1,233,
Saving Deposits	154,32	172,58	193,36	241,73	296,35	281,49	333,92	438,57	498,58	605,44	733,15	898,29

Source: Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

Amongst others, the manufacturing sector was recognised as the biggest receiver of bank credit between 2000 and 2003, other sectors gained domination later until 2012. This change of domination was the result of a decrease in the growth of credit to the manufacturing whilst the growth of credit to the other sectors was increasing.

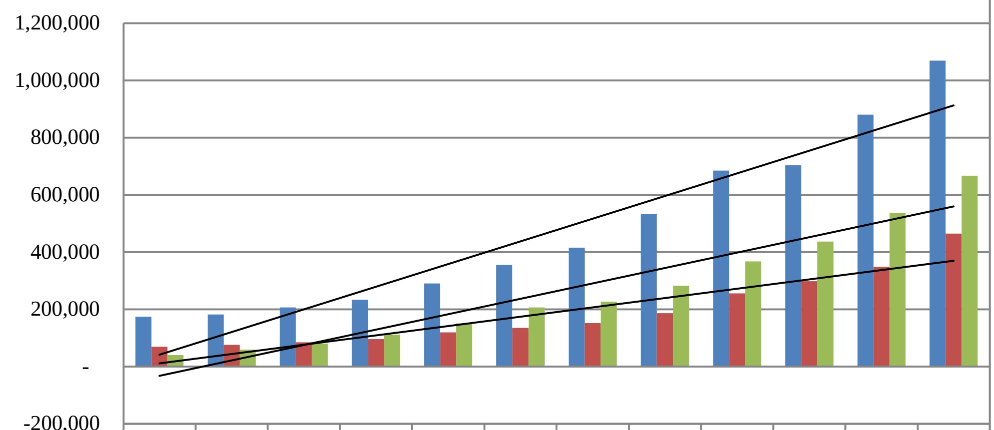
Figure 2.14 indicates the sectors allocated the least bank credit were social services, mining and electricity, gas and power sectors. The growths of these sectors were not improved during the period, nor were the agriculture, construction, and transportation sectors. The sizeable negative growth of credit per sector only occurred at the beginning of the period. In 2009, around the global crisis the negative credit growth only apparent in manufacturing and business services.

Figure 2.14: Credit Distribution by Economic Sectors (%)



Source: Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

Figure 2.15: Credit by Use (billion IDR)



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total Working Capital	174,02	181,60	206,64	233,51	289,66	354,55	414,74	533,24	684,67	703,00	880,20	1,068,
Total Investment	68,807	75,842	84,424	95,775	118,72	134,40	151,20	186,21	255,90	297,93	348,51	464,26
Total Consumption	40,261	58,598	79,987	111,21	151,08	206,69	226,33	282,55	367,11	436,98	537,11	667,15

Source: Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

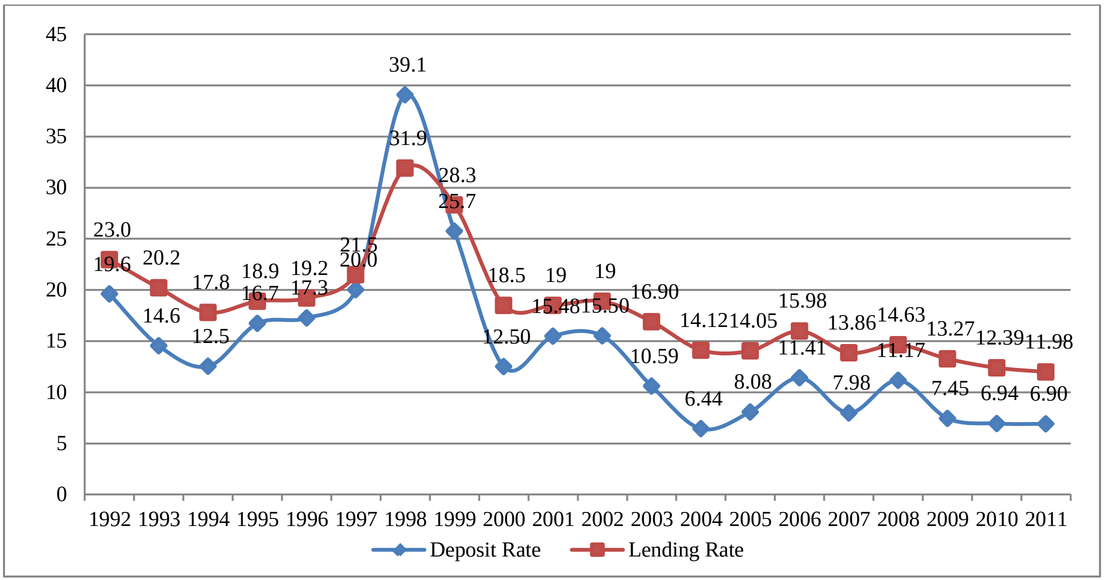
In terms of utilisation, bank credits are classified into three types of use: working capital, investment and consumption. Figure 2.15 reveals the distribution of bank credits by type of credit utilisation. The figure suggests that the use of credit for working capital has dominated the total credits. However, the share of this kind of credit used was decreasing. The annual growth of credit to this utilisation constantly increased until 2008 before dropping in 2009. At the same time, two other types also improved in nominal credits received. Indeed, the share of credit to consumption has increased whilst its share of investment tended to decrease.

2.4.4 The Interest Rate

Deregulation in 1983 initiated freedom in determining the interest rate. Since that time, the banking industry in Indonesia has been free to determine their deposit and lending rates. Although for deposit interest rates, the central bank had gradually freed the state banks to determine deposit rates before the 1983 deregulation (Astiyah 2001). The liberalisation of interest rates had resulted in the positive spread between lending and deposit rates until 1997. As reported by Astiyah (2001), the spread declined substantially during the 1988 to 1991 period, which was associated with the competitive condition since the number of banks increased extensively.

Figure 2.16 presents the movement of deposit and lending rates during the period from 1990s to 2000s. After having a small differential in 1991, the industry again enjoyed the larger positive spread until June 1997, but it swung back to a negative spread in 1998 during the Asian financial crisis. Successively, the positive spread recovered quickly in the following year, which was related to the common phenomenon that lending rates rise faster, but are slower to decrease. As deposit rates fell substantially by more than 50%, the lending rates only fell by 11%, which kept the lending rates high.

Figure 2.16: Deposit and Lending Interest Rates (%)

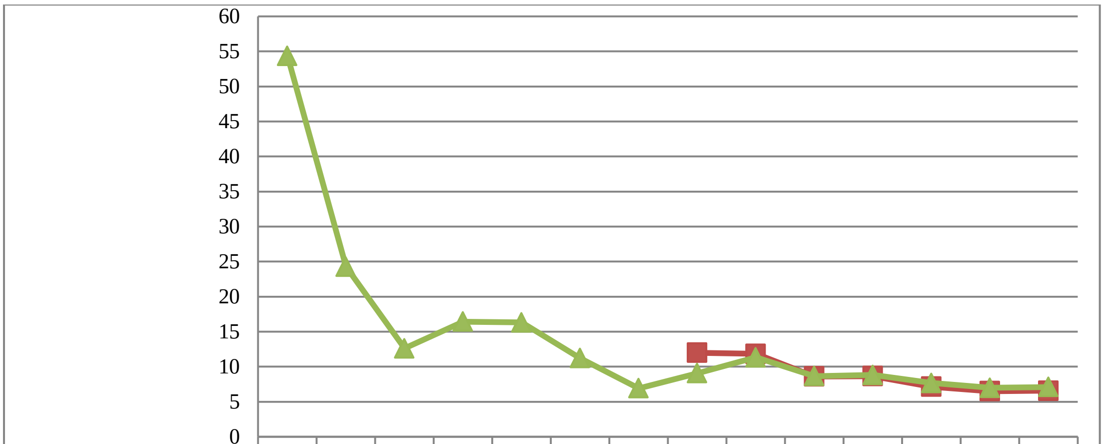


Note: Deposit rate is an average of three months' time deposit rate, lending rate is an average of working capital credit rate.
Source: Author's calculation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

As part of a blanket guarantee scheme, the central bank had set the maximum deposit rates in the mid of 1998 until the establishment of the IDIC in 2004. Along with the restoration of public confidence, the deposit rate was gradually decreased and had only a small fluctuation during the global financial crisis.

Since the implementation of the blanket guarantee programs, followed by the establishment of the IDIC, the banks have had to refer to the guarantee rate or insurance rate in order to determine its deposit rates. The movement of the guarantee rate is depicted in Figure 2.17 along with the Bank Indonesia rate (BI rate). The BI rate is the rate that reflects the monetary policy stance. It is implemented in the monetary operation conducted by the central bank in order to manage the liquidity in the money market. The rate is decided in a monthly meeting of the central bank board of governors and then announced to the public.

Figure 2.17: Deposit Insurance and BI Rate (%)



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
BI Rate								12.0	11.8	8.6	8.7	7.1	6.5	6.6
Deposit Ins. Rate	54.4	24.3	12.6	16.4	16.3	11.2	6.9	9.1	11.3	8.7	8.8	7.7	7.0	7.1

Note: - From 1998 to 2005 deposit insurance rate is the average of one and three months deposit guarantee rate in respected year (author's calculation)
- From 2006 onward is taken directly from published insurance rate

Source: Indonesian Financial Statistic, Bank Indonesia (2005c, 2011c)

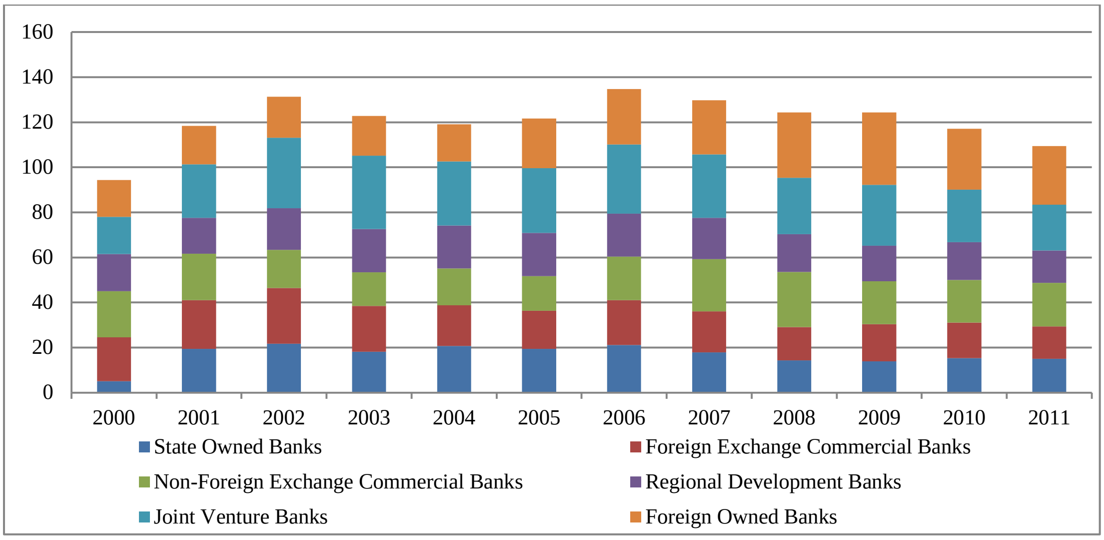
The deposit insurance rate is determined and published by the IDIC. It reveals in the figure above that the movement of both, BI rate and deposit insurance rates, are constantly decreasing especially since 2006. The extreme guarantee rate is shown in 1998 (54.5%) which was the period of crisis.

2.4.5 Performance of Commercial Banks

As the main contributor in the Indonesian banking industry, it can be concluded that the performance of commercial banks represents the performance of the industry. The financial reforms have made a significant impact on the industry, including the performance of the six groups of commercial banks. The measures of performance are observed in term of capital adequacy, liquidity, profitability and non-performing loan ratio.

The requirement for capital adequacy for banking during the reforms periods has been changed several times. The requirement is related to the minimum ratio of capital to risk weighted assets[10]. The average capital adequacy ratio (CAR) for each group is illustrated in Figure 2.18. In general, all the groups have improved their CAR. However, the state owned banks and regional development banks were the least improved among the groups. While joint venture banks and foreign banks performed better and constantly held the ratio above 25%.

Figure 2.18: Capital Adequacy Ratio of Commercial Banks (%)



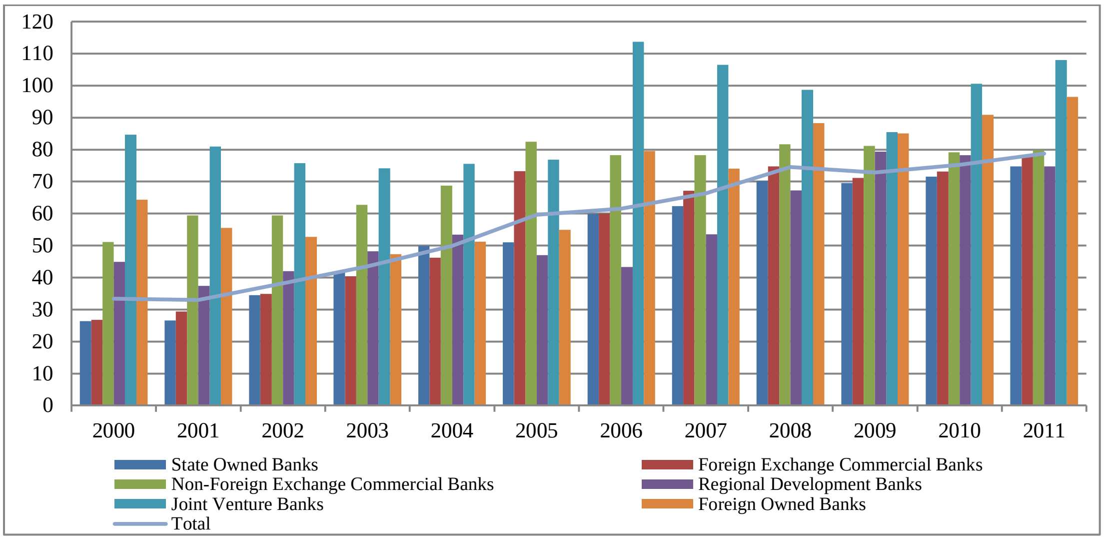
Source: Author's compilation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c).

Liquidity is measured by the ratio of the total loans to total deposit (LDR). Figure 2.19 depicts the LDR achievement of bank groups. It shows that the LDR for all groups were increasing constantly. The state and regional banks again tended to be the lowest among the groups which indicates their inability to circulate the deposit

[10] Risks weighted assets consist of credit risk, operational risk and market risk.

generated into credit. This performance was in contrast with the joint venture banks, which were able to distribute funds in the form of credit at 90% on average, and even more than 100 % in 2006, 2010 and 2011.

Figure 2.19: Loan to Deposit Ratio of Commercial Banks (%)



Source: Author's compilation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

The profitability of banks is indicated by the return on assets ratio (ROA), which is the ratio of profit to the total assets, the ratio of operating expenses and operating income and net interest margin (NIM). These three ratios present a converse trend in term of percentage size.

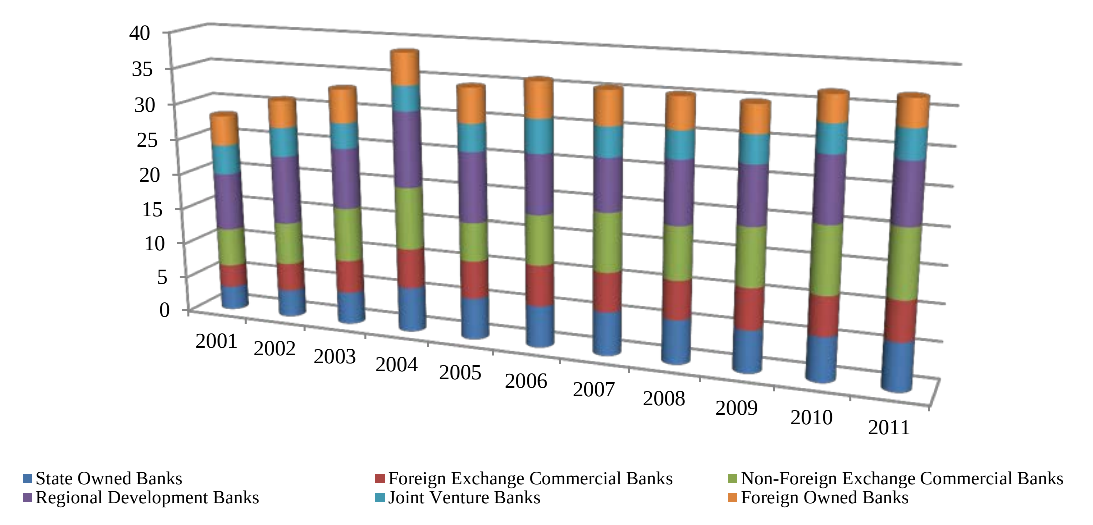
Table 2.8: Profitability of Commercial Banks (%)

Year	State Owned Banks		Foreign Exchange Commercial Banks		Non-Foreign Exchange Commercial Banks		Regional Development Banks		Joint Venture Banks		Foreign Owned Banks	
	*)	**)	*)	**)	*)	**)	*)	**)	*)	**)	*)	**)
2000	1.47	106.6	0.77	90.3	1.77	90.6	1.91	88.9	5.41	72.08	3.14	80.52
2001	0.99	104.07	1.23	95.59	1.97	91.65	4.1	78.8	4.42	81.75	2.45	97.24
2002	2	98.43	0.98	97	2.17	91.27	3.83	77.67	2.42	86.64	4.41	80.4
2003	2.67	92.07	2.16	86.62	0.95	95.33	3.05	80.39	3.36	79.15	4.4	81.94
2004	3.46	75.73	3.09	78.25	2.79	83.94	3.99	68.39	3	76.95	5.22	75.71
2005	2.54	95.17	2.17	88.31	0.96	97.48	3.38	76.17	3.31	74.92	2.9	82.8
2006	2.22	97.05	2.35	82.53	2.08	92.25	3.38	76.15	3.72	79.05	4.35	81.18
2007	2.76	90.68	2.44	81.85	2.99	83.58	3.08	76.06	3.06	79.78	3.83	79.98
2008	2.72	89.68	1.25	93.76	2.2	86.73	3.7	73.04	2.87	83.57	3.89	83.38
2009	2.71	92.35	2.2	86.27	1.35	95.02	3.7	73.64	2.32	84.5	3.89	78.78
2010	3.08	88.23	2.58	85.53	1.82	89.91	3.82	77.65	2.03	84.1	3.05	88.61
2011	3.6	91.94	2.46	80.47	2.95	83.91	3.36	79.14	2.05	85.99	3.55	83.24

Note: *): Return on Assets (ROA), **): Operation expenses to operation income
Source: Author's compilation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

Table 2.8 shows the first two ratios together for each group of banks, while Figure 2.20 illustrates the net interest margin per group. As indicated in Table 2.8, foreign and non-foreign exchange commercials banks were the lowest groups in generating profit, while foreign banks and regional development banks made a higher profit compared to others. Net interest margin is measured by the ratio of net interest income to the average earning assets. Figure 2.20 suggests that the regional development banks were the group that able to generate wider margins relative to earning assets. While joint venture and foreign banks were the smallest groups in this ratio.

Figure 2.20: Net Interest Margin of Commercial Banks (%)

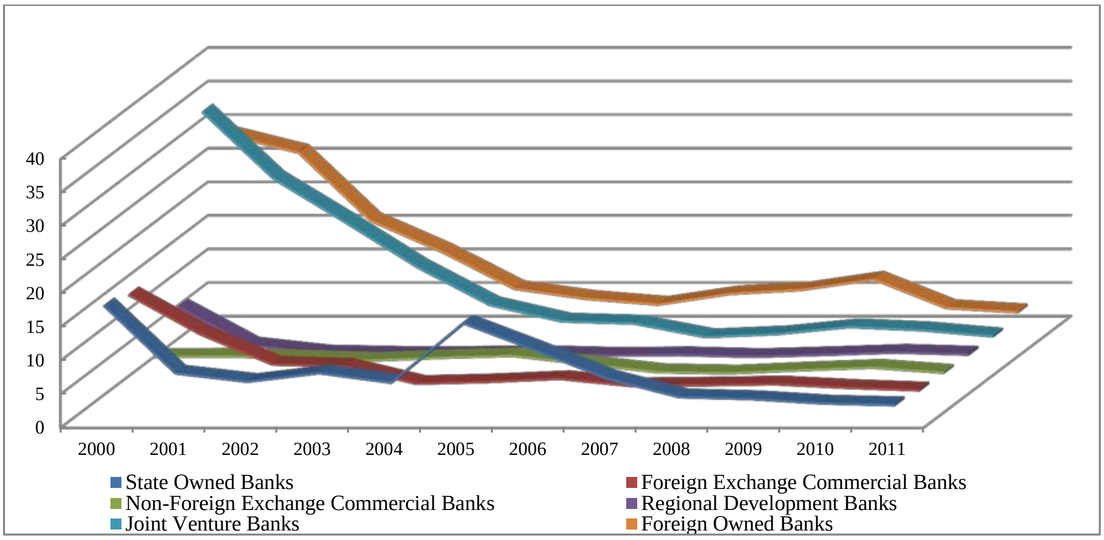


Source: Author’s compilation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

A good performance of commercial banks is demonstrated in the non-performing loan ratio (NPL). Although the industry had suffered with a substantial bad loans for a long period (before the 1997 crisis until the beginning of 2000s period), the NPL ratio shows a declining trend for the rest of the data period.

Figure 2.21 presents the non-performing loan ratio by each group of commercial banks. After peaking at the highest level in 1999, the NPL of all groups is decreasing constantly especially after 2005. The groups of the joint venture, foreign owned and state owned banks have been turned out to be the highest in the NPL rate during the period of analysis, while the regional development banks tend to be the lowest.

Figure 2.21: Non Performing Loan of Commercial Banks (%)

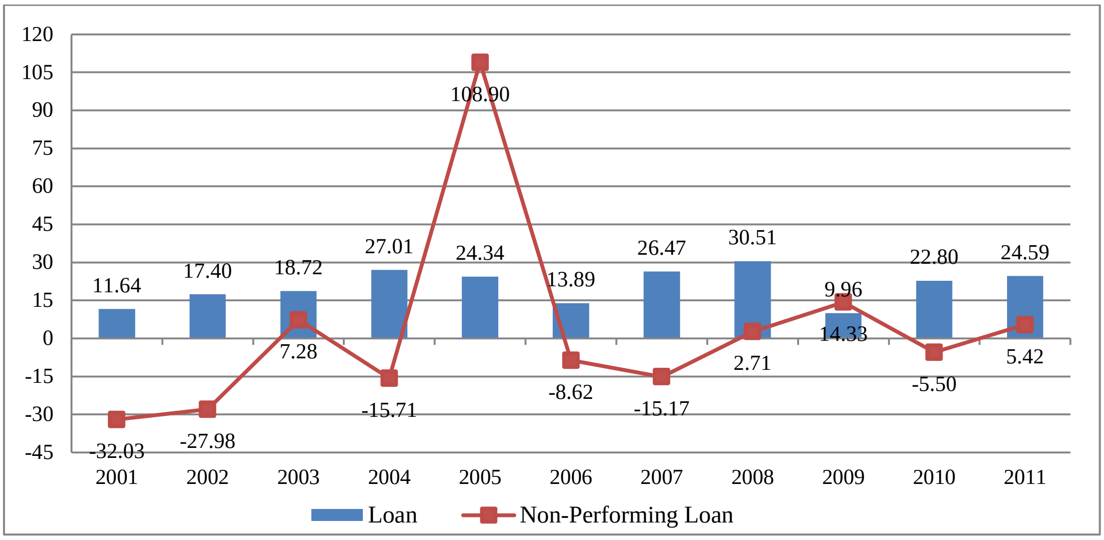


Source: Author's compilation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

One possible explanation could be that the regional development banks had little engagement in financing multinational enterprises which were the most affected by the financial crisis. Their main role has been as local banks, which circulate the funds mostly to local businesses. This limited role has arguably saved them from deepening the NPL. Although the NPL of foreign exchange and non-foreign exchange commercial banks fluctuated during the period under analysis, the rate tends to decline.

In general, the trend of credits and NPL of commercial banks was preceded in an opposite path. This condition is considered to be ideal for a healthy banking industry, with the increase in credits followed by the decreased of NPL. However, in terms of the annual growth, credits and the NPL present dissimilar features as shown in Figure 2.22. The growths did not fluctuate accordingly during the period of analysis. The growth of NPL was not always negative, even when the growth of credits declined. Instead, it had grown even higher than credits in 2005 and 2009. During these two years, the growth of credits was 24.3% and 10% whilst the NPL grew at 108.9% and 14.3%, respectively. These exceptional growths were contributed mainly by state owned banks.

Figure 2.22: Annual Growth of Credits and NPL of Commercial Banks (%)



Source: Author's calculation based on Indonesian Banking Statistic, Bank Indonesia (2005c, 2011c)

So far, the discussion has shown that the reforms have changed the Indonesian banking structure, improved the banking resilient and generated significant improvement in the banking business. In addition, as the reforms have decreased the number of banks, hence the competition is likely to shift to the branch level. Having the improvement in place, the next challenge for Indonesian banking industry is the competition at international level or at least at a regional level.

2.5 Conclusion

This chapter presents an overview of the banking industry in Indonesia. It also discusses the series of major financial reforms introduced since the 1980s and the apparent impact on the banking sector. The banking industry holds the foremost share in the financial sector of the country, and the commercial banks are the main players in this sector. The existence and development of rural and sharia banks have not changed the domination of commercial banks.

The initial sequence of the financial reform resulted in eliminating the government intervention, increasing competition among banks by easing entry requirements in the industry, 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 reforms process and thereafter. The subsequent series of reforms were a setback to the previous radical reforms. Nonetheless, the reforms have affected the banking structure and improved the banking activities during the last decade.

Learning from the 1997 financial crisis, the government seems to be more prepared with more effective strategies in managing the impact and aftermath of the 2008 global financial crisis. The continuing restructuring programs have resulted in a steadily declining number of commercial banks. The consistent policies toward a stronger banking structure are recently supported by the establishment of mandatory regulatory institutions such as the IDIC and the FSA.

The outcome of the financial reforms on the banking industry can be evaluated in various ways. As noted in the literature, financial reforms tend to have different outcomes in different countries since many factors are involved. The multiple goals of financial reforms present another challenge to conduct a comprehensive study to investigate the achievements of these goals. Hence, it is worth assessing the impact of reforms on the efficiency and productivity growth of the Indonesian banking industry. The subsequent chapters develop appropriate approaches in order to investigate the impact of various reform programs and evaluate banking performance in terms of efficiency and productivity growth.

Chapter 3
Bank Efficiency and Productivity: A Review of the Theoretical and Empirical Literature

3.1 Introduction

Chapter 2 has discussed the background of the Indonesian banking sector and the series of changes due to deregulation, liberalisation and bank reforms since the 1980s. It maps the trends and development of the Indonesia banking sector up to the present. The impact of financial reform on bank performance so far has been in the number of banks which decreased in the country, while the total asset is increased significantly. Although this can be seen as a positive signal for the performance of the Indonesian banking industry, it does not necessarily imply that the efficiency and productivity of Indonesian banks improved after the implementation of the series of deregulation and liberalisation reform. This infers the need for further investigation of the impact of deregulation on bank efficiency and productivity with up to date data and appropriate techniques.

The aim of this chapter is to provide a critical review of the theoretical and empirical literature on bank efficiency and productivity. This chapter comprises six main parts starting with an introduction, followed by the concepts of efficiency and productivity discussed in Section 3.2. Empirical evidence from international studies is discussed in Section 3.3, comprising two subsections; subsection 3.3.1 reviews cross-country studies, and subsection 3.3.2 reviews of single country studies of bank efficiency and productivity. Section 3.4 reviews studies of deregulation and bank efficiency and productivity. Following this section is the empirical evidence of Indonesian banking efficiency studies in Section 3.5. The discussion under this section mainly covers cross-country studies, which included Indonesian banks in their sample, and also presents the review of Indonesian bank efficiency and productivity studies as a single country. The last section of this chapter is Section 3.6, which summarises the whole chapter.

3.2 The Concepts of Efficiency and Productivity

The foundation of modern efficiency measurement begins with the seminal work of Farrell (1957). Following the ideas of Debreu (1951) and Koopmans (1951), Farrell initiated a study into measuring efficiency and productivity. Farrell's basic assumption is that of an input-output allocation allows for inefficient operation. The fraction of the actual production to its possible production is defined as the level of efficiency of the decision making unit (DMU). Inefficiency is expressed as the gap between a DMU outcomes and frontier production function, which is established as the standard. If a DMU's actual production lies on the frontier, thus it is fully efficient, however if it lies below the frontier, it means inefficiency. Efficiency ratios take values between zero and one, where one implies that the DMU is fully efficient, otherwise it is inefficient.

Farrell (1957) proposes that a firm's efficiency is comprised of two major elements; technical efficiency (TE) and allocative efficiency (AE). Technical efficiency (sometimes called X-efficiency) reflects the physical relationship of the amount of output produced from a given level of inputs. The TE can be decomposed into scale efficiency (SE), which reflects the most productive scale size, and pure technical efficiency (PTE), which indicates the effectiveness of a firm's production plan in transforming its inputs into outputs. Allocative efficiency is defined as the ratio of minimum cost where a firm can produce output using its inputs in optimal proportion given their respective price and technology. Technical efficiency and allocative efficiency are then combined to present an overall efficiency (OE) which is also known as economic efficiency (EE).

Productivity is defined as the relationship between output (produced goods) and input (consumed resources). A firm can achieve productivity gains by producing either a greater output from a given level of inputs or by using a minimum amount of inputs to produce a given level of outputs (Coelli, Rao, and Battese 1999). Productivity in this context refers to as total factor productivity (TFP), which is a productivity measure involving all factors of production.[11] Hence TFP estimates the overall effectiveness of utilisation of inputs to produce outputs. The measure of TFP

[11] Other measure is partial-factor productivity which is usually expressed in specific attributes such as labour productivity, land productivity, expenses as percentage of total assets and others.

can be obtained using the index number method, in which the Malmquist productivity index (MPI) is one of the options.

The MPI is developed by Caves, Christensen, and Diewert (1982) based on the idea of Sten Malmquist (Malmquist 1953). In their paper, Caves, Christensen, and Diewert state that the Malmquist index is the ratio between two distance functions that compares a firm's productivity with that of an alternative firm. Later, Färe et al. (1994) combine and extend the idea of Caves, Christensen, and Diewert (1982) and Farrell (1957) to measure MPI and decompose it into technical efficiency change (TEC), also known as the catching up effect, and technological change (TC), or frontier shift effect. TEC measures the capacity of a firm to improve its production position relative to the production frontier from one period to another, which reflects an improvement or deterioration in the performance of best-practice firms. The TC captures the shift in the production frontier from period to period. If the value of MPI is greater than one, then it indicates that the productivity has improved, whilst, an MPI less than one indicates declining in productivity.

Two alternative methods are commonly used to construct efficiency frontier and to measure the deviation from it (also known as X-inefficiencies). These are the stochastic frontier approach (SFA) and the data envelopment analysis (DEA) method. SFA is an econometric approach that requires specifying the functional form of the frontier and it is referred to as a parametric method (Ferrier and Lovell 1990; Berger 2007). Other methods under the parametric approach are thick frontier approach (TFA) and the distributional free approach (DFA). However, these last two methods are not as popular as the SFA in the literature.

DEA is a mathematical linear programming that does not require the functional form of the frontier. It is a non-parametric method pioneered by Farrell (1957) and developed by Charnes, Cooper, and Rhodes (1978) and Färe, Grosskopf, and Lovell (1985). Further discussion about this method is presented in the next chapter.

3.3 Empirical Evidence from International Studies

The number of international studies of productivity and efficiency in banking sector has been growing enormously employing either parametric or non-parametric frontier techniques, or both. Amongst other variants in each technique, the SFA and DEA have notably gained more attention in both theoretical and empirical literature. The measures of bank performance studied ranges from technical efficiency and scale efficiency to allocative efficiency.

These methods have been used in many empirical studies to measure efficiency and productivity growth in various industries including financial institutions. An important international survey conducted by Berger and Humphrey (1997) provides evidence regarding the use of these two methods aforementioned to examine the efficiency and productivity of financial institutions. The authors review 130 studies that analyse financial institution efficiency in 21 countries, covering commercial banks, saving banks and loan institutions, credit unions and insurance companies. Accordingly, the authors report that the average efficiency is approximately 77 % (median 82%) of best practice and that the efficiency estimates are mostly the same between parametric and non-parametric studies.

Kourouche (2008) presents an updated list of bank efficiency and productivity studies using frontier methods and records 72 studies utilise non-parametric method, and 53 studies employ the parametric method. Moreover, the study shows that the efficiency score using non-parametric methods tend to be estimated lower than parametric methods. The average and median efficiencies from the above form for the non-parametric techniques are 73% and 77%, respectively; whereas the parametric techniques have a mean of 80% and median of 83%.

With respect to the use of DEA method, a specific survey of studies has been done by Emrouznejad, Parker, and Tavares (2008). They list more than 4000 research articles that are written by 2500 different authors published in journals or book chapters. Likewise, Fethi and Pasiouras (2010) conduct a review on 196 studies and reveal that DEA is the most commonly used operational research technique in examining bank performance. The authors reveal that the method has been used to examine banking sector in almost all country around the world. These surveys imply that in the non-parametric method, DEA has been gaining an extensive number of studies in the literature.

Similarly, although the number of productivity studies in the banking industry is limited compared to bank efficiency studies, recently, the number of research in this area has augmented. In some cases, both measurements are even employed concurrently. Especially the Malmquist Productivity Index (MPI) is recorded to be practiced more often to calculate productivity growth. Kourouche (2008) list the annual average of productivity change from various international studies. A simple descriptive statistic reported by the author shows that mean productivity change is 6.4% (1.064) with a median of 2.9% (1.029) and the standard deviation of 0.13.

Aside from that, Berger and Humphrey (1997) also reveal that previous studies regarding banking efficiency and productivity were dominated by developed countries such as the US and European countries. Nonetheless, with the increase of globalisation of financial services and the development of banking industry there is a significant growth in the number of studies in developing countries, either cross-country or single country studies. The focus of country studies has been shifted to the emerging economies including Asian countries in the late of the 1990s following the Asian financial crisis in 1997. The next subsection presents a review of some empirical studies concerning bank efficiency and productivity using cross-country and single country data.

3.3.1 Cross-Country Studies of Bank Efficiency and Productivity

The cross-country study refers the study of bank efficiency and productivity that utilise multiple countries banking data in the analysis. In the survey of Berger and Humphrey (1997), there are six cross-country studies listed. Latter Kourouche (2008) updates the list and includes 14 studies. The pace of economic integration and globalisation is likely to lead to an increase of such studies. Cross-country studies of bank efficiency and productivity that include Indonesian banks are not included in this section. However, they are included in the Section 3.5 which discusses empirical evidence from Indonesian studies.

Study by Berg et al. (1993) is known as a pioneer for comparing bank efficiency across different countries. The authors measure the level of technical efficiency of three Nordic countries using DEA method. Findings from Berg et al. are based on an analysis of 1990 data relating to 503 Finnish, 150 Norwegian and 126 Swedish banks. This research covered most of the banking industry in these three countries The results indicate that under both assumptions, variables return to scale (VRS) and constant return to scale (CRS), Swedish banks are found to be the most technically efficient and productive, followed by Norwegian banks with Finnish banks the least efficient. Moreover, the authors justify that Swedish banks are in favour of expanding in a future common Nordic banking market. Nonetheless, the authors note that their own findings indicate the output vectors were regarded as a less suitable measure of true production activities in large banks than small banks.

A number of cross-country studies have, subsequently, been conducted around the world presenting differing results. Such studies are mostly conducted within countries that are grouped based on specific features such as, region/zone, economic development stage, financial crisis experience and deregulation. Following Berg et al. (1993), a cross-country study that also employ non-parametric DEA includes Casu and Moluneux (2003) who investigate whether the productive efficiency of European banking system improved between 1993 and 1997. This study analyses banks in France, Germany, Spain and United Kingdom and employs a Tobit regression model in the second stage to evaluate the determinant bank efficiency. The average efficiency score obtained is 0.65, is virtually similar to the result of Berg et al. (1993), Lozano-Vivas, Pastor, and Pastor (2002). Furthermore, the second stage results show that most of the efficiency differences across European banking systems seem to be due to country-specific aspects of the banking technology.

Another study in the European countries that also employs non-parametric method is a study done by includes Brissimis, Delis, and Papanikolaou (2008), exploring the relationship between performance, reform, competition and risk-taking across ten newly acceded European Union (EU) countries for the period of 1994 to 2005. This study measures the TFP along with the double-bootstrap of Simar and Wilson (2007) to obtain the efficiency score and the determinant of efficiency. The findings conclude that the efficiency and TFP improve and that banking sector reforms stimulate a positive effect on bank efficiency. The effect is particularly pronounced in the competition and risk-taking by banks. A similar claim is also reported by Kessy (2007) in an article using three African countries during the period of 1994-2005. A fixed-effects panel model is employed in the second stage to evaluate the relationship between bank efficiency of African countries and economic growth. This study argues that scale efficiency is more favourable than TE in African banks, with relatively efficient banking sector associate with faster economic growth.

Cross-country studies using the parametric approach, such as SFA, also present significant findings. Study by Delis, Molyneux, and Pasiouras (2011) show that both cost and profit efficiencies are positively related and affected by a higher official supervisory power. Using panel data of 615 commercial banks reside in 74 countries; the authors investigate the impact of the regulatory and supervisory framework on cost and profit efficiency. The study reveals that although higher capital requirement simulate a positive impact on cost efficiency, but it shows a negative effect on profit efficiency.

Accordingly, Yildirim and Philippatos (2007), covering 12 countries in Central and Eastern Europe (CEE), assess the efficiency of commercial banks during liberalisation, restructuring and deregulation process over the period 1993 and 2000. The distribution-free approach (DFA) and SFA are utilised to obtain the result. The finding concludes that the managerial inefficiencies in CEE countries are substantial, with the average level of efficiency 72% and 77% by the DFA and SFA, respectively. Subsequently, this study is extended by Koutsomanoli-Filippaki, Margaritis, and Staikouras (2009) for the period of 1998-2003 in the same region but with two less countries than the previous study. The productivity change is measured along with the efficiency by employing directional technology distance method. This study confirms the finding of Yildirim and Philippatos regarding the significant level of inefficiency for the whole CEE region, with a marked variation across countries. Moreover, this study also reveals that banks' efficiency is stagnant, and the productivity only begins to increase after 2000. In addition, banks with a foreign strategic investor appear to have achieved the highest productivity gains amongst all types of credit institutions.

Taking a combination of the SFA and DEA, Wezel (2010) assesses the efficiency of domestic and foreign banks in the Central American region during foreign entry in the region for the period of 2002 -2007. This paper analyses banks' efficiency in Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras and Nicaragua both by country and type of bank. The results show that foreign banks are virtually more efficient than local banks, which is typically found in bank efficiency studies. However this research contradicts a study by Koutsomanoli-Filippaki, Margaritis, and Staikouras (2009), who find that domestic and regional banks generally achieve a higher productivity improvements compared to international banks.

The increasing number of multiple country studies on bank efficiency and productivity in fact provides further evidence regarding the comparison of bank performance across countries. Although it is useful to analyse the performance of countries directly comparable to others, it is difficult to conclude that a country's banking sector is more efficient or productive than others. This is due to the fact that the banking industry in each country faces different government policy, regulations, economic development and political conditions, even if the studies are conducted in countries situated in the same region. Common frontier methods used by many researchers are still unable to accommodate these differences.[12]

Given the difficulties of direct interpretation of cross-country studies, a single country study may provide a better, simpler and reasonable approach to review banks performance. The next subsection discusses several single country studies.

3.3.2 Single-Country Studies of Efficiency and Productivity

The first application of DEA in banking efficiency in a single country study is attributed to Sherman and Gold (1985). The authors examine the overall efficiency of the US savings bank at the branch level, and find that six of the sample branches are

[12] There is an increasing trend of studies using the meta-frontier method to accommodate the heterogeneity in the production frontier of bank groups, countries or regions. The method allows for the possibility of technological disparities in the efficiency measurement. O'Donnell, Rao, and Battese (2008), who develop the meta-frontier method for DEA, define the method as "the boundary of an unrestricted technology set". Among others, Kontolaimou and Tsekouras (2010), Ben Naceur, Ben-Khedhiri, and Casu (2011), and Liu and Chen (2012), are studies that employ meta-frontier estimation in their empirical research to analyse banks in different countries.

inefficient compared to the others. Despite the significant findings in this paper, it, however, gains less attention in the literature. Recently, most of the research using the DEA and other frontier methods in the banking industry shifts the unit of evaluation to the consolidated bank instead of focussing on the branch level. Following Sherman and Gold (1985), amongst others, Rangan et al. (1988), Aly et al. (1990) and Elyasiani and Mehdian (1992) are studies that have employed DEA to larger samples of banks in the US.

Updating the work of Fukuyama (1993) within the Japanese banking industry, Drake and Hall (2003) use cross-section data covering all bank types in Japan (149 banks), in 1997 to estimate cost efficiency. Drake and Hall measure banks size using total lending and divide the sample into six groups. Even though the results imply some similarity to Fukuyama (1993), but the inefficiency is found to be much higher in this study. The technical efficiency of Japanese bank is 72.36% and the main sources of inefficiency are attributed to pure technical efficiency (92.78 %) rather than scale efficiency (78.11 %). In addition, the authors identify that bank size and bank types strongly influence the scale efficiency.

Besides the efficiency, the measurement of productivity growth using the MPI in the banking industry has been an interest of many researchers around the world. A study by Berg, Førsund, and Jansen (1992) is believed to be the first application of MPI within the banking industry. This study use 152 sample Norwegian banks and find that productivity growth is relatively small over the study period. A similar method is used by Sathye (2002) to examine the pattern of productivity change in Australian banks using panel data of 17 incorporated banks during the period of 1995 – 1999. Sathye observes that all Malmquist indices decline and the technical progress during the study has not been satisfactory. An additional simple regression at the end of the paper concludes that there is no strong correlation between bank size and productivity.

Conversely, Lee, Worthington, and Leong (2010) find that the productivity growth of Singaporean banks improves between during 2000 and 2005. This study uses double-bootstrap of MPI to measure productivity, technological and efficiency change and to analyse the determinants of the productivity change. Nevertheless, the coefficients of the variables are not for the most part statistically significant, due to small sample size of the data. A bootstrapped Malmquist index approach is chosen by Arjomandi, Valadkhani, and Harvie (2010) to examine the productivity changes in the Iranian banking industry during 2003-2008. The findings conclude that the efficiency and productivity of private banks depreciate after experienced an improvement in the initial period of study.

Using three approaches, -the intermediation, the value-added and the operation approach- to justify input and output, Das and Ghosh (2006) investigate the performance of Indian commercial banks. The results suggest that medium-sized public sector banks perform reasonably well and the banks are more likely to operate at higher levels of technical efficiency.

Another group of studies combine the DEA along with the MPI to measure efficiency and productivity growth in banking industry. These include Drake (2001), Sturm and Williams (2004) and Salim, Hoquea, and Suyanto (2010). Drake finds that larger banks tend to be more technically efficient than smaller banks in the UK. Productivity growth is evident over the period of study, as the result of a net combination of positive frontier shifts and negative bank "catch-up". Likewise, Sturm and Williams (2004) find foreign banks have a superior scale efficiency compared to the big four banks or the other domestic banks in Australia. Later, Salim, Hoquea, and Suyanto (2010) expand the period of study in Australia and reveal that technical efficiency is the main contributor of overall efficiency in Australian banks. The results also indicate that major banks perform better than the regional bank, which is similar to typical findings in banking efficiency studies.

Built on above single country studies, various methods and data used lead to mixed findings. Although most bank efficiency and productivity studies tend to adopt an intermediation approach to set input and output variables, nevertheless the combinations are varied amongst the studies. The standard measurement in bank efficiency research still includes technical efficiency followed by productivity growth. However, the empirical evidence shows that bank efficiency and productivity studies provide differential levels of results that obviously diverge across banks, years, approach and countries.

3.4 Deregulation and Bank Efficiency and Productivity

This subsection aims to review various studies which have focused on examining the impact of financial reform on efficiency and productivity of the banking industry. Historically, the banking industry in most countries is an industry that operates in a heavily regulated environment. The objective of financial reform is primarily to improve the economic performance, including raising the efficiency of the investment allocation, efficiency and productivity of country financial sector and enhancing the provision of financial services to all sectors of the economy.

The relationship between banking deregulation and banking performance has been discussed over recent decades and this has attracted both theoretical and empirical attention. There have been a number of studies around the world regarding this issue starting from advanced economies and then moving to emerging economies. Table 3.1 lists some selected international studies on the impact of change in regulation on bank efficiency and productivity.

Table 3.1: Summary of Selected International Studies on Impact of Deregulation on Bank Efficiency and Productivity

No	Author(s)	Country	Period of Data	Method	Result
1	Gilbert and Wilson (1998)	Korea	1980-1994	Malmquist indexes	Privatisation and deregulation enhance productivity.
2	Canhoto and Dermine (2003)	Portugal	1990-1995	DEA	Efficiency improves for the overall sample over time in the order of 59%.
3	Isik and Hassan (2003b)	Turkey	1981-1990	DEA-type Malmquist TFP	Bank productivity and efficiency significant improves after deregulation
4	Leightner and Lovell (1998)	Thailand	1989-1994	Malmquist growth indexes and productivity indexes	Productivity improves for most banks and the banks adapt well after financial liberalisation.
5	Bhattacharyya, Lovell, and Sahay (1997)	India	1986-1991	DEA, SFA	Publicly owned banks are most efficient after liberalisation followed private and foreign banks
6	Humphrey (1993)	US	1977-1988	The standard time trend approach, a time specific, annual shifts in cross-section cost functions.	Turns strongly negative when deregulation is initiated in 1981 up the period in an overall negative position.
7	Grabowski, Rangan, and Rezvanian (1994)	US	1979, 1983, 1987	DEA	Decline in the overall, technical, pure technical, and scale measures, while the allocative measure remains unchanged.

8	Wheelock and Wilson (1999)	US	1984-1993	DEA, MPI	Efficiency and productivity generally decline over time among banks of all sizes.
9	Kumbhakar et al. (2001)	Spain	1986-1995	Profit Function model	Declining levels of output technical efficiency along with a significantly high rate of technical progress
10	Grifell-Tatjé and Lovell (1996)	Spain	1986-1991	MPI	Productivity decreases swiftly even for the slowest amid large branch networks banks
11	Lozano-Vivas (1998)	Spain	1985-1991	TFA	Decrease in relative interquartile efficiency for commercial banks and no improvement for savings banks
12	Chen, Skully, and Brown (2005)	China	1993-2000	DEA	Improvement in cost efficiency levels including both technical and allocative efficiency
13	Berg, Førsund, and Jansen (1992)	Norway	1980-1989	MPI, DEA	Deregulation has created a more competitive banking industry.
14	Bonaccorsi di Patti and Hardy (2005)	Pakistan	1981-1992	profit and cost function	Profit and cost productivity increase in pre-reform but regress during the third reform period.
15	Drake, Hall, and Simper (2006)	Hong Kong	1995-2001	DEA	Relatively high inefficiency in Hong Kong bank industry and it tends to increase during study period.
16	Fu and Heffernan (2007)	China	1985-2002	SFA	X-efficiency declines during the second phase of bank reform.

Source: Author's compilation

Note: DEA, SFA, TFA, MPI and TFP denote data envelopment analysis, stochastic frontier approach, thick frontier approach, Malmquist productivity index and total factor productivity, respectively.

The essential feature of deregulation is its effect upon the performance of the industry being deregulated. The improvement in resource distribution will benefit society and may lead to price reduction and enhance services to the customer (Berger and Humphrey 1997). Financial reform also has direct effects upon the efficiency of the financial system, where the main objective of financial and banking deregulation is to improve banking efficiency. However, deregulation does not always lead to the positive result expected. The findings of empirical studies with respect to the impact of deregulation on efficiency and productivity are mixed across the nations.

The research on the impact of deregulation upon efficiency provides three kinds of results. First, a group of studies find that deregulation improves efficiency in Korea (Gilbert and Wilson 1998), Portugal (Canhoto and Dermine 2003), Norway (Berg, Førsund, and Jansen 1992), Turkey (Zaim 1995; Isik and Hassan 2003b), Thailand

(Leightner and Lovell 1998), and India (Bhattacharyya, Lovell, and Sahay 1997). A second group of studies report efficiency declines after deregulation, namely in the US (Humphrey 1993; Grabowski, Rangan, and Rezvanian 1994; Humphrey and Pulley 1997), Spain (Grifell-Tatjé and Lovell 1996; Lozano-Vivas 1998; Kumbhakar et al. 2001) and China (Fu and Heffernan 2007). The third group identifies no change in banking efficiency after deregulation, as reported by Elyasiani and Mehdian (1995), Hao, Hunter, and Yang (2001) and Havrylchyk (2006).

Critical parts of the efficiency and productivity measurement are the input and output specifications. Although, each of the above study utilises different frontier method, study period and sample size, most of them adopt an intermediation approach to justify input and output (Gilbert and Wilson 1998; Isik and Hassan 2003b; Leightner and Lovell 1998; Grabowski, Rangan, and Rezvanian 1994; Canhoto and Dermine 2003; Chen, Skully, and Brown 2005). The rest adopts a value added approach (Berg, Førsund, and Jansen 1992; Grifell-Tatjé and Lovell 1996; Kumbhakar et al. 2001) and profit oriented approach following Berger and Mester (2003) (Drake, Hall, and Simper 2006) .

Studies using the DEA provide various evidence of the deregulation impact. Canhoto and Dermine (2003) find that efficiency improves over the years of study and suggest new banks are more efficient (77%) than the old ones (62%). Similarly, Chen, Skully, and Brown (2005) cover 43 Chinese banks and find the financial deregulation in 1995 is found to improve cost efficiency level including technical and allocative efficiency in Chinese banks. Slightly different, Berg, Førsund, and Jansen (1992) combine the DEA and MPI and find that prior to the deregulation in 1980s, total productivity of Norwegian banking industry is decreased, nonetheless an improvement is shown afterward. The authors justify this result by suggesting that the industry was building up its idle capacity in the advent of deregulation and use that capacity after that. This finding is identical to Isik and Hassan (2003b) who include off-balance sheet items in their outputs sequence to investigate the effect of the deregulation on productivity growth, efficiency change and technical progress in Turkish commercial banking.

An opposite outcome, however, is reported by Grabowski, Rangan, and Rezvanian (1994), Wheelock and Wilson (1999) and Drake, Hall, and Simper (2006) for US and Hong Kong banks, respectively. Grabowski, Rangan, and Rezvanian (1994) utilise three inputs and five outputs to analyse the 1980s US deregulation on efficiency and production economies. From 1979 to 1983, the overall and allocative efficiency escalate whilst the technical, pure technical, and scale efficiency remain static. Conversely, all the efficiency measurements are weakened for the rest of the period, which is in contrast to the result by Humphrey (1993).

Using a two-stage analysis of DEA, Drake, Hall, and Simper (2006) find a relatively high inefficiency in Hong Kong banks which tends to increase over the study period. The Tobit regression employed in the second-stage shows that macroeconomic cycle is the main external influence on Hong Kong banking efficiency. However, the analysis is derived during the deregulation process where the impact of deregulation upon efficiency might not instantly appear.

The findings of Gilbert and Wilson (1998), who employ the Malmquist index, confirm the view that privatisation and deregulation improved potential output, as well as productivity. Likewise, Leightner and Lovell (1998) suggest that majority of Thai banks are well adapted to financial liberalisation and the performance in meeting their own objectives and improvements throughout the period. In addition, Thai small banks reportedly perform poorly under financial liberalisation compare to others and are even less so than similar-sized foreign banks. The authors justify this as due to the more professional staff employed by other banks. A different result for Spanish banking is reported by Grifell-Tatjé and Lovell (1996). The decline in productivity is due mostly to the impact of deterioration in technological change. The authors also indicate that there is no evidence of the effect of mergers and acquisitions on productivity changes.

Bhattacharyya, Lovell, and Sahay (1997) combine the DEA and SFA to examine the productive efficiency in Indian commercial banks during the initial stage of the implementation of the liberalisation. By using DEA at the first step and SFA at the second step, the authors find that the average radial efficiency of all banks during the period of analysis is 80.35, and the most efficient group of bank is publicly owned with a score of 87.40, followed by private and then foreign owned banks with scores of 75.88 and 75.37, respectively.

Using a variant of parametric approach, thick frontier method, Lozano-Vivas (1998) estimates cost efficiency and technical change of Spanish commercial and savings banks during the deregulation of interest rates and removal of geographical restrictions. The results indicate that the average relative inefficiency over the period is 13.5% for commercial banks with saving banks at 11.4%. Fu and Heffernan (2007) find X-efficiency declines during the second phase of bank reform where two state banks and two joint stock banks are reported some significant decreases. Agency problems and strict control of the interest rate are pointed out as the cause of relatively low X-efficiency in Chinese banks.

The result of cost and profit function model also provide different result as reported by some researchers such as Humphrey (1993), Kumbhakar et al. (2001) and Bonaccorsi di Patti and Hardy (2005). Specifically, Humphrey (1993) reports that the average rate of net technical change in the US banking lies between -0.8% and -1.4%. Even though Kumbhakar et al. (2001) make some distinctions with two previous Spanish banking studies (Grifell-Tatjé and Lovell 1996; Lozano-Vivas 1998), their findings confirms that technical efficiency deteriorates during the period of analysis. This also supports the argument that deregulation typically shows positive impact over a longer time. In contrast, Bonaccorsi di Patti and Hardy (2005) find that the impact of banking system reform in Pakistan fluctuates during study period. Their cost and profit function methods reveal that the efficiency increases in pre-reform and at the first round of reform, but then decline during the third reform period of implementation. However, the methodology used in this study assumes that efficiencies are relatively stable over time and unbalanced small sample of banks were used.

Thus, based on the literature, it can be understood that deregulation does not always lead to the improvement of bank efficiency and productivity growth, even in a well-managed and developed economy. Also, the findings reveal that the effect regulatory change on bank efficiency and productivity varies across countries. This may be closer to the existing environment surrounding the banking industry such as the macroeconomic, political and social condition within which policy reform is implemented. Besides, the initial condition of the industry may possibly influence the result. In some cases, the time window affects the real impact on any change in regulation with the net gain of deregulation on efficiency and productivity may only appear in the long run.

3.5 Empirical Evidence from Indonesian Studies

As stated previously, Indonesia has undergone a series of changes in regulations and financial liberalisation, over several periods of transformation. In contrast, however, with international studies, empirical studies on bank efficiency and productivity in Indonesia are relatively sparse. This section documents the empirical studies specifically concerning Indonesian bank efficiency and productivity and begins with cross-country studies that include Indonesian banks in the analysis. This is to provide an illustration of how the Indonesian banking sector performs against other sample countries. What follows is a review of Indonesian bank efficiency and productivity as a single country within the literature.

Cross-country studies that include Indonesian banks as part of sample data can be seen in Table 3.2. Most of those studies cover the East Asian region, except Reynaud and Rokhim (2005) whose sample comprises only two countries from different regions (Indonesia and Turkey). As mentioned earlier, these cross-country studies are documented to present an initial sketch of the performance of the Indonesian banking sector among other country. The findings are varied with respect to the level of relative efficiency and progress during the study period.

Table 3.2: Summary of Cross-Country Empirical Studies on Bank Efficiency and Productivity where Indonesian Banks are Included

No	Author(s)	Period of data	Method	Countries (sample)	Total sample banks	Result for Indonesian bank
1	Laeven (1999)	1992-1996	DEA	Indonesia (54) Korea (25) Malaysia (34) The Philippines (29) Thailand (29)	146	There are substantial increase in efficiency before the crises
2	Karim (2001)	1989-1996	SFA	Indonesia (82) Malaysia (31) The Philippine (27) Thailand (15)	155	Indonesia at the second place of least efficient banks
3	Williams and Nguyen (2005)	1990-2003	SFA	Indonesia, Korea, Malaysia, the Philippines, and Thailand	231	Bank privatisation has raised bank performance to levels in excess of pre-privatisation bank performance
4	Reynaud and Rokhim (2005)	1990-2001	SFA	Indonesia (143) Turkey (57)	200	Indonesian banking sector less efficient in the post crises period
5	Ariff and Can (2009)	1991-2005	DEA	Indonesia (66) Korea (26) The Philippine (32) Thailand (14)	138	Indonesian banks are the least efficient. A reduction of 17% in its average efficiency scores
6	Thoraneenitiyan and Avkiran (2009)	1997-2001	DEA SFA	Indonesia (37) South Korea (15) Thailand (16) Malaysia (23) The Philippines (19)	110	Second least technical efficient at stage 1, however during 2000-2001 were the best performer
7	Hermes and Nhung (2010)	1991–2000	DEA	Argentina, Brazil, Peru, Mexico, India, Indonesia, Korea, Pakistan, Philippines and Thailand	4002 observations	Positive impact of financial liberalisation programmes on bank efficiency
8	Gardener, Molyneux, and Nguyen-Linh (2011)	1998–2004	DEA, Two-stage Tobit Model	Indonesia, Malaysia, The Philippines, Thailand and Vietnam	1419 observations	Overall, the efficiency significantly declines over the period of analysis.

Source: Author's compilation
Note: DEA denotes data envelopment analysis, and SFA stochastic frontier approach.

Some similarities across the studies can be observed in Table 3.2: Firstly, Indonesia is always the biggest contributor in their sample of banks. Secondly, most of these studies evaluate bank performance related to the Asian crisis in 1997. They examine the efficiency and productivity before the crisis (Laeven, 1999; Karim, 2001), both before and after the crisis (Williams and Nguyen, 2005; Ariff and Can, 2009; Reynaud and Rokhim, 2005) and post crisis only (Thoraneenitiyan and Avkiran, 2009; Gardener, Molyneux, and Nguyen-Linh 2011). An exception is Karim (2001), who just compares the bank performance of sample country across of ASEAN without explicitly associating it to the Asian crises. Thirdly, all of these studies employ the intermediation approach in justifying their input and output variables.

Beside the resemblances, these cross-country studies show some differences among them. For instances, Laeven (1999), Ariff and Can (2009) and Hermes and Nhung (2010) employ DEA method in their study, but cover different number of countries, different period of data, variables and present different results. Ariff and Can (2009) use longer data periods and analyse the effects of environmental variables (degree of monetisation, density of demand, population density, overall economic condition, and average asset quality) on bank efficiency. Indonesian banks are found to be the least efficient. Hermes and Nhung (2010) investigate the impact of financial liberalisation on bank efficiency across Latin America and Asia. Their measure of financial liberalisation use a financial liberalisation index developed by Laeven (2003). In general, the findings strongly support the positive impact of financial liberalisation programmes on bank efficiency. This result holds across all three measures, overall technical efficiency, pure technical efficiency and scale efficiency.

Using SFA, studies of Karim (2001), Williams and Nguyen (2005) and Reynaud and Rokhim (2005) present some remarkable findings. In line with the work of Ariff and Can (2009), Karim (2001) reports that Thai banks is the least inefficient, followed by the Malaysian banks, the Indonesian banks and the Philippine banks. The cost efficiency offsets scale efficiency for larger banks in most of ASEAN banks, and state owned banks are least cost efficient compare to privately-owned banks. Williams and Nguyen (2005) add Korea in their sample to measure alternative profit efficiency, technical change, and productivity. Williams and Nguyen inexplicitly compare the result amongst sample countries; but, in general, their result indicates economic justification for the policy of bank privatisation. In terms of state versus private ownership, state owned banks underperform. Although, only comparing two countries, study by Reynaud and Rokhim (2005) is likely to support the results of Ariff and Can (2009) that the Indonesian banking sector tend to be less efficient in the post crises.

In contrast to Laeven (1999), Thoraneenitiyan and Avkiran (2009) investigate the impact of restructuring and country-specific factors on bank efficiency of post-crisis in East Asian banking systems. Their study employs both SFA and DEA to construct the efficiency frontier, and justify three inputs and four outputs. However, the representation of Indonesian banks is relatively small compared to the number of banks in the country. In general, the authors find that bank restructuring does not necessarily enhance bank efficiency.

Based on the discussion above, it is evident that the performance of the Indonesian banking sector, measured in term of efficiency and productivity, amongst other countries tends to be low on average. The next section explores studies related to Indonesian banking efficiency and productivity as an individual country. A search of the literature suggests there have been nine papers related to the Indonesian banking efficiency and productivity analysis.

Table 3.3 shows empirical studies on Indonesian bank efficiency and productivity as single country study. Although the table reveals DEA method have been used more frequently compared to SFA method, nevertheless, these DEA studies present some distinctions between each over their similarities (i.e. mostly adopt intermediation approach and employ conventional DEA).

Table 3.3: Summary of Indonesian Banking Efficiency and Productivity Studies

No	Author(s)	Period of data	Method	Sample banks	Result
1	Harada and Ito (2005)	1999-2003	DEA	10	The average efficiency is on a recovery trend since 1999.
2	Omar, Majid, and Rulindo (2007)	2002-2004	DEA and MPI	21	The average efficiency for the whole industry has decreased significantly.
3	Hadad et al. (2008b)	2007 (Quarterly data)	DEA	130	The average efficiency within the industry during 2007 lies between 62% and 67%.
4	Hadad et al. (2008a)	Jan’ 2006 - July 2007 (monthly data)	DEA and MPI	131	The efficiency ranges between 70% and 82% and main driver of productivity growth is technological progress.
5	Hadad et al. (2010b)	2003-2007 (Quarterly data)	DEA and MPI	129	Malmquist index relatively stable at around 0.964 to 1.704
6	Hadad et al. (2010a)	2003-2007	DEA, and MPI	24 listed banks	Wide dispersion in average efficiency scores from 34% to 97%
7	Margono, Sharma, and Melvin (2010)	1993-2000	SFA	134	Cost efficiency increases from 65% to 91% during pre-crises and decreases to 53 % after crisis
8	Sufian (2010)	1999-2008	DEA	33	The decline in the bank efficiency is mainly due to scale efficiency
9	Zhang and Matthews (2012)	1992-2007	DEA	171,98 and 312 obs.	Cost efficiency is improved post crisis but then falls

Source: Author’s compilation.
Note: DEA, SFA and SBM denote data envelopment analysis, stochastic frontier approach and slack-based efficiency measurement, respectively.

Harada and Ito (2005) use panel data to assess the soundness of the Indonesian banking sector by describing its transition and current status. They find that, in general, the efficiency of the banking sector has been on a recovery trend since the public funds injection of 1999, and the TFP constantly rises after 1999. Using similar approaches, Omar, Majid, and Rulindo (2007) obtain contrary results. The latter study reports that the average efficiency for the whole industry is decreased significantly both under CRS and VRS. However, they find that the TFP improves during the period of 2002-2004; with the year 2003-2004 is noted the highest growth. In addition, the technical change is found to be the main contributor to the TFP growth. Both studies employ a conventional DEA, adopt an intermediation approach to justify output-input variables and cover a relatively small sample banks compared to the number of bank in the industry.

Similarly, a conventional DEA is also used with a relatively small sample size by Sufian (2010) and Hadad et al. (2010a). The first paper, however, extends analysis for 10 years to analyse TE, PTE and SE under intermediation and value added approach of input-output variables. Under the intermediation approach, scale inefficiency is reported the main contributor to inefficiency in all Indonesian commercial bank performing sub-optimally. A later study by Hadad et al. (2010a), uses a small sample, but the study is designed to analyse the listing banks only in relation to stock market performance. They reveal that the efficiency scores of listing banks are relatively broad from 34 % to 97 %.

Hadad et al. (2008a) and Hadad et al. (2008b) improve the sample banks to 131 and 130 banks, respectively, and find that the Indonesian banking industry is to be inefficient. In particular, the first study identifies that technological progress is the main driver of productivity growth. This result is also similar to Margono, Sharma, and Melvin (2010), who use parametric approach to conclude that technological progress take place in the pre-crises period (1993-1997). Furthermore, Margono, Sharma and Melvin report that the average economic of scale before the crises is greater than after the crisis. The TFP outcome is found to be decreased by 1.5% during pre-crisis and even worsened in the post crisis period, especially for joint venture and foreign banks. The authors argue that there are lags in information availability on borrower quality due to the fact that branches are managed centrally, making these two groups (joint venture and foreign banks) underperform. However, the analysis in the post-crisis period is relatively short (three years) to be compared with the pre-crisis, since the impact of the Asian financial crisis to Indonesian economy was prolonged.

Hadad et al. (2008b) employ input-oriented, slacks-based model (SBM) and modified slack-based model (MSBM) of DEA. This study also apply double bootstrapping methodology of Simar and Wilson (2007). Although the whole banking industry is covered, this paper use just the quarterly data in 2007, similar to Hadad et al. (2010b). Hadad et al. (2008b) reveal that state owned banks is the most technically efficient, followed by foreign banks, joint-venture banks, foreign exchange private banks, non-foreign exchange private banks, and regional development banks in that order. The double bootstrap results indicate that large and listed banks are much more efficient than small and non-listed banks. Nonetheless, the improved methodology in this paper is limited by the short period of data analysis where the improvement in efficiency may be hard to observe.

The double bootstrapped method of Simar and Wilson (2007) is also utilised by Hadad et al. (2010a), Hadad et al. (2010b), and Zhang and Matthews (2012) to complement the DEA method. Although the first two papers cover the same period of study and employ similar methods, the sample bank is different. Semi-oriented radial measure (SORM-DEA), and SBM, are adopted to construct Malmquist indices, and decompose the indices into technical efficiency change and technological change. The findings indicate that the average productivity remains relatively steady, except at the beginning of the period where state owned and foreign bank experience an instable productivity.

Amongst others, Zhang and Matthews (2012) conduct a study that utilise the longest period of data (16 years) and use relatively large sample bank. Their research uses different number of observations for three different periods, namely; the pre-crisis period (1992-1996, 171 observations), the period of crises (1997-1999, 98 observations) and post-crisis (2000-2007, 312 observations). The authors also apply three different models of outputs and inputs set to measure the efficiency with regard to assets creation and use of pure stock variables, revenue efficiency and a combination of the two aforementioned measures. The results of the conventional DEA are reported as significantly biased. All the models show that cost efficiency improves in the post-crisis period and reach a peak in 2000-2001, before regressing.

The authors justify this by suggesting that the structural reform program on bank efficiency has generally been positive on Indonesian banks.

Based on the discussion above, it is apparent from these studies on the Indonesian banking efficiency and productivity provides some important empirical findings. The outcomes are varied and a range of methodologies are used. Each empirical study provides different evidence and imposes its own limitations regarding the measurement of efficiency and productivity. A short time span of analysis, partially measured (cover certain group of bank only), and a lack of date post 2008, are some elements that have make these studies are inconclusive. Recent study by Zhang and Matthews (2012) focus the analysis on the efficiency convergence and its determinants without providing productivity analysis. Two studies that incorporate DEA and Malmquist index to measure productivity change (Omar, Majid, and Rulindo 2007; Hadad et al. 2010b) cover small samples, short period of analysis and use quarterly data.

In addition to the existing void found in Indonesian studies, none of those studies focus their analysis on the effect of the change in regulation, especially during the restructuring period following the Asian financial crisis 1997. Therefore, there is some gaps in empirical literature regarding the efficiency and productivity of the Indonesian banking sector. This thesis represents the first attempt to analyse the impact of change in regulations after the Asian financial crisis on bank efficiency and productivity growth.

3.6 Conclusion

This chapter reviews selected theoretical and empirical literature on bank efficiency and productivity growth. The theoretical literature provides two frontier concepts, parametric and non-parametric, to measure efficiency and productivity. Among the available choices in each method, empirical literature identifies the SFA and DEA as the commonly used approaches in assessing bank efficiency and productivity. The domination of these two approaches appears in both cross-country and single country studies. The findings are diverse, some correlate with the theory, but some are opposite to it. In particular, empirical studies on the effect of change in regulations on bank efficiency and productivity provide mixed evidence. The results do not necessarily lead to a positive effect as dictated in economic theories. In some cases, the effect is not clearly shown, whereas others even have a negative impact. Various aspects of the research may lead to the differences in these findings. For instance, variable specification, period of data, the choice of method or the economic environment of the banking industry may have influenced the results. Thus, the effect of deregulation remains an empirical question.

Despite the increasing number of bank efficiency and productivity studies in developing countries, studies focus on the Indonesian case is still limited. The few empirical studies on Indonesian bank efficiency and productivity have provided some important findings. The findings are varied. Various limitations exist and the lacks of statistical inference in the DEA as most adopted methods have created the voids in the empirical literature in Indonesian. Moreover, research in assessing effects of the change in regulation following the Asian financial crisis on bank efficiency and productivity has not been comprehensively conducted.

This thesis will investigate the impact of financial reform on the efficiency and productivity growth in Indonesian banking industry. The research will be conducted by employing data envelopment analysis and Malmquist productivity index complemented by bootstrapping methods to provide statistical inference. Subsequently, a regression analysis will be performed at the second stage to identify the determinant of efficiency and productivity growth. A detailed discussion of the DEA and MPI method will be provided in the following chapter.

Chapter 4
The Analytical Framework

4.1 Introduction

Chapter 3 reveals that frontier approach has been used extensively for measuring performance of financial institutions such as banks. The frontier approach is used to estimate and select the most efficient firm or decision making unit (DMU). The increasing number of studies using the frontier method, as reported in various surveys, is evidenced that this method has become a favoured approach (see Berger, Hunter, and Timme 1993; Berger and Humphrey 1997; Emrouznejad, Parker, and Tavares 2008; Fethi and Pasiouras 2010). This method is further divided into a parametric and a non-parametric approach. Up to the present, no consensus exists in the literature as which approach works best.

The effect of regulatory change is examined in relation to banks' technical efficiency level and productivity growth. In the first stage, the data envelopment analysis (DEA) is used to investigate the impact of regulatory change on the technical efficiency level of banks. Likewise, the effect of regulatory change in productivity growth is analysed using the Malmquist productivity index (MPI). Under MPI, productivity growth is decomposed into technical efficiency change and technological change. Lastly, using the obtained technical efficiency and productivity index from the above mentioned measures, a Tobit regression is employed to identify the determinants of efficiency level and productivity growth.

The rest of this chapter is organised as follows: Section 4.2 presents the frontier approaches to estimate efficiency and productivity. Subsequently, Section 4.3 and Section 4.4 discuss the detail of the stochastic frontier and the data envelopment analysis approaches, respectively. Section 4.5 presents the discussion of the measurement of productivity growth, which includes the Malmquist productivity index and its decomposition. The method of bootstrapping DEA is presented in Section 4.6, followed by the discussion of input and output used to measure the efficiency and productivity in Section 4.7. In Section 4.8, the second stage analysis using the Tobit model is presented. The final section concludes the chapter.

4.2 Frontier Approaches to Estimate Efficiency and Productivity

Among the available approaches, the production frontier approach has gained popularity in measuring bank efficiency and productivity growth. Given the production function is unknown, empirical studies used sample data provided to establish the production frontier for estimating efficiency and productivity gains. As mentioned earlier, theory suggests the frontier could be constructed either by using parametric or non-parametric method. The review of literature in the previous chapter reveals that from these two methods, the stochastic frontier analysis (SFA) (parametric) and data envelopment analysis (DEA) (non-parametric) are the most frequent frontier methods used in the banking literature.[13] The objective of this section is to present an overview of these two alternative frontier models.

4.3 The Stochastic Frontier Analysis (SFA)

The stochastic frontier approach is an econometric estimation of production technologies. The first application of SFA method to the banking industry refers to a study conducted by Ferrier and Lovell (1990). The development of this approach can be traced back to the two pioneering studies, conducted independently by two teams: Aigner, Lovell, and Schmidt (1977) and Meeusen and Van Den Broeck (1977). Their work stems from the early work Aigner and Chu (1968) who used a Cob-Douglas production function of the form:

$$\ln y_i = x_i'\beta - u_i \qquad i = 1, \ldots, I, \qquad 4.1$$

where y_i represents the output of the i-th (i = 1, …, N) firm; x_i is a (K x 1) row vector containing the logarithms of inputs used by i-th; β is unknown parameters to be estimated; and u_i is a non-negative random variable correlated with technical inefficiency. Later, Afriat (1972) assumes that the u_i's follows a gamma distribution

[13] Beside the SFA, the other parametric methods include the distribution free approach (DFA), and the thick frontier approach (TFA), while beside the DEA, the other non-parametric method is free disposal hull (FDH).

of random variables and uses the maximum-likelihood method to estimate the parameters. Subsequently, the least squares method, also known as corrected ordinary least squares (COLS), is introduced by Richmond (1974) to estimate the parameters.

The problem regarding the deterministic frontier model in Equation 4.1 is that it does not take into account of possible measurement errors and other statistical noises upon the frontier. All deviation from the frontier are considered as to be the result of technical inefficiency (Coelli et al. 2005). Aigner, Lovell, and Schmidt (1977) and Meeusen and Van Den Broeck (1977) provide a solution to the problem by including another random variable to denote statistical noise representing uncontrollable factors such as weather, luck, measurement errors and others. These properties differentiate their model with the conventional production function approach described earlier. Their frontier model, which is known as stochastic production function, is simply by adding v_i in Equation 4.1 to form

$$\ln y_i = x_i'\beta + v_i - u_i \qquad 4.2$$

The additional v_i represents other random variables on the value of the output variables (x_1), as well as measurement and approximation errors. The output values are bounded by from above by the stochastic (random) factors $\exp(x_i'\beta + v_i)$ so that is why the model is called the stochastic frontier production function. The value of v_i can be positive or negative and so the stochastic frontier outputs vary with regard to the deterministic part of the model ($\exp(x_i'\beta)$).[14]

The measure of technical efficiency of the *i*-th firm is generally defined as the ratio of the observed output (y_i) of the *i*-th firm relative to the stochastic frontier output, given the input vector (x_i):

$$TE_i = \frac{y_i}{\exp(x_i'\beta + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp(x_i'\beta + v_i)} = \exp(-u_i) \qquad 4.3$$

[14] Details of the important features of the stochastic frontier model are outlined and illustrated in Coelli et al. (2005, p 243 -244).

The main phase to estimate the technical efficiency (TE_i) is to estimate the parameters of production technologies (β) in Equation 4.3, as well as to measure the technical inefficiency by separating the two error components (v_i and u_i). Two methods are commonly used to estimate the parameters the stochastic production frontier model; the maximum likelihood (ML) method and a variant of the corrected ordinary least squares (COLS) method suggested by Richmond (1974).

4.3.1 Estimating the Parameters

The pioneering paper of Aigner, Lovell, and Schmidt (1977) and Meeusen and Van Den Broeck (1977) recommend to use the ML method to estimate the parameters. This method is often more preferred due to the availability of automated ML routines and it has significantly better large sample (i.e., asymptotic) properties (see Coelli (1995) for evidence using Monte Carlo). This method requires a distributional assumption regarding the two error components (v_i *and* u_i) and an assumption of non-correlation between the one-side term (u_i) and input variables (x_i).

In regard to the distributional assumption, Aigner, Lovell, and Schmidt (1977) propose normal $(v_i \sim iidN(0, \sigma_v^2)$ and half-normal $(u_i \sim iidN^+(0, \sigma_u^2)$ distributions for v_i and u_i, respectively. Among other, the half-normal distributions are commonly assumed in many empirical applications to obtain ML estimators for the parameters of the stochastic frontier model, thus the discussion will focus on this type of distributions. Aigner, Lovell, and Schmidt (1977) express the likelihood function for the half-normal model in terms of the two variance parameters, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda^2 = \sigma_u^2/\sigma_v^2 \geq 0$. In term of this parameterisation, the function of log-likelihood is

$$\ln L\,(\mathrm{y}|\beta, \sigma, \lambda) = -\frac{N}{2}\ln\left(\frac{\pi\sigma^2}{2}\right) + \sum_{i=1}^{N} \ln\Phi\left(-\frac{\varepsilon_i\lambda}{\sigma}\right) - \frac{1}{2\sigma^2}\sum_{i=1}^{N}\varepsilon_i^2 \qquad 4.4$$

Where y is a vector of log output; $\Phi(.)$ is the distribution function of the standard normal random variable, and $\varepsilon_i = v_i - u_i = \ln y_i - x_i'\beta$.

Apart from that common choice, there are various distributional assumptions developed by a number of researches. For instance, only slightly different than that of Aigner, Lovell, and Schmidt (1977), Meeusen and Van Den Broeck (1977) propose normal and exponential distribution, Greene (1990) provides a more flexible distributional assumption in suggesting normal and gamma distributions. Similarly Stevenson (1980) proposes normal and truncated-normal distribution by allowing normal distribution, which is truncated below zero to have a non-zero mode.

Although Greene (1990) finds the distributional assumption tends to influence the mean of technical efficiency, several studies show the ranking of the firm by their technical efficiency, in fact, does not seem to be sensitive to the distributional assumption choices. These studies include, Kumbhakar and C. A. Knox (2003), Horrace (2005) and Ritter and Simar (1997). The assumptions might be essential for cross-sectional data. However, recent development of stochastic frontier model in using panel data has relaxed strong distributional assumptions. The repetitions of the observations over time in panel data are argued to provide more reliable statistical properties.

4.3.2 Technical Efficiency

Recalling Equation 4.3, the mean technical efficiency is defined by $TE_i = \exp(-u_i)$. The equation clearly suggests calculating the u_i in order to estimate the technical efficiency. Given u_i is unobservable, the best predictor for u_i is the conditional expectation of u_i, given the difference value between v_i and u_i. Jondrow et al. (1982), known as the first to apply this the stochastic frontier model, propose the following predictor of u_i expect:

$$\hat{u}_i = E(u_i|y_i) = u_i^* + \sigma_* \left[\frac{\phi(u_i^*/\sigma_*)}{\Phi(u_i^*/\sigma_*)}\right] \qquad 4.5$$

where $\phi(x)$ is the probability density function of a standard normal random variable at x. Although Jondrow et al. suggest to predict the technical efficiency of the *i-th* firm using $1 - E[u_i|e_i]$, some other researchers use a natural predictor $\exp(-\hat{u}_i)$, where $\hat{u}_i$ is associated with Equation 4.5. Later, an alternative method to derive predictor is provided by Battese and Coelli (1988) by using $p[u_i|y_i]$ as follows:

$$E[\exp(-u_i)|y_i] = \left\{\Phi\left(\frac{u_i^*}{\sigma_*} - \sigma_*\right)\Big/\Phi\left(\frac{u_i^*}{\sigma_*}\right)\right\}\exp\left[\frac{\sigma_u^2}{2} - u_i^*\right] \qquad 4.6$$

The above predictor can be shown to be most favorable on the grounds that it minimises the mean square prediction error. In the case of industry efficiency, the technical efficiency can be examined by taking into account the average of all individual firm efficiency in the industry. The mean technical efficiency can be estimated, assume the distributions of u_i's are half-normal random variables to obtain the result. The unconditional density function can be used to obtain the result as the method applied to individual firm previously. The optimal estimator of industry efficiency can be derived as follows:

$$T\hat{E} \equiv E[\exp(-u_i)] = 2\Phi(-\sigma_u)\exp\left[\frac{\sigma_u^2}{2}\right] \qquad 4.7$$

4.3.3 The Merit and Demerit of SFA

Some advantages of this method over the DEA are: first, it can test the hypotheses in regard to the inefficiency existence. Similarly, the structure of production function can be performed using the SFA. Second, it can take into account for a random noise (e.g measurement error, weather, and other external disturbances) in which might be contributed to the inefficiency if measured in DEA.

Despite the ability to account for random noise in the efficiency measures and to test the hypotheses, stochastic frontier approach is argued to have several problems. These include, first, the SFA requires a particular functional form as well as a distribution type in advance to construct the production technology that presumes the frontier shape. The requirement of the functional form could be a disadvantage if it is misspecified in which case the efficiency measures may potentially be confounded with specification errors. Second, the method demands a large sample of data in order to avoid lack of degrees of freedom. Concerning the misspecification of functional form, it is usually solved by local approximation using the trans-log functional form. However, this approximation has been argued as incompatible with banking studies due to large variation in banking data (see McAllister and McManus 1993; Mitchell and Onvural 1996).

4.4 The Data Envelopment Analysis

Charnes, Cooper, and Rhodes (1978) develop DEA method based on Farrell's (1957) pioneering work. Their original formulation, known as the CCR-model (or Charnes Cooper and Rhodes model), defines a DMU relative efficiency measure by maximising the ratio of weighted outputs to inputs. Thus, an efficient DMU has a weight equal to one and if it is less than one then it is considered to be inefficient. Up to the present this method has been applied to study various industries in a large number of empirical studies. The application of the DEA in the banking industry has been noted since Sherman and Gold (1985) applied this approach to measure the efficiency of bank branches in the US.

There are two common and basic DEA models which have been applied in empirical studies. These are, the CCR-model, mentioned above, and the BCC-model (after Banker, Charnes, and Cooper (1984)), which is an extension of the CCR-model. The principal difference between these two models is the assumption of returns to scale. The CCR-model is based on an assumption of constant returns to scale (CRS) technology when enveloping the actual data to define the shape of the production frontier, while the BCC-model allows variable returns to scale (VRS) technology for identifying the envelopment surface.

4.4.1 Technical Efficiency

DEA is also commonly used to measure technical efficiency and scale efficiency. Technical efficiency is defined as the ability of a firm to use the minimal amount of inputs to produce maximum outputs. Furthermore, technical efficiency can be determined by using either an input or an output orientation. The CCR-model provides a DEA model that is based on input orientation and assumes CRS.

The CCR-model uses an optimisation method of mathematical programming to generalise the single output and input technical measure to the multiple outputs and multiple inputs cases. It reduces the multiple inputs and multiple outputs of each

DMU into a single virtual input and single virtual output. Thus, the efficiency measure for a DMU is determined by the ratio of single virtual input and single virtual output, which is to be maximised and form the objective function of the particular DMU being evaluated.

Assume that there are N inputs and M outputs for each of the I DMUs. The inputs and outputs are represented by the column vectors x_i and y_i, respectively, for the i^{th} DMU. The $N \times I$ input matrix, X, and the $M \times I$ output matrix, Y, represent the data for all I DMUs. If u is an $M \times 1$ vector of output weights, and v is a $N \times 1$ vector of input weights, then the measure of the ratio of all outputs to all inputs for a DMU is $u'y_i/v'x_i$. The optimal weight to be selected is proposed as follows:

$$\begin{aligned} &Max_{\,u,v}\ (u'y_i/v'x_i) \\ &\text{subject to}\quad u'y_j/v'x_j \leq 1 \\ &\qquad\qquad v,u \geq 0\,,\quad i,j = 1,2,\ldots,I, \end{aligned} \tag{4.8}$$

Hence, the efficiency measure for the i^{th} DMU is maximised subject to the constraint that all efficiency measures have to be less than or equal to unity. The problem with this ratio formulation is that it has an infinite number of solutions, where if (u*, $\boldsymbol{v}$*) is a solution, then (αu*, αv*) is also another solution for $\alpha > 0$ (Coelli et al. 2005, p. 163). To avoid this, the transformation for linear fractional programming selects a representative solution where one can impose the constraint $v'x_i = 1$ which provides:

$$\begin{aligned} &Max_{\,\mu,\nu}\ (\mu'y_i) \\ &\text{subject to}\quad \nu'x_i = 1, \\ &\mu'y_j - \nu'x_j \leq 0\,,\quad j = 1,2,\ldots,I, \\ &\qquad\qquad \mu,\nu \geq 0, \end{aligned} \tag{4.9}$$

The transformation of notation from u and v to μ and ν is used to highlight the different linear programming problem. The model in Equation 4.9 is known as the multiplier form of the DEA linear programming problem. Using the duality in linear programming, one can derive an equivalent envelopment form:

$$Min_{\theta,\lambda}\ \theta,$$

$$\text{Subject to}\quad -y_i + Y\lambda\ \geq 0,$$
$$\theta x_i - X\lambda\ \geq 0,$$
$$\lambda\ \geq 0, \qquad 4.10$$

where λ is a $I \times 1$ vector of constants and θ is a scalar value between 0 and 1. This envelopment form is commonly the preferred form to solve since it contains fewer constraints than the multiplier form ($N + M < I + 1$). The optimal value of θ acquired is the efficiency score for the particular DMU (i^{th} firm). The efficiency score gained will satisfy $\theta \leq 1$, where if the combination point of virtual input and virtual output is on the frontier then the value of 1 indicates a point on the frontier, and thus the DMUs is considered technically efficient as defined by Farrell (1957). Those for which θ is less than 1 are inefficient. A value of θ for each DMU is obtained by repeating the process where the linear programming problem must be solved I times, once for each DMU in the sample.

The above discussion about the CCR-model assumes constant returns to scale, where this assumption is only valid when all DMUs are operating at an optimal scale. However, because of external conditions, such as imperfect competition, constraints on finance, and others, a DMU may not operate at optimal scale (Coelli et al. 2005). In addition to these limitations, the scale efficiency effect is accommodated in the BCC-model which allows for variable returns to scale (VRS) conditions. The application of a VRS specification allows for the measurement of technical efficiency without the scale efficiency effect. The VRS model can be simply constructed through modifying the CRS linear programming by adding the convexity constraint: $\text{I}1'\lambda = 1$ to Equation 4.10 to provide:

$$Min_{\theta,\lambda}\ \theta,$$

$$\text{Subject to}\quad -y_i + Y\lambda\ \geq 0,$$
$$\theta x_i - X\lambda\ \geq 0,$$
$$\text{I}1'\lambda = 1,$$
$$\lambda\ \geq 0 \qquad 4.11$$

where I1 is an I x1 vector of ones. This concept offers technical efficiency scores which are greater than or equal to those obtained using the CRS model because it forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull. The convexity constraint (I1'λ) essentially ensures that an inefficient firm is only "benchmarked" against firms of similar size indicating that the projected points for that DMU on the DEA frontier will be a convex combination of observed DMUs (Coelli et al. 2005).

4.4.2 Scale Efficiency

The scale efficiency calculation under DEA is done by conducting both a CRS DEA (CCR-model) and VRS DEA (BCC-model) using the same dataset. The technical efficiency score from the CRS DEA is then decomposed into two components: that due to scale inefficiency and that due to pure technical inefficiency (or VRS technical efficiency). If there is a difference in these two technical efficiency scores for a specific DMU, then this implies that the DMU has scale inefficiency. That is, the scale inefficiency can be calculated from the difference between the CRS technical efficiency and VRS technical efficiency scores.

Coelli et al. (2005) illustrate the scale inefficiency by assuming a one input (x) and one output (y) scenario, as depicted in Figure 4.1. Under the CRS specification, the input oriented technical inefficiency of point P is the distance PPc. But, the technical inefficiency under the VRS specification would only be PPv. The difference between these two measures, $PcPv$, is attributed to scale inefficiency. These concepts can be expressed in a ratio efficiency measure as:

$$TE_{CRS} = AP_C/AP \quad 4.12$$

$$TE_{VRS} = AP_V/AP \quad 4.13$$

$$SE = AP_C/AP_V \quad 4.14$$

It is also noted that

$$TE_{CRS} = TE_{VRS}/SE \quad 4.15$$

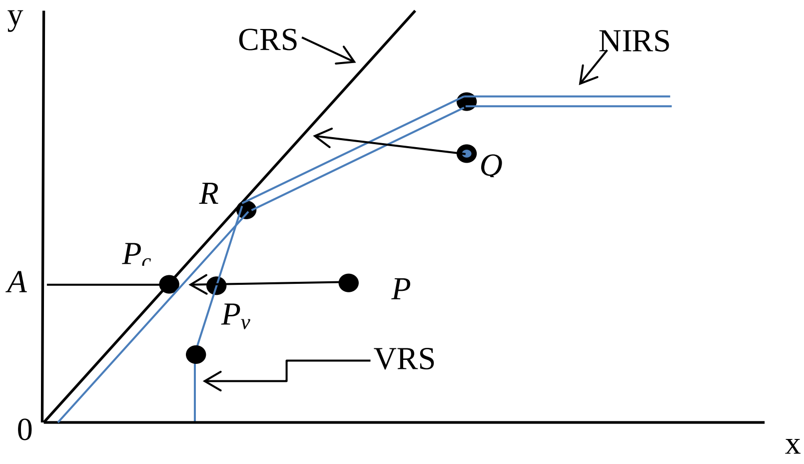
because $AP_C/AP = (AP_V/AP) \times (AP_C/AP)$.

Since TE_{VRS} is the pure technical efficiency measure, hence

$$TE = PTE \times SE \qquad 4.16$$

Note that all these measures are bounded by zero and one.

Figure 4.1: Scale Efficiency Measurement



Source: Coelli et al. (2005, 174)

However, the measure of scale efficiency above has the shortcoming that it does not specify whether the DMU is experiencing increasing returns to scale (IRS) or decreasing returns to scale (DRS). To verify whether a DMU is operating at IRS or DRS, non-increasing returns to scale (NIRS) is imposed on the DEA problem. This can be solved by replacing the $I1'\lambda = 1$ restriction with $I1'\lambda \leq 1$ in the DEA model (Equation 4.11) to provide:

$Min_{\theta,\lambda}\, \theta,$

Subject to $-y_i + Y\lambda \geq 0,$

$\theta x_i - X\lambda \geq 0,$

$I1'\lambda \leq 1,$

$\lambda \geq 0, \qquad 4.17$

The constraint $I1'\lambda \leq 1$ certifies that the *i*-th DMU will not be "benchmarked" against those which are substantially larger than it, but may be compared with a DMU smaller than it.

The nature of scale inefficiency for certain DMUs can be determined by seeing whether the NIRS technical efficiency score is equal to the score of VRS technical efficiency. If the case as depicted by the DMU at point P in Figure 4.1, these scores are not equal, then IRS exists for that DMU. However, if they are equal, as in the case of point Q, then DRS apply. If $TE_{CRS} = TE_{VRS}$, then by definition the DMU is operating at optimal scale.

So far the discussion is about the method that seeks to identify technical inefficiency essentially ensures that an inefficient firm is only "benchmarked" against firms of similar size. It indicates that the projected points for that DMU on the DEA frontier will be a convex combination of observed DMUs by how much input can be reduced, with output levels held constant. This is known as the input-oriented model of DEA and corresponds to Farrell's input based measure of technical efficiency. Another way to identify technical inefficiency is by employing an output-oriented DEA model. Here technical efficiency is measured as a proportional increase in output produced, given a constant level of input used.

Even though the input and output-oriented measures provide the same value under CRS, they are unequal under a VRS assumption. The choice of orientation is not as crucial as it is in the case of econometric estimation, since the statistical problems of simultaneous equation bias does not exist as a problem in linear programming (Coelli et al. 2005). Coelli et al. (2005) suggest that the selection of orientation should be made by considering the particular objective and specific situation faced by the industry. Some industries are more appropriately analysed by the input-oriented model as they need to choose an input combination to produce a particular output level. While for other industries, output orientation may be more appropriate, since they may be given a fixed amount of resources and be asked to produce as much as possible. In addition, Coelli and Perelman (1996) argue that the choice of orientation has only a minor influence upon the score obtained.

The models of output-oriented DEA are similar to their input-oriented models. An output-oriented VRS model follows:

$$
\begin{aligned}
& Min_{\phi,\lambda}\ \phi, \\
& \text{Subject to} \quad -\phi y_i + Y\lambda \ \geq 0, \\
& \qquad\qquad\quad x_i - X\lambda \ \geq 0, \\
& \qquad\qquad\quad \mathrm{I}1'\lambda = 1 \\
& \qquad\qquad\quad \lambda \ \geq 0,
\end{aligned}
\qquad 4.18
$$

where $1 \leq \phi < \infty$, and $\phi - 1$ is the proportional increase in outputs that could be attained by the *i*-th DMU, given a fixed amount of input. $1/\phi$ defines a technical efficiency score, which is bounded between zero and one.

4.4.3 The Merit and Demerit of DEA

The advantages and disadvantages of the DEA method are, in fact, mainly reversed the merit and demerit of the SFA. The advantages include; DEA works well with small data sample which is not suitable with SFA; it does not requires assuming a specific functional form to construct the production frontier; and DEA deals with individual units rather than population averages, thus it allows direct comparison with a peer. With regard to the small data sample, however, Avkiran (1999) suggests to use a substantial larger sample data than the number of inputs and outputs used, especially to examine distinction between efficient and inefficient DMU.

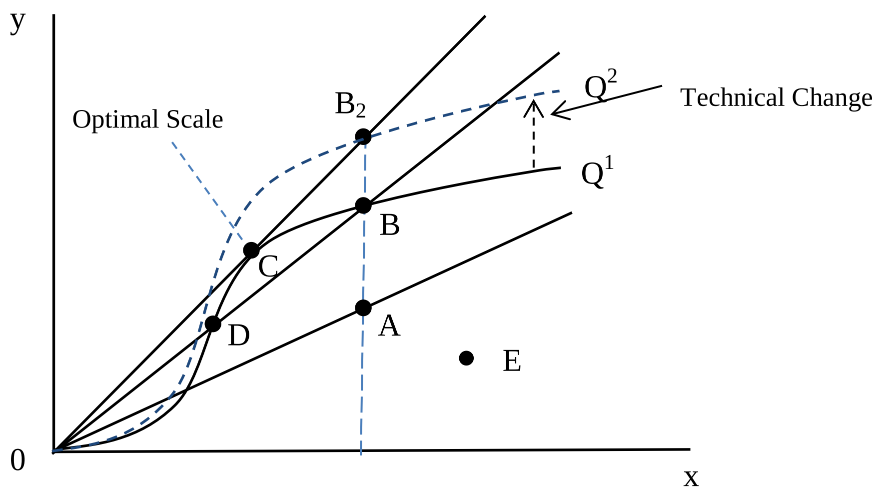
On the other side, the DEA drawbacks include; it does not accommodate random noise and measurement errors, therefore noises are effectively part of the score; it cannot test hypotheses because it uses mathematical programming; the efficiency score obtained are only comparable to the best-practice firms in the sample; and some important inputs may not be able to be incorporated in the direct measurement of DEA.

The selection between the two methods depends on several circumstances such as data, assumption, price information and others. For instance, Coelli, Rao, and Battese (1999) argue that the SFA is to be likely more suitable over the DEA in agricultural sector application, especially in developing countries, where the data are typically affected by measurement errors. Nevertheless, the authors indicate if the random noises are not a significant issue, price information is not available, cost minimisation or profit maximisation assumption are difficult to validate and the firm produce various outputs, then the DEA method is commonly chosen.

4.5 The Measurement of Productivity Growth

As previously discussed, the measurement of efficiency is referred to as technical efficiency. This section discusses productivity growth (or productivity change), which refers to change in productivity performance of a firm or an industry from one period to another. The distinction between technical efficiency and productivity is illustrated by. Coelli et al. (2005) using the diagram in Figure 4.2.

Figure 4.2: Productivity, Technical Efficiency and Scale Efficiency.



Source: Coelli et al. (2005)

Given productivity as the ratio of outputs to inputs, then the slope of the ray through the origin at a particular data point can be used to measure productivity. If the firm operating at point A wants to attain the same technical efficiency as firm at point B, the slope of the ray would need to be greater, meaning that the firm at point A must acquire a higher level of productivity than before. Firms at both points, A and B, also can move to point C to achieve a higher level of productivity. However, at point C, the ray from the origin is at a tangent to the productivity frontier where the outputs to inputs ratio is at the highest level, hence it is defined as the point of maximum possible productivity. Any movement to the point C is an example of exploiting scale economies, thus the point C is the point of optimal scale. This implies any firm which is operating at any other point on the productivity frontier has lower productivity. All other firms on the production frontier are technically efficient but may still be able to improve their productivity by exploiting scale economies.

The discussion above explains productivity measurement in one period of time. If the time component is included to observe productivity comparisons through time, then an additional source of productivity change known as technical change (or technological change) is possible. Technical change is represented by an upward shift in the production frontier and this involves technology improvement in the production process. The upward shift is illustrated in Figure 4.2 by the movement of the production frontier from $0Q^1$ in period 0 to $0Q^2$ in period 1. It is indicated from the diagram that in period 1 a firm can technically produce more output at each level of input relative to what was possible in period 0. However, if a firm's productivity has increased from one year to the next, the improvement might not have been due to efficiency improvement only, instead, it may have been from technical change, exploitation of scale economies or a combination of these three elements.

Productivity growth or TFP can be estimated using production frontier methods and index number approaches. Production frontiers use observed data to construct the production frontier for estimating efficiency and productivity gains. On the other hand the index number is an alternative method and known as the most commonly used instrument to measure change in various economic variables which can be applied for estimating productivity.

Grifell-Tatjé and Lovell (1996) have identified three alternative indices of productivity change. These are the Törnqvist index, the Fischer ideal index (which is the geometric mean of the Laspeyres and Paasche indexes) and the Malmquist index which is also known as Malmquist productivity index (MPI) or the Malmquist TFP index. The last of these three alternatives has specific merit over the other two.

According to Grifell-Tatjé and Lovell (1996), the attractiveness of the Malmquist index stems from a different source. First, it is calculated from quantity data only, which is an attractive feature if price information is unavailable or the price is distorted. Second, it does not require profit maximisation or cost minimisation. Last, if panel data are available, the MPI provides a decomposition of the productivity change into technical change (also called the changes in the best-practice index) and technical efficiency change (also called the catching up index). Hence, it offers insight into the source of productivity change. Further discussion regarding the MPI approach to measuring productivity growth is presented in the next subsection.

4.5.1 The Malmquist Productivity Index (MPI) Approach

Since its introduction by Caves, Christensen, and Diewert (1982), two main studies that have influenced the developments based on MPI are the works of Nishimizu and Page (1982) and Färe et al. (1994). The principle differences between these two papers is that Nishimizu and Page (1982) employ parametric techniques, calculate technological change and technical efficiency change directly and sum these to provide a measure of TFP change. On the other hand, Färe et al. (1994) employ non-parametric techniques, calculate the component distance function, followed by calculating the Malmquist TFP indices and decomposing these into technological change and technical efficiency change components. More recent studies, extending Färe et al. (1994), on MPI use a DEA approach that relaxes the assumption of constant returns to scale for separating scale efficiency change from technical efficiency change. These studies include Grifell-Tatjé and Lovell (1995), Fare and Grassgopf (1996) and Lovell (2003).

The number of studies published shows that the popularity of MPI has grown rapidly over the years and it has been widely employed in empirical studies of productivity growth. The use of MPI to measure productivity improvements in the banking industry has also increased (selected studies such as Berg, Førsund, and Jansen 1992; Grifell-Tatjé and Lovell 1996; Sathye 2002; Lee, Worthington, and Leong 2010; Park and Weber 2006; Prodromos et al. 2010).

As mentioned in the previous chapter, Caves, Christensen, and Diewert (1982) introduce the idea of using a distance function to analyse productivity change. The decomposition of MPI is defined in terms of Shephard's (1970) distance function. This distance function allows one to describe a multi-input and multi-output production technology without the need to specify any behavioural objective such as cost minimisation or profit maximisation. It can be generalised from two types of distance function: an input-distance function or an output-distance function. The input-distance function is described as the minimum proportional reduction of the input vector, given a fixed output vector. Likewise, the output-distance function is defined as a maximum proportional increase of the output vector, given a fixed input vector.

The Malmquist productivity index can be defined by using the technology set, *S*. Assume that for every time period *t* = 1, 2, …., *T*, *S* transforms inputs into outputs as:

$$S = \{(x, y) : x \text{ can produce } y\} \qquad 4.19$$

Given the a production technology defined by *S* in Equation 4.19, it is similarly defined using the output set, *P(x)*, which represents the set of all output vectors, *y*, which can be produced using the input vector, *x*. Hence,

$$P(x) = \{y : x \text{ can produce } y\} \qquad 4.20$$

The underlying assumptions of above model regarding $P(x)$, are;

(i) nothing can be produced out of a given set of inputs ($0 \in P(x)$);
(ii) all production requires the use of some inputs that is $(x, y) \notin P(x)$ if $y > 0, x > 0$;
(iii) satisfies strong disposability of both inputs and outputs, that is, if $(x, y) \in P(x)$ then $x^* \geq x \Rightarrow (x^*, y)$ and $y^* \geq y \Rightarrow (x, y^*)$;
(iv) is convex, bounded and closed for all *x* (Coelli et al. 2005).

The output distance function is defined on the output set, *P(x)*, as:

$$d_0(x, y) = \min\{\delta: (y/\delta) \in P(x)\} \qquad 4.21$$

The distance function, $d_0(x, y)$, will take a value less than or equal to one if the output vector, *y*, is an element of the feasible production set *P(x)*. Moreover, if *y* is located on the outer boundary of the feasible production set then the distance function will take the value of unity, and if *y* is situated outside the feasible production set it will take a value greater than one.

4.5.2 The Decomposition of MPI

The MPI measures the TFP change between two data points by computing the ratio of the distances of each data point relative to a common technology. Using an output distance function proposed by Shephard (1970), Caves, Christensen, and Diewert (1982) describe how a change in a firm's technology frontier between two consecutive periods can be decomposed into two components; technological change and efficiency change.

Following Färe et al. (1994), the output-orientated Malmquist TFP index is expressed using the distance function with respect to two periods: period *s* (the base period) and period *t*, as follow;

$$m_0\ (y_s, x_s, y_t, x_t) = \left[\frac{d_0^s\ (x_t, y_t)}{d_0^s\ (x_{s,}\ y_s)} \times \frac{d_0^t\ (x_t, y_t)}{d_0^t\ (x_{s,}\ y_s)}\right]^{1/2} \qquad 4.22$$

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 and $m_0\ (y_s, x_s, y_t, x_t)$ represents the MPI, which shows the change in productivity of the DMU under review. If the value of m_0 is greater than one then it indicates a positive growth of TFP from period *s* to period *t*, whereas, if it is less than one, implies a declining TFP between the two periods. The first is assessed with respect to period *s* technology and the second with respect to period *t* technology.

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

$$m_0\ (y_s, x_s, y_t, x_t\ ) = \frac{d_0^t\ (x_t, y_t)}{d_0^s\ (x_{s,}\ y_s)}\left[\frac{d_0^s\ (x_t, y_t)}{d_0^t\ (x_t, y_t)} \times \frac{d_0^s\ (x_{s,}\ y_s)}{d_0^t\ (x_{s,}\ y_s)}\right]^{1/2} \qquad 4.23$$

The term outside the square brackets in Equation 4.23 represents the change in the output-oriented measure of Farrell technical efficiency between period *s* and *t*. Hence, the change in technical efficiency is equivalent to the ratio of Farrell technical efficiency in period *t* to the Farrell technical efficiency in period *s*. The term in the square brackets in Equation 4.23 stands for the technical change (or the technological change) between period *s* and *t*. Based on the above equation, two separate equations have been constructed to estimate the technical efficiency change and technological change.

$$Technical\ Efficiency\ Change\ = \frac{d_0^t\ (x_t, y_t)}{d_0^s\ (x_{s,}\ y_s)} \qquad 4.24$$

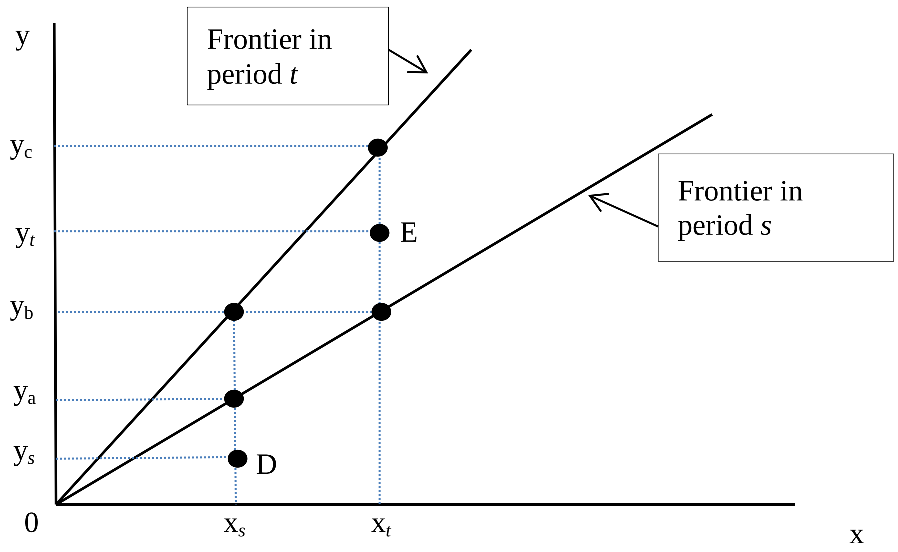
and

$$Technological\ Change\ = \left[\frac{d_0^s\ (x_t, y_t)}{d_0^t\ (x_t, y_t)} \times \frac{d_0^s\ (x_{s,}\ y_s)}{d_0^t\ (x_{s,}\ y_s)}\right]^{1/2} \qquad 4.25$$

$$\text{Technological Change}\ = \left[\frac{y_t/y_b}{y_s/y_c} \times \frac{y_s/y_a}{y_s/y_b}\right]^{1/2} \qquad 4.27$$

Figure 4.3 illustrates the decomposition described above under constant returns to scale technology involving a single input and a single output. A DMU produces at the points *D* and *E* in period *s* and *t*, respectively. The figure shows that there is technical inefficiency in both periods because the DMU, in each period, is operating below the technology for that period.

Figure 4.3: Malmquist Productivity Indices



Source: Coelli et al. (2005, 71).

Thus, using Equation 4.24 and 4.25 the following measures are obtained:

$$Technical\ Eficiency\ Change = \frac{y_t/y_c}{y_s/y_a} \tag{4.26}$$

$$Technological\ Change = \left[\frac{y_t/y_b}{y_s/y_c} \times \frac{y_s/y_a}{y_s/y_b}\right]^{1/2} \tag{4.27}$$

After the original decomposition of MPI, as given by Equation 4.23, a number of studies propose various additional decompositions of these technical efficiency change components and technological change components (Grifell-Tatjé and Lovell 1995; Fare and Grassgopf 1996; and Ray and Desli 1997). One possible decomposition is to take into account the scale efficiency change in order to relax the CRS assumption. Grifell-Tatjé and Lovell (1995) argue that a decomposition of MPI may not measure productivity change if scale efficiency is not considered in the decomposition. The essential idea is shared by Coelli et al. (2005), who suggests that a firm could increase its productivity by changing the scale of its operation, if the firm operates at a technologically optimal scale of production. Färe et al. (1994) and

Grifell-Tatjé and Lovell (1997) suggest generalising the MPI with a scale component that takes into account the involvement of returns to scale.

Färe et al. (1994) provide an additional decomposition of Equation 4.24 into a pure technical efficiency change component and a scale efficiency change component. This is done by introducing a variable returns to scale (VRS) distance function to obtain:

$$Pure\ Efficiency\ Change\ = \frac{d_{ov}^{t}\ (x_t, y_t)}{d_{ov}^{s}\ (x_{s,}\ y_s)} \qquad 4.28$$

and

$$Scale\ Efficiency\ Change$$
$$= \left[\frac{d_{ov}^{t}\ (x_t, y_t)/d_{oc}^{t}\ (x_t, y_t)}{d_{ov}^{t}\ (x_s, y_s)/d_{oc}^{t}\ (x_s, y_s)} \times \frac{d_{ov}^{s}\ (x_t, y_t)/d_{oc}^{s}\ (x_t, y_t)}{d_{ov}^{s}\ \left(x_{s,}\ y_s\right)/d_{oc}^{s}\ \left(x_{s,}\ y_s\right)}\right]^{1/2} \qquad 4.29$$

Note that the extra subscripts, v and c, represent the VRS and CRS technologies respectively.

The next step after decomposition is to estimate the production technology, hence, measure the distance functions that make up the Malmquist TFP index. Among a number of different methods, two most popular methods of measuring the distance function are DEA-like linear programming methods and the stochastic frontier methods. As explained earlier, these two methods constitute the non-parametric approach and parametric approach, respectively. The discussion over which one is the more appropriate continues.

In their survey over 169 bank efficiency studies, Fethi and Pasiouras (2010) reveal that generally studies that obtained the estimates of total factor productivity growth employed a DEA-like Malmquist index. This implies the widespread of this method in investigating the productivity growth in banking sector. Beside for consistency with DEA adopted in the previous section, this thesis employs DEA-based linear programming methods suggested by Färe et al. (1994). The next subsection describes this selected method to estimate the MPI.

4.5.3 The Estimation of MPI Using DEA-Based Approach

Using panel data, the Malmquist TFP index can be measured using DEA-based linear programs. The solution to the distance function using linear programming techniques can be obtained by assuming there are i = 1, 2, …., I observations of n = 1, 2, …, N inputs denoted $x_n^{i,t}$ which are employed to produce i = 1, 2, …, I observation of m = 1, 2, …, M outputs expressed $x_m^{i,t}$ in each period t = 1, 2, …, T. The number of observation is also assumed unchanged, that is, $I^t = I$. The technology in period t can be explained as follows:

$$S^t = (x_t, y_t):$$

$$\sum_{i=1}^{I} \lambda^{i,t} X_n^{i,t} \le x_n^t, \qquad n = 1, 2, \ldots., N$$

$$\sum_{i=1}^{I} \lambda^{i,t} Y_n^{i,t} \le y_m^t, \qquad m = 1, 2, \ldots., M$$

$$\sum_{i=1}^{I} \lambda^{i,t} \le 1; \ \lambda^{i,t} \ge 0, \qquad i = 1, 2, \ldots., I \qquad 4.30$$

where $\lambda^{i,t}$ is the convex of observed inputs and input combinations, and therefore the constructing technology set (Mahadevan 2004).

Following Färe et al. (1994), the Malmquist TFP index given by Equation 4.22, can be obtained by calculating the four distance function, $d_o^t(y_t, x_t)$, $d_o^s(y_s, x_s)$, $d_o^t(y_s, x_t)$ and $d_o^s(y_t, x_s)$ for the i^{th} firm between two periods, s and t. This requires the solving of four linear programming (LP) problems. The required LPs are:

$$[d_o^t(y_t, x_t)]^{-1} = \text{Max}_{\phi,\lambda}\, \phi,$$

Subject to $-\phi y_{it} + Y_t\lambda \ge 0,$

$$x_{it} - X_t\lambda \ge 0,$$

$$\lambda \ge 0, \qquad 4.31$$

$$[d_o^s(y_s, x_s)]^{-1} = \text{Max}_{\phi,\lambda}\, \phi,$$
$$\text{Subject to} \quad -\phi y_{is} + Y_s\lambda \geq 0,$$
$$x_{is} - X_s\lambda \geq 0,$$
$$\lambda \geq 0, \qquad 4.32$$

$$[d_o^t(y_s, x_t)]^{-1} = \text{Max}_{\phi,\lambda}\, \phi,$$
$$\text{Subject to} \quad -\phi y_{is} + Y_t\lambda \geq 0,$$
$$x_{is} - X_t\lambda \geq 0,$$
$$\lambda \geq 0, \qquad 4.33$$

and

$$[d_o^s(y_t, x_s)]^{-1} = \text{Max}_{\phi,\lambda}\, \phi,$$
$$\text{Subject to} \quad -\phi y_{it} + Y_s\lambda \geq 0,$$
$$x_{it} - X_s\lambda \geq 0,$$
$$\lambda \geq 0, \qquad 4.34$$

where y_{it} and y_{is} are $M \times 1$ vectors of output quantities for the i^{th} firm at time *t* and time *s*; x_{it} and x_{is} are $N \times 1$ vectors of input quantities for the i^{th} firm at times *t* and *s*; Y_t and Y_s are $I \times M$ matrices of output quantities for all *I* observations at times *t* and *s*; X_t and X_s are $I \times N$ matrices of input quantities for all *I* observation at times *t* and *s*; λ is a vector of weights and ϕ is a scalar which takes a value between 0 and 1. In the last two equations, Equation 4.33 and 4.34, where production points are compared with technologies from period *t* and *s* respectively, the ϕ parameter does not need to be more than or equal to one, as for the calculation of Farrell output-oriented technical efficiencies. In this case, the data point could be positioned above the production frontier. This most likely takes place in the last LP (Equation 4.34) since it compares two periods of a production point from period *t* with technology in an earlier period, *s*. The value of $\phi < 1$ is possible if technological progress has occurred. The value of the ϕs and the λs in the above four LPs are likely to take different values (Coelli et al. 2005).

The above four LPs must be solved for each bank in the sample. However, since technical efficiency change is extended into a scale efficiency change and pure technical efficiency change, Equations 4.28 and 4.29, it requires the solution of two additional LPs. In order to provide estimates of distance functions relative to a VRS technology, the two initial LPs, Equation 4.31 and 4.32, are repeated with the convexity restriction ($I1'\lambda = 1$) added to each.

4.6 Bootstrapping DEA

Despite the superiority of DEA over the misspecification problems, it is important to note that the conventional DEA approach suffers from a number of drawbacks. These include, that the DEA does not consider errors due to chance, measurement error, or environmental differences. These may influence the shape and position of the frontier. In addition, in the case of multiple inputs and outputs, the finite sample bias is inconsistent due to the slow convergence rate. Large bias, large variance and very wide confidence intervals may be produced when the number of different inputs and outputs is large, unless data available are very large (Kneip, Park, and Simar 1998). Also, the efficiency measure is sensitive to outliers and this may influence the result. Furthermore, the lack of statistical inference makes it difficult to analyse the sensitivity of the value obtained relative to sample variation. Theories indicate that since the estimates obtained using DEA are based on finite samples, they are subjects to sampling variation of the frontier as well as subject to finite sample bias.

To overcome, bootstrapping provides an alternative to reduce finite sample bias and finite sample errors in the rejection probability of statistical tests. The bootstrap method was first introduced by Efron (1979). Subsequently, a number of studies have proposed the bootstrapping procedure. Simar (1992) is attributed as being the first to apply of the bootstrap method to the frontier models. Studies that provide bootstrapping techniques for the non-parametric approach are Simar and Wilson (1998b, 1999b, 2000a) and Kneip, Simar, and Wilson (2008). The essence of the bootstrap idea is to approximate the sampling distributions of interest by simulating or mimicking (usually through resampling) the data generating process (DGP). The process is based on the construction of a pseudo sample and re-solving the DEA model for each DMU with the new data. This applies the original estimator to each simulated sample so that the resulting estimates mimic the sampling distribution of the original estimator (Simar and Wilson 1998b). Using this approximated distribution, the bias in the DEA estimator can be estimated and a confidence interval can be built. In their work, Simar and Wilson (1998b) highlight the importance of consistent mimicking of the DGP when bootstrapping in frontier models.[15] The consistent replication relates to the statistically consistent estimation of the confidence interval.

According to the authors, the basis of this problem refers to the procedure for distance estimation that gives value close to unity. Therefore, re-sampling directly from the original data (known as naïve bootstrap) to construct pseudo-sample will provide a poor estimation of the confidence intervals. To overcome this problem, they propose a smoothed bootstrap procedure which estimates the original density of technical efficiency using a univariate kernel estimator. However, since the efficiency scores are bounded from above unity in which no probability mass should exist beyond that point, Simar and Wilson (1998b, 1999a) suggest to adapt a univariate reflection method proposed by Silverman (1986). By using smoothed bootstrap, all these attributes must be taken into account to achieve consistent mimic of the DGP.

In the case of productivity, Simar and Wilson (1999a) also show how to adapt the above bootstrapping procedure to estimate the Malmquist indices. Given that Malmquist indices use panel data, with the probability of temporal correlation, they propose to apply a bivariate kernel density estimate using the covariance matrix of data from adjacent year. Detailed of the bootstrap procedure for DEA and Malmquist index will be presented in the beginning of each empirical chapter efficiency and productivity, respectively.

4.7 Input and Output Choices

Previous parts of this chapter have discussed the formula on how to measure efficiency and productivity. The next step is to determine input and output combinations to measure efficiency and productivity. The specification of input and

[15] Simar and Wilson (2000b) provide a comprehensive analysis based in Monte Carlo evidence.

output is critical to banking efficiency studies and it significantly affects the outcomes (see Das and Ghosh 2006; Sathye 2001). Therefore, the efficiency of a bank can be measured properly only if inputs and outputs are appropriately specified. This can be difficult because there appears to be no existing consensus in the literature about the specification of output and input variables required for estimating relative efficiency in frontier modelling.

There are various approaches identified by researchers to specify input and output variables in the banking industry. Mester (1987) and Berger and Humphrey (1997) emphasise two approaches, production and intermediation approach, which are commonly used in the banking industry. Furthermore, Das and Ghosh (2006) highlight three approaches that dominate the literature: the production approach, the intermediation approach and the modern approach.[16] Favero and Papi (1995) have identified five approaches: the production, intermediation, assets, user cost and value-added approaches. The first three approaches are directly linked to operational functions of banks while the last two approaches mainly consider the nature and significance of banking activities. However, in empirical studies, researchers have selected different variables even though they have used similar approaches. In some empirical studies, researchers even combine the approaches used in their work. For instances, Drake (2001) and Hermes and Nhung (2010) who combine an intermediation and a production approach to justify inputs and outputs combination.

The production approach, introduced by Benston (1965), regards banks as production centres of services to both depositor and borrower (Denizer 2000). Under this approach, banks use inputs such as labour and capital to generate deposits and loans (Avkiran 2000). Deposits are placed among the outputs because they are viewed as part of the services offered by banks. Banks perform as intermediaries in the financial system between borrower and depositor. In order to be successful, banks must satisfy both parties; maximise loan products to satisfy borrowers and deposit products to satisfy savers. Hence, the production approach considers both variables as output.

[16] The authors explain the modern approach as a further modification of the two other approaches (production and intermediation approach) by incorporating some of banking specific activities.

On the other hand, the intermediation approach, introduced by Sealey and Lindley (1977), regards banks primarily generating intermediate financial assets from saver to borrowers. Under this approach, deposits are viewed as an input which is used to produce the other banking outputs. The reason for that treatment is based on the assumption that a bank's main role is to provide a financial transaction channel for surplus holders (savers) and deficit holders (borrowers). Banks produce intermediation services through the collection of deposits and other liabilities and their application to interest earning assets. Four inputs (deposits, labour, interest expense, and non-interest expense) and three outputs (net loans, net interest income, and non-interest income) have been commonly used (Avkiran 1999). According to Favero and Papi (1995), this approach is most relevant for banks where most activities consist of turning large deposits and funds purchased into loan and financial investments. Particularly, interest expense is included as the major cost element of a bank.[17]

The assets approach is similar to the intermediation approach, which focuses on the role of banks as financial intermediaries between depositors and borrower. Inputs in this approach include deposits, labour, capital, and other liabilities whereas outputs are strictly defined by bank assets, such as loans (Sealey and Lindley 1977).

The user-cost approach defines whether a bank product is an input or an output based on its net contribution to the bank revenue. The liability item and opportunity cost of each asset is compared with the financial cost and return. If the financial return on assets is greater than the opportunity cost of assets, or alternatively, if the financial cost of a liability is less than the opportunity cost, the item is considered as an output. Otherwise, it should be considered as an input (Hancock 1985). In the value-added approach, items in the balance sheet which contribute substantially to the bank value

[17] A recent development of the banking efficiency studies with regard to the input and output measurement is the consideration of the quality of loan such as bad loans or NPLs. Some empirical studies include NPL as an undesirable output, such as study of Barros, Managi, and Matousek (2012), Fujii, Managi, and Matousek (2014) and Ji and Wang (2014). Others (e.g., Lensink, Meesters, and Naaborg 2008; Chang et al. 2012) subtract the loan loss reserve from the total loan to ensure the comparability of the loan quality.

added are considered as the outputs. In general, under this approach the main categories of deposits and loans are regarded as outputs since they are a significant share of value added.

The suitability of each approach varies according to the circumstances. It is significant that, as discussed in the previous chapter, most of the existing studies adopt the intermediation approach to specify input-output variables. In addition, Heffernan (1996) emphasises one reason for adopting the intermediation approach as the fact that there are fewer problems with the required data.

4.8 Second-Stage Approaches

Having the efficiency and productivity growth are estimated using the DEA and MPI approaches, it is important to discuss an alternative technique to identify factors affect the relative efficiency and productivity. Some external factors could not be directly included in the measurement of DEA efficiency and productivity, instead they are mainly incorporated indirectly in the DEA measurement (Hoff 2007).

Many studies in the bank efficiency literature attempt to explain the source of efficiency or the reasons for the existence of inefficiency using second-stage analysis (see for example, Drake, Hall, and Simper 2006; Bhattacharyya, Lovell, and Sahay 1997). This method is commonly known as the two-stage method.[18] In the first stage, traditional inputs and outputs are used to estimate efficiency using DEA and MPI. Traditional inputs and outputs are the variables that influence firm efficiency directly and which are generally under the control of the manager. Subsequently, in the second stage, the efficiency scores obtained in the first stage are regressed on the environmental variables (Coelli et al. 2005, 194).

The environmental variables are typically a set of factors that cannot be controlled by a firm's managers, but most likely influence the efficiency and production process. In the banking industry these factors might be differences in ownership, regulatory constraint, business environment and competition among the banks under analysis.

[18] The utilisation of the two-stage approach is one of DEA's disadvantages, where this is unnecessary when SFA is chosen.

The censored (Tobit) and the ordinary least squares (OLS) are two regression models that appear most frequently in the literature employed in the second stage.

The standard Tobit model can be defined as follows for observation (bank) *i*:

$$y_i^* = \beta' z_i + \varepsilon_i; \qquad 4.35$$

$y_i = y_i^*$, if $y_i^* \geq 0$, and $y_i = 0$, otherwise

where $\varepsilon_i \approx N(0, \sigma^2)$, z is vector of observed variables explaining the banks' efficiency or productivity, β is an unknown parameter, and y and y^* are the vector of the observed efficiency or productivity score and the vector of latent variable, respectively. Accordingly, the value for unknown parameter of the explanatory variables can be estimated by maximising a likelihood function (L) as follows:

$$L = \prod_{y_i > 0} \frac{1}{\sigma} \int \left(\frac{y_i - \beta z_i}{\sigma} \right) \prod_{y_i \leq 0} \int \left(-\frac{\beta z_i}{\sigma} \right) \qquad \mathbf{4.36}$$

4.9 Conclusion

This chapter provides a discussion of the method for estimating bank efficiency and productivity growth. Two popular approaches commonly found in the literature are the parametric approach and the non-parametric approach. Each of the methods has its own advantages over the other, as well as the disadvantages. Despite its limitations, the non-parametric approach does not require specification of a functional form. The two alternative methods of the non-parametric approach suggested are DEA to measure efficiency and MPI to measure productivity growth (TFP).

With regards to productivity growth estimation, the MPI is well regarded and has gained increasing popularity. The MPI decomposes productivity growth into two distinctive components, technical efficiency change and technological change, hence providing a framework for estimating the source of bank productivity growth through these two alternative elements.

The semi-parametric bootstrap model offers a procedure for robustly regressing efficiency estimates derived from non-parametric techniques. Subsequently after the DEA and MPI estimations, a second-stage analysis may need to be conducted. A set of explanatory variables which are non-traditional inputs or outputs of a bank are incorporated to identify the determinants of bank efficiency and productivity growth. The first stage of the analysis starts from the estimation of bank relative efficiency and productivity growth, which are discussed in the next two chapters.

Chapter 5
The Efficiency Measure of Indonesian Banks Based on the DEA Bootstrapping Approach

5.1 Introduction

The measurement of efficiency and productivity growth in the banking sector in relation to changes in regulations has produced mixed results. As discussed in Chapter 3, differences in research methods, datasets, time periods and economic policies of the countries examined lead to various conclusions. Such conclusions can primarily be classified as follows: first, efficiency and productivity improve after deregulation; second, efficiency and productivity decline after deregulation; and third, efficiency and productivity are relatively unchanged after deregulation. A rigorous analysis of the effects of regulatory changes on efficiency and productivity in the banking sector of Indonesia is expected to provide a significant contribution to the literature.

This analysis is particularly important, given the financial reforms and recent policies in the banking sectors of developing countries, including Indonesia, that have been undertaken in efforts to improve the role of the financial sector in sustaining economic growth. The purpose of this chapter and the next two chapters is to present the empirical findings of this study. The previous chapter discussed the measurement of efficiency and productivity using frontier methods, including their application and development in empirical studies of the banking sector. Two alternative methods were proposed in Chapter 4 to examine the efficiency and productivity of the Indonesian banking sector. The non-parametric DEA method is utilised in this chapter to estimate the efficiency of the banking sector, and the Malmquist productivity index is applied in the following chapter.

As indicated in Chapter 4, the main disadvantage of the original DEA result is the lack of statistical verification, which leads to there being no measure of the accuracy in the estimated efficiency scores. To address this limitation, this chapter employs the DEA bootstrapping procedure developed by Simar and Wilson (1998b). This approach has frequently been applied by researchers to resolve problems of statistical inference of the DEA. With this method, bias-corrected estimates and confidence intervals of the original DEA efficiency score can be obtained.

The rest of this chapter is organised as follows. Section 5.2 describes the formulation of the bootstrap procedures used in the DEA efficiency analysis. A discussion of the choice of inputs and outputs that are used to estimate efficiency is presented in Section 5.3 followed by a description of the data sources in Section 5.4. Section 5.5 presents the empirical results of the bootstrapped DEA analysis, which include results for the industry as a whole and for banks that are grouped according to bank type and by size. In Section 5.6, a comparison with earlier studies is provided. Section 5.7 concludes the chapter.

5.2 Formulation of the Bootstrap

The use of bootstrapping in frontier models to obtain non-parametric envelopment estimators is pioneered by the works of Simar (1992) and Simar and Wilson (1998b). Bootstrapping consists of using a random selection of pseudo-samples obtained by sampling with replacement from the original data. The underlying idea is to approximate the sampling distribution by mimicking the data generating process.

Because efficiency scores range from 0 to unity, with the empirical distribution discontinuous in the interval, re-sampling directly from the original data (so-called naïve bootstrap) leads to inconsistencies in the bootstrap measure. To overcome this problem, Simar and Wilson (1998b) propose the adoption of a smoothed bootstrapping procedure. Specifically, the authors suggest using a univariate kernel density estimator of the original distance function and obtaining pseudo-data from the estimated probability density function.

The smoothed bootstrap procedure is used to repeatedly re-estimate the efficiency score to mimic the sampling distribution of the original scores from which inferences can be drawn. The process can be summarised in the following steps:

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

Following the computation of these bootstrap estimates, the probability distribution of efficiency scores can now be inferred. To construct a confidence interval, Simar and Wilson (1999a, 2000b) propose an improved procedure that automatically corrects for bias without the explicit use of a noisy bias estimate. If the distribution of $\left(\hat{\theta}^*_{ib} - \hat{\theta}_i\right)$ is known, then it would be possible to approximate a_α and b_α such that

$$Pr\left(-b_\alpha \leq \hat{\theta}_i - \theta \leq -a_\alpha\right) = 1 - \alpha \qquad 5.1$$

This term can thus be approximated by estimating the values a^*_α and b^*_α given by the following:

$$Pr(-b^*_\alpha \leq \theta^*_{ib} - \theta_i \leq - a^*_\alpha) = 1 - \alpha \qquad 5.2$$

Sort the values $\hat{\theta}^*_{ib} - \hat{\theta}_i$ for $b = 1, \dots, B$ in increasing order, and delete $(\alpha/2\ x\ 100)\%$ of the rows at either end of the sorted list. After setting $-\hat{b}^*_\alpha$, $-\hat{a}^*_\alpha$ to the endpoint of the sorted array, the estimated $(1 - \alpha)$ percentage confidence interval is as follows:

$$\hat{\theta}_i + \hat{a}^*_\alpha \leq \theta \leq \hat{\theta} + \hat{b}^*_\alpha. \qquad 5.3$$

In addition, the empirical bootstrap distribution can be utilised to estimate bias. The difference between the empirical mean of the bootstrap distribution and the original efficiency point estimate is defined as a bias estimate. As noted by Simar and Wilson (2000b), the bootstrap estimates above $\{\hat{\theta}^*_{ib}, b = 1, \dots, B\}$ are biased by construction. By definition, the bootstrap bias estimate of the original estimator is as follows:

$$\widehat{bias}_i(\hat{\theta}_i) = \bar{\theta}^*_i - \hat{\theta}_i \quad 5.4$$

where $\bar{\theta}^*_i = \frac{1}{B}\Sigma^B_{b=1}\hat{\theta}^*_{ib}$. Therefore, the empirical bias-corrected estimate for the original estimator can be computed as follows:

$$\tilde{\theta}_i = 2\hat{\theta}_i - \bar{\theta}^*_i. \quad 5.5$$

Nevertheless, as observed by Simar and Wilson (2000b), this correction should be considered only if the following holds true:

$$\hat{\sigma}^2 < \frac{1}{1}\left[\widehat{bias}_i(\hat{\theta}_i)\right]^2 \quad 5.6$$

where $\hat{\sigma}^2$e denotes the sample variance of the bootstrap values. This procedure can be performed using Performance Improvement Management software (PIM-DEAsoft) version 3.1.

5.3 Choice of Input and Output Variables

Section 4.7 of Chapter 4 has identified the methods that have emerged in the literature to determine the input and output variables for estimating efficiency and productivity. Given that there is no consensus as to which approach works best, the present study specifies two models that can be used to specify input and output variables. The first model follows the intermediation approach (hereafter referred to as model A) pioneered by Sealey and Lindley (1977), whereas the second model is based on the revenue or operating approach (hereafter referred to as model B) of Drake, Hall, and Simper (2006).

Model A focuses on the role of banks' in intermediating funds from surplus to deficit units. The intermediation approach is chosen (rather than the production approach) because the Indonesian banking industry has moved beyond the basic level of development. However, it is not as sophisticated as Western systems that are fully engaged in derivative market, heavily involved in "structured" products and widely diversified in off-balance sheet activities.

In contrast, the second model, which uses interest and non-interest costs, captures banks' activities in maximising both interest and non-interest revenues. According to Avkiran (1999), the latter model measures the efficiency that is directly attributable to management in controlling costs and generating revenue, whereas the former model provides a less direct measure of efficiency. Similarly, two separate model analyses have been used in many studies, such as Avkiran (1999) for Australian banks, Sathye (2003) for Indian banks and Sufian (2010) for Indonesian banks. Details regarding the input and output variables included in both models are presented in Table 5.1.

Table 5.1: List of the 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)

The variables are defined as follows: total deposits refer to the total amount of customer deposits, which consist of demand deposits, savings deposits and time deposits, and commercial borrowing, which in turn consists of inter-bank and other liabilities. Fixed assets refer to the book value of the premises and other capital assets. Interest expenses refer to total interest paid, provisions and commissions. Non-interest expenses consist of employee expenses, general expenses, and other expenditures such as services and promotion expenses. Total loans include the total value of customer loans. Other earning assets comprise placements in the BI, interbank placements, securities held, equity participation and cash. Interest income is the total amount of interest revenue, provisions and commissions. Non-interest income refers to operating income other than interest income.

5.4 Data Sources and Sample

The data for the selected input and output variables are collected primarily from the individual bank financial statements that are available from the Indonesian Banks Directory. The data are audited and published annually by the Indonesian central bank (BI) over the period from 1993 to 2011. From 1993 to 2000, the data are in the form of hard copy reports and thus needed to be inputted manually, whereas the data for the remainder of the period (2001-2011) exist in soft-copy form on the Indonesian central bank website. The utilisation of data that are collected directly from the central bank appears to be more reliable than the standard publicly available databases such as *Bankscope*. This is particularly true for Indonesian case, in which data for some of Indonesian banks are unavailable or inconsistent throughout the required period in those databases.

According to Erhmann et al. (2001), the use of datasets such as those maintained by the central bank is recommended because such data yield stable and robust results compared with publicly available databases, such as Bankscope. In addition, Bhattacharya (2003) reports that the Bankscope databases includes only aggregate data and does not include comprehensive data.[19]

The dataset is composed of annual observations for 101 commercial banks covering a period of 19 years. Obtaining a balanced panel of data for a relatively large number of banks over an extensive period is challenging, given that the industry has experienced substantial transformation and structural changes. Isik and Hassan (2002) emphasise that panel data provide the advantage of observing each bank more

[19] The Erhmann et al. (2001) suggestion is based on their examination on the structure of banking and financial markets in the euro area using micro data on banks, while Bhattacharya (2003) is based on the analysis of Indian banks individual data. Both studies compare the results from Bankscope and country own-system dataset.

than once during the sample period. Given that the number of commercial banks in Indonesia decreased from more than 200 before the Asian financial crisis (AFC) in 1997 to 120 by the end of 2011, some adjustments must be made to obtain a balanced panel dataset. These adjustments are as follows:

1. The banks that are included in the dataset are those that exist continuously from 1993 until 2011.[20]
2. The banks that are excluded from the dataset include banks that liquidated or closed during the period of study, have extensive missing data, were just established within the covered period (11 banks) or converted their business from commercial banking to Islamic banking within the covered period (eight banks). The latter are excluded because their accounting procedures differ from those of conventional commercial banks.
3. Banks that merged within the sample period are retained in the dataset by aggregating the data from both the previous bank and the merged bank.

Given the banking groups as officially defined by BI, banks are grouped as follows: state owned banks, foreign exchange commercial banks, non-foreign exchange commercial banks, regional development banks, joint venture banks and foreign-owned banks (see Figure 2.6 in Chapter 2). Although the average representation of data in terms of total commercial bank assets is 93% over the period of analysis, the bank groups must be adjusted to present proper results for each bank group. Thus, foreign exchange commercial banks and non-foreign exchange commercial banks are combined under the more general heading of private national banks.

The reason for this re-categorisation is to maintain a balanced panel data within the group given that some banks within these groups switched from one group to the other during the sample period, hence creating an unstable number of banks within these categories. For instance, bank A in 1994 was a non-foreign exchange commercial bank, but became a foreign exchange commercial bank in the following year because it was then able to meet the criteria to be categorised as such.

[20] Dropped banks may lead to survivor bias in the estimation, and the effect on the estimated result is unknown.

Therefore, rather than six groups, as stated earlier, this study obtains its empirical results based on only five groups.

Detailed information regarding the groups, including their composition, is provided in Table 5.2. The third column presents the number of banks included in the dataset (outside of the brackets) and the total number of banks in the industry (including those not in the dataset) of the respective groups (inside of the brackets). The fourth column shows the share of total assets in the industry for each group.

Table 5.2: Bank Groups (2011)

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

Notes: The number outside of the brackets is the number of banks in the sample; the current number of banks (2011) is present inside of the brackets.
* Private national banks include forex commercial banks and non-forex commercial banks.

The monetary values of all inputs and outputs are converted into real values using the Indonesian GDP deflator (with GDP for 2000 = 100) obtained from the World Bank national accounts. Table 5.3 presents the summary statistics of the inputs and outputs used for both models, including for all groups, over the 1993-2011 period. These statistics exhibit a range of variation in Indonesian banks across banking groups. Two especially noteworthy statistics are the mean size of all variables across groups and the substantial gap between the maximum and minimum values for each of the variables.

As shown in Table 5.3, although there are fewer state owned banks than other banks, the mean size of the state owned banks is greater than that of the banks in the other categories. The gap is considerable, even far above the industry average. For instance, the average value of total loans provided by state owned banks is 14 times that of private national banks, 44 times that of regional development banks 21 times that of joint venture banks, 11 times that of foreign banks and nine times that of the industry average. A similar pattern is evident for other variables, particularly the pattern of deposits. Especially noteworthy are the dramatic gaps among banks with respect to interest and non-interest income, for which state banks have 177 and 287 times, respectively, the levels of foreign banks. Private national banks and foreign banks are interchangeable in that they have the second largest values for all variables. In addition, regional banks, joint venture banks and foreign banks are interchangeable in that they have the lowest means for all variables. These findings suggest that the industry average is still dominated by small and medium-sized banks, despite the dominance of large banks among state banks and private national banks.

Table 5.3: Descriptive Statistics of the Outputs and Inputs for Indonesia Banks, 1993-2011 (IDR millions at 2000 prices)

Groups		Total Loans	Other Earning Assets	Interest Income	Non-Interest Income	Total Deposits	Fixed Assets	Interest Expenses	Non-Interest Expenses
All	Mean	47,898.83	27,410.02	10,115.41	1,434.00	74,765.25	2,179.09	7,994.35	4,894.40
	Max	973,979.27	625,001.56	273,344.02	72,447.24	2,461,022.61	54,090.65	1,361,209.05	556,933.81
	Min	4.78	39.29	10.27	0.10	14.51	3.64	0.96	9.50
	SD	126,638.28	72,941.01	28,332.74	4,411.30	218,286.08	6,111.27	49,257.12	24,124.68
State owned banks	Mean	451,116.44	216,244.38	97,678.34	11,229.41	690,448.86	19,891.61	81,994.93	51,027.22
	Max	956,352.66	625,001.56	273,344.02	39,015.76	2,461,022.61	54,090.65	1,361,209.05	556,933.81
	Min	73,595.07	13,652.05	18,056.66	1,642.60	70,536.94	3,273.15	15,427.15	8,460.55
	SD	235,929.04	151,494.79	48,593.21	7,064.13	465,279.43	12,787.59	155,449.26	79,273.07
Private national banks	Mean	31,768.43	18,139.34	7,093.23	1,271.17	49,668.62	1,669.28	4,247.44	3,041.58
	Max	973,979.27	562,024.13	220,673.66	72,447.24	1,100,091.59	30,060.47	426,314.95	207,546.53
	Min	4.78	39.29	86.97	0.38	14.51	10.47	5.35	73.63
	SD	83,020.27	52,281.41	16,255.30	3,326.81	134,981.18	4,027.62	17,563.45	8,501.90
Regional Development banks	Mean	10,226.88	9,379.16	3,163.62	324.62	17,106.09	545.19	2,044.65	1,348.79
	Max	99,401.83	66,665.63	47,461.75	43,194.53	139,696.27	3,492.81	56,118.37	122,815.96
	Min	169.03	87.43	45.90	0.25	403.95	10.14	9.78	20.89
	SD	13,706.21	11,203.90	6,117.38	2,059.24	19,646.06	601.16	5,030.19	6,336.00
Joint venture banks	Mean	21,206.74	10,094.41	2,958.65	359.43	20,572.70	338.49	2,508.05	1,596.21
	Max	85,165.98	61,751.80	91,690.84	14,498.57	106,408.38	1,631.01	113,787.74	152,802.01
	Min	312.77	525.80	11.95	0.10	147.65	4.86	0.96	9.50
	SD	18,197.89	11,375.51	11,408.62	1,594.11	23,818.35	371.96	11,236.88	11,055.69
Foreign banks	Mean	39,504.18	33,682.99	547.92	41.01	55,466.39	815.38	392.19	242.17
	Max	136,012.01	604,480.48	3,783.67	1,118.23	215,928.20	3,955.47	6,235.05	12,144.44
	Min	21.85	1,127.85	10.27	0.14	1,350.17	3.64	2.16	14.00
	SD	34,047.17	56,005.98	729.85	144.86	52,167.62	976.79	705.58	998.98

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

On average, the ratio of loans is twice that of other earning assets. In addition, the balance sheets of most Indonesian banks are dominated by loans and customer deposits. The average amount of loans is 65% of total deposits, and the percentage is even higher (118%) for joint venture banks. This shows typical features of a traditional banking system in which a major source of funding is customer deposits and investments are primarily in the form of credits rather than other investment products, such as securities.

The variations in the differences between the maximum and minimum values of all variables are also large. For all banks, the average disparity between the maximum and minimum values of the eight variables is 324.189 times for the entire period. The largest and the smallest gaps are found in the volume of interest expenses and for fixed assets, respectively. This pattern is a feature of all groups, except for state banks, which are characterised by moderate gaps in the values of the variables. The smallest values of the variables are found among the private national banks (loans, other earning assets and deposits), joint venture banks (interest income, non-interest income and fixed assets) and joint venture banks (interest expenses and non-interest expenses). By contrast, the maximum values are easy to predict because the contributor is primarily state owned banks, followed by private national banks for loan and non-interest income. These observations demonstrate the large gap between large and small banks.

5.5 Empirical Results of the Bootstrapped DEA

The input-oriented DEA is employed to estimate the technical efficiency of each of the 101 banks in each year over the 1993-2011 period under the assumption of variable returns to scale (VRS). Using panel data consisting of 1,919 observations, the efficiency frontier is constructed as a benchmark of best practices to determine efficiency scores across banks. The bootstrapping procedure described earlier is applied to obtain bias-corrected estimates of efficiency. Each set of input and output variables (i.e., Model A and Model B) is employed separately to obtain the results.

As described above, the DEA efficiency scores are between zero and unity. A value of unity implies that a bank lies on the efficient frontier and is therefore technically efficient, whereas a score of less than unity indicates that the firm lies below the frontier and is technically inefficient. The results of the estimations for the individual banks are not presented in this paper because of space limitations but can be obtained upon request.

Hence, for the sake of simplicity, the empirical results are classified and presented in three main subsections. The first subsection presents the results for the entire industry during the period of study. In the second subsection, the results are classified in terms of the five groups of banks, as described in the previous section. Finally, the results are presented based on bank size categories.

5.5.1 The Empirical Results for the Entire Industry

Table 5.4 summarises the annual means of DEA technical efficiency scores for the entire banking industry during the 1993-2011 period. Each measure presents the results for both approaches, Model A and Model B, beginning with the estimated efficiency (the original DEA efficiency) in columns 2 and 3, followed by bias-corrected estimates in columns 4 and 5 and estimates of bias in columns 6 and 7. The remaining four columns provide the lower and upper bounds of the efficiency estimates for the 95% confidence interval.

Table 5.4 shows that as a whole, the Indonesian banking industry is technically inefficient during the period of analysis. Although inefficiency is evident under both approaches, the two approaches show different patterns throughout the period. As shown in the table, the average efficiency estimate for Model A is 59.42% for the entire period, with annual average scores ranging from 48% to 71%. These scores are lower than those found for model B, for which the average efficiency estimate is 69.23%, with annual average scores ranging from 36% to 82%. However, there is a slight improvement trend under Model A during the period of analysis. These empirical results imply a substantial asymmetry between institutions in terms of their technical efficiency. In particular, different approaches of input and output specification appear to generate different efficiency estimates.

Table 5.4: Annual Mean Efficiency Estimates for the Indonesian Banking Industry

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

Source: Author’s calculations.

The different results above also indicate the flexibility of the DEA method in producing efficiency scores when alternative sets of input and output variables are considered. The industry is revealed to be more efficient under model B, in which the mean efficiency score is 69.23%, indicating that there is a scope for the Indonesian banking industry to reduce its use of inputs by 30.77% on average, given current levels of output. By contrast, the average score for model A suggests that reductions in inputs can be as high as 40.58%, without a reduction in the amount of output produced. Hence, the analysis suggests that the industry is more efficient in business operations that maximise revenues than in intermediating fund between savers and borrowers. It is worthy to note that the pre-crisis improvements in efficiency coincide with the implementation of deregulation in the 1990s by the Indonesian government.

It can be inferred that the deregulation may have increased competition among banks, leading to the efficiency improvement in the banking sector.

The sensitivity of the efficiency estimates with respect to sampling variation is also revealed in the table. Although the results of the original efficiency estimate lie within the confidence interval, they are upwardly biased compared with bias-corrected efficiency scores.[21] The results of the bias-corrected estimates, as presented in columns 4 and 5, are shown to differ from the original efficiency estimates, as presented in columns 2 and 3. The biases vary not only across the period, but across the models. As presented in columns 6 and 7, the bias in model A is less than 0.05 in 1996, 1998-2000, 2002-2007 and 2011, whereas in the remaining years, the bias is above 0.05, with 1994 showing the largest bias.

The bias in model B is small relative to that in model A. Particularly most bias estimates are less than 0.05 over the period, except in 1999, 2003 and 2004, in which the values are 0.085, 0.073 and 0.08, respectively. The mean bias for model A is 0.052, and the mean for model B is 0.04.

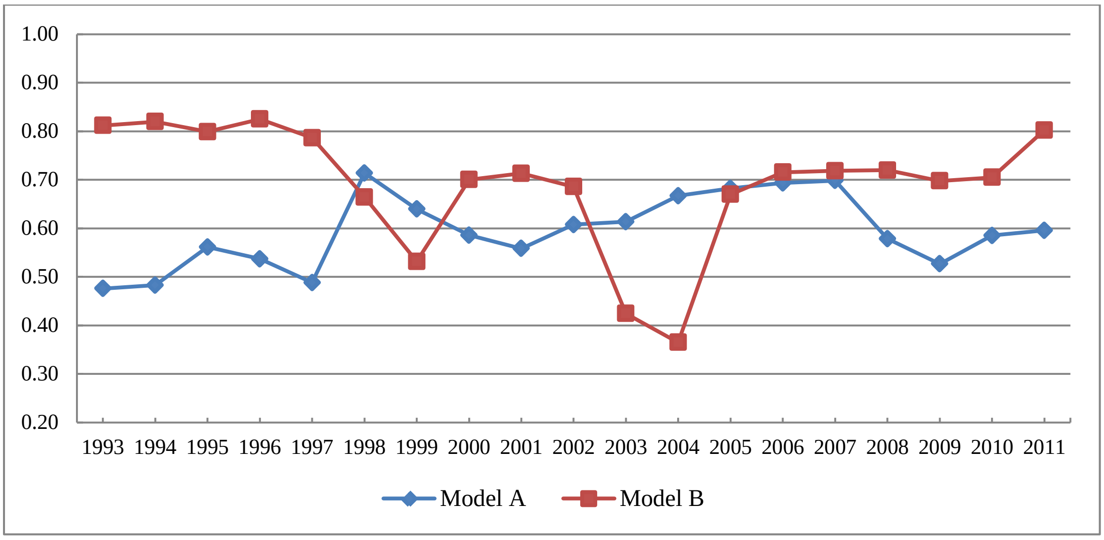
Models A and B exhibit interesting opposing patterns during the period of analysis. Figure 5.1 clearly displays the trend of estimated efficiency over the study period, showing that the models tend to move in an opposite directions from the beginning of the sample period until 2008 but subsequently move in the same direction from 2009 onward. Although both approaches indicate inefficiency throughout the period, the intermediation approach (Model A) shows efficiency improvement, whereas the revenue approach (Model B) shows efficiency deterioration towards the end of period.

During the initial period, efficiency as measured by Model A begins at the lowest level of average efficiency (47.59%) but overall increases slightly throughout the period, although notable ups and downs occurred. Given that low score, financial liberalisation in the late 1980s does not appear to have had a substantial effect on

[21] This result is similar to those reported by Simar and Wilson (1998b) but contrast with those , Arjomandi, Valadkhani, and Harvie (2010) and Tortosa-Ausina et al. (2008). The two latter studies notably report an original estimate that is outside of the confidence interval.

bank efficiency at the beginning of the 1990s. By contrast, Model B begins with an average efficiency level that is 1.7 times higher than that of Model A in 1993 (81.17%) and reach its highest level at 82.50% in 1996. This early period presents a significant efficiency gain for this model before it decreases considerably, declining to its low point at 36.50% in 2004. Furthermore, Model B also generally exhibits a higher level of efficiency, except in the 1998-1999 and 2003-2005 periods. The pattern of these initial results is similar to the pattern identified by Zhang and Matthews (2012), who also find that cost efficiency in the Indonesian banking industry is low in the initial period (1992-1993) in their asset creation model (which is similar to Model A in this study) but is relatively high in their income flow model.

Figure 5.1: Annual Mean of Estimated Efficiency for All Banks



Source: Author's DEA results (Table 5.4).

The diversity of the models highlights the sensitivity of the outcome to the choice of inputs and outputs. Moreover, the finding suggests that the liberalisation policies adopted by the government did not appear to maximise the efficiency of the intermediation function of banks, instead it created an opportunity for banks to exploit the business side to maximise revenue.

Following that initial divergence, Figure 5.1 also shows fluctuations during three periods of the time frame under investigation: 1997-1999, 2003-2004 and 2008-2009. These three main periods of fluctuation may have possibly associated to the three major events during the sample period that caused a decline in the average efficiency: the AFC in 1997, the re-privatisation process following the AFC and the global financial crisis.

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

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

With regard to the question of the sources of differences in the efficiency, the annual mean of scores that is reported above is broad and hinder the analysis on the efficiency levels of individual banks. Which banks and/or groups of banks contribute the most to industry efficiency? The next subsection discusses the relative efficiencies of different groups of banks.

5.5.2 The Empirical Results Based on Groups of Banks

Turning to the results for groups of banks, Table 5.5 and Table 5.6 present the annual means of the bootstrapped efficiency scores for each group of banks under Models A and B. Each table includes five groups of banks, as classified in Table 5.2: state owned banks, private national banks, regional development banks, joint venture banks and foreign banks. The measurement results are presented horizontally for each bank group, moving consecutively from the original measures of efficiency, the bootstrapped bias-corrected scores, and the bias estimates, as well as the lower and upper bounds of the 95% confidence interval. To support the broad results presented in these two tables and to facilitate identification of the sources of efficiency, Table 5.7 presents the number of efficient banks for each group under both models.

A comparison of Table 5.5 and Table 5.6 provides two different pictures or patterns of efficiency among the bank groups. This difference again shows the sensitivity of the results to the choice of input and output variables. Model A as presented in Table 5.5 and displayed in Figure 5.2, reveals disparities between the efficiency levels of bank groups, although fluctuations still occur. The group of state owned banks is found to be the best performing group throughout the period, average efficiency scores ranging from 81% to 100%, which is far above the industry average (47.6% to 71.4%). This score is also supported by the percentage of efficient banks in this group (see Table 5.7) with a minimum of 25% of banks on the efficient frontier.

Following state owned bank group is the foreign and joint venture bank groups as the second and third most efficient groups, respectively. The mean efficiency of the foreign banks ranges from 51% to 97%, while the joint venture banks ranges from 66% to 90%, exceeding the average industry efficiency by 18% and 22%, respectively.

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Table 5.5: Model A – Annual Mean of Efficiency Estimates per Group, 1993-2011

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

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

Table 5.6: Model B – Annual Mean of Efficiency Estimates per Group, 1993-2011

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

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

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

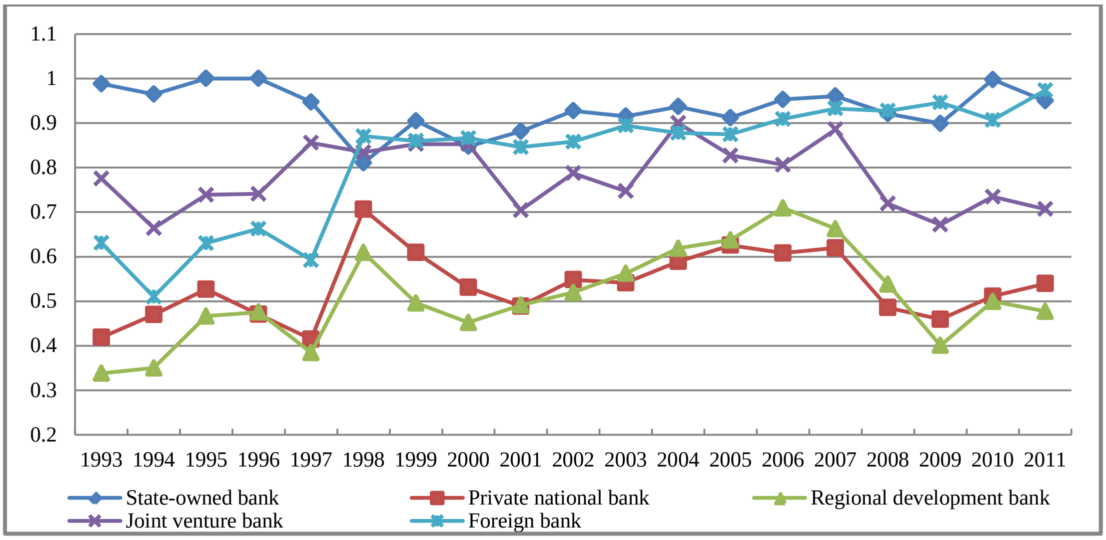
The group rankings in Table 5.5 are based on annual means of efficiency, which provides only a partial view of the performance of the groups as a whole. Table 5.7 supports the results by showing the number of efficient banks in each group. The table shows that the state owned bank group has the highest number of efficient bank (at least one out of four) and ranks as the top among bank groups. By contrast, the group of regional development banks has the highest proportion only once, in 1996, with four of 25 banks (or 16%) found to be efficient, and in some years, 1993, 2001, 2003, 2004 and 2009 to 2011, this group of banks did not have any efficient banks at all.

The difference in efficiency between state owned and regional banks is noteworthy. Banks in both of these groups are government-owned, but they are unequal in terms of business size. State owned banks are owned by the state government, whereas regional development banks are owned by local governments. However, the status of regional development banks as the least efficient amongst different types of banks has become a serious concern, as this group ranks third in customer deposits (see Table 2.8 in Chapter 2).

The results under the revenue approach (Model B) show some differences in the efficiency levels of these groups, as presented in Table 5.6 and displayed in Figure 5.3. The point of commonality between this model and Model A is that state banks are ranked at the top, with an average efficiency ranging from 55% to unity, whereas the other groups and the industry as a whole have much lower efficiency levels (see

Figure 5.3). The figure also shows that the average scores of the other groups appear to be only slightly different from each other.

Figure 5.2: DEA Estimates of Efficiency for Model A, 1993-2011

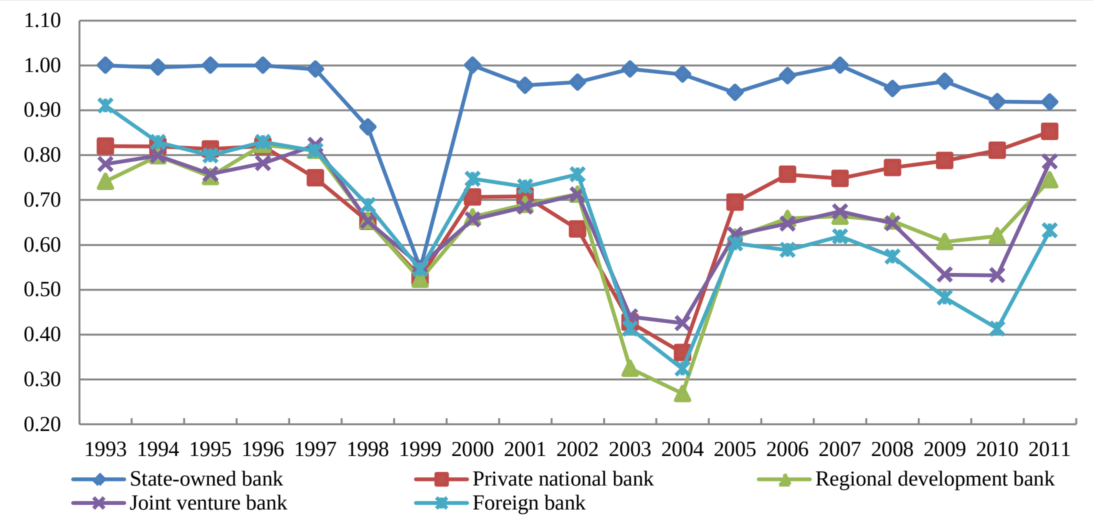


Source: Author's DEA results (Table 5.5)

In Table 5.6 and Figure 5.3 the rankings of the groups below state banks are marginally different from Table 5.5 and Figure 5.2. Based on the mean efficiency scores for the entire period, the second ranking is occupied by private national banks, with an average score ranging from 36% to 85%, followed by joint -venture banks between 42% and 82%. A surprising result emerges for foreign banks. Although these banks perform relatively well in the former model in which they are just slightly below state banks, however, in Model B, this group tends to follow the trend of other non-state banks (see Figure 5.3).

In general, this group is shown to be only marginally above the regional development banks. This consideration is based on the overall mean of bias-corrected efficiency, although the original mean efficiency is slightly lower than regional banks. Moreover, the annual efficiency average for foreign banks varies from 32% to 91%, whereas that for regional development banks show a lower range from 23% to 82%. Looking at the annual result, the lower efficiency average of foreign banks is primarily sourced from the lowest annual mean during 2006 to 2011.

Figure 5.3: DEA Estimates of Efficiency for Model B, 1993-2011



Source: Author's DEA results (Table 5.6)

The remarkable differences of foreign banks in these two models are interesting to observe because the change in regulations of the Indonesian banking sector appears to have dissimilar effect on its role. According to Figure 5.3, all groups, except for state banks, experienced fluctuations during the three periods, as described above. A remarkable downturn occurred in 2003-2004, when banks reached their lowest average efficiency levels: 36%, 27%, 42%, 32% and 36% for private national banks, regional development banks, joint venture banks, foreign banks and the industry as a whole, respectively.

Although the effect of the downturn in the last period (2009-2010) is not as severe as the effects of the former downturn, foreign banks fall to the bottom of the rankings among the bank groups. The lowest position of these banks is observed over the last six years of the period, beginning in 2005. For the duration of this period, the average efficiency estimate of foreign banks is the lowest among the groups and far below the industry average, with the largest gap of 29% in 2010. This pattern could be attributed to the worldwide recession and the global financial crisis.

A comparison of Table 5.5 and Table 5.6 shows that state owned banks are the best performers in both models. Although there are only four banks in this group, they are "old banks" that are classified as large in size, with the most significant presence throughout the country. It could be argued that state owned banks, with extensive branch networks across the nation and large depositor bases, have an advantage over their counterparts, as these banks can attract more deposits and loan transactions and thereby command larger interest rate spreads. Moreover, Sufian (2010) states that as is typical with large banks, most offer a variety of services from which they can derive substantial non-interest income from commissions, fees and other treasury activities.

Table 5.7: The Number of Efficient Banks by Group

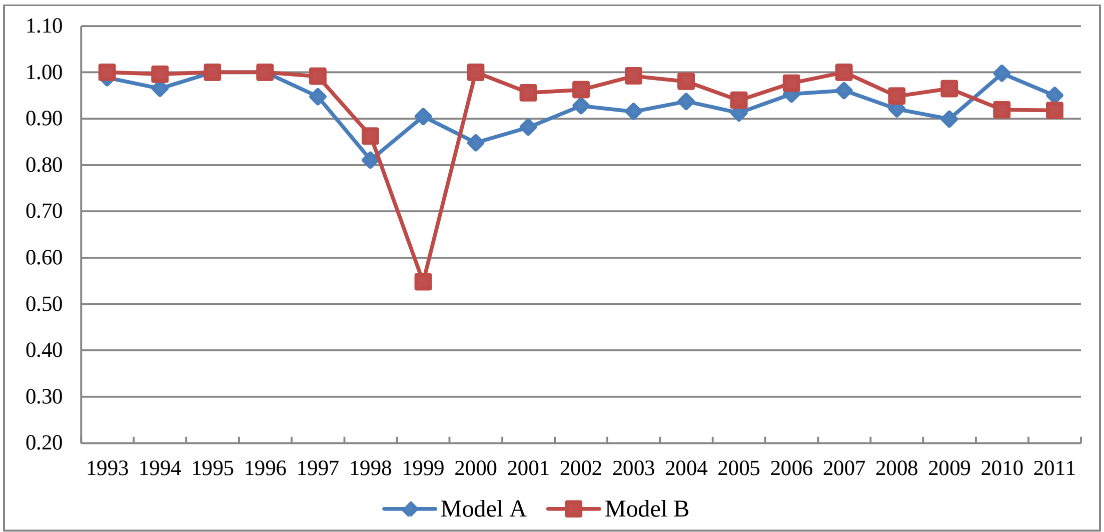
Groups	State owned bank (4 banks)		Private national bank (53 banks)		Regional development bank (25 banks)		Joint venture bank (10 banks)		Foreign bank (9 banks)		Total (101 banks)	
	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B	Model A	Model B
1993	3	4	3	9	2	0	3	1	2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

Source: Author’s compilation.

To clearly compare the two models, the annual means for Models A and B for state owned banks, private national banks, regional development banks, joint venture banks and foreign banks are displayed in Figure 5.4, Figure 5.5, Figure 5.6, Figure 5.7 and Figure 5.8, respectively.

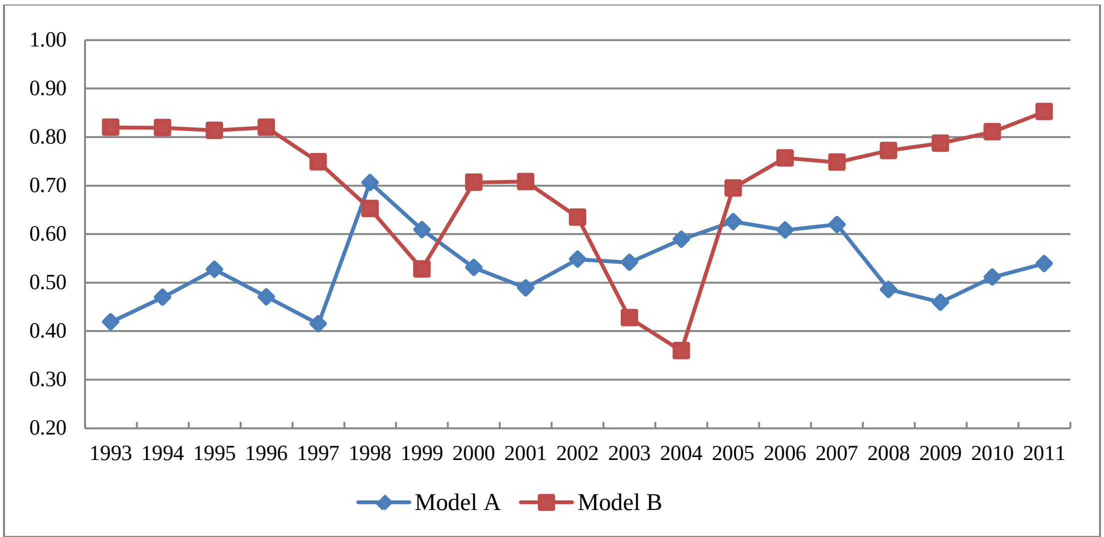
In addition to being the most efficient group and performing consistently above the rest of the industry, there are two other appealing aspects of the efficiency performance of state owned banks (see Figure 5.4). First, the technical efficiency of this group fluctuates less than that of other groups, except in the period of the AFC, in which it reached the lowest level of 55%. Second, under both approaches, the technical efficiency of this group moves in the same direction. For most periods, the efficiency under the revenue approach exceeds the efficiency under the intermediation approach, except during 1999-2000 and 2010-2011. This group shows the most stable efficiency performance in the industry.

Figure 5.4: DEA Estimates of the Efficiency of State Owned Banks



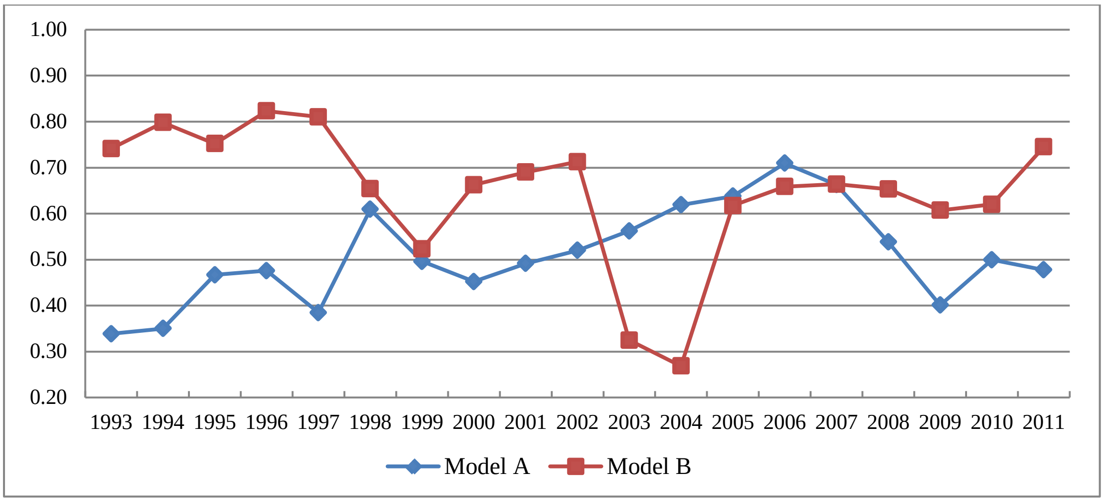
Source: Author's DEA results.

Figure 5.5: DEA Estimates of the Efficiency of Private National Banks



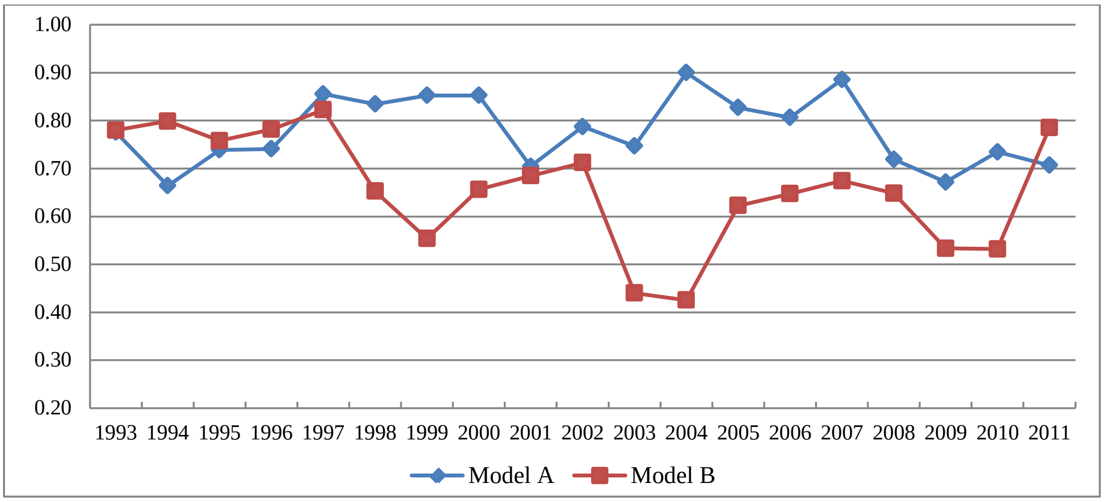
Source: Author's DEA results.

Figure 5.6: DEA Estimates of the Efficiency of Regional Development Banks



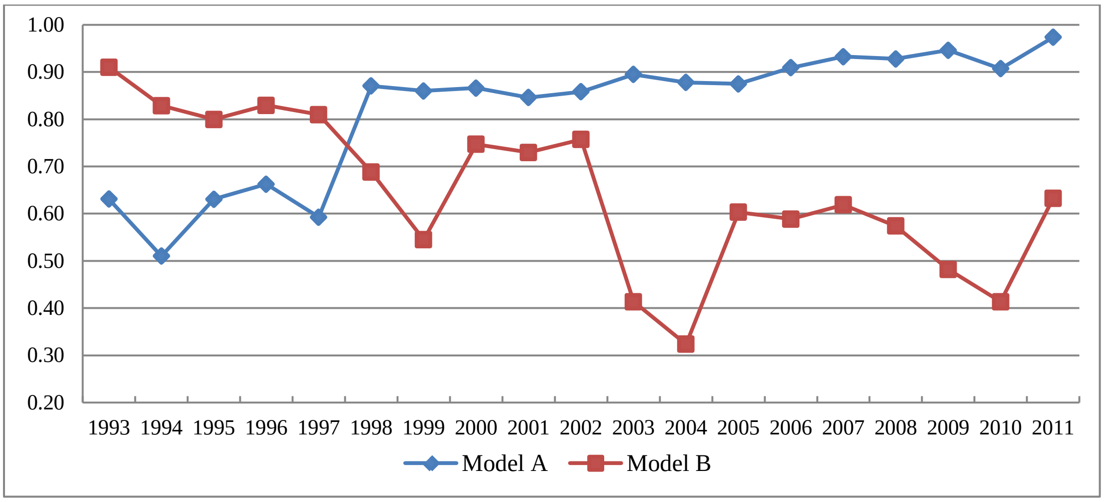
Source: Author's DEA results.

Figure 5.7: DEA Estimates of the Efficiency of Joint Venture Banks



Source: Author's DEA results.

Figure 5.8: DEA Estimates of the Efficiency of Foreign Banks, 1993-2011



Source: Author's DEA results.

With the exception of joint venture banks, all groups begin the period with great disparities in their efficiency scores under the different models. At the beginning of the period, performance under model B is much higher than under model A and this result is shown in the pattern of industry performance as a whole. Interestingly, although the average efficiency scores of private national banks in both models are above those of regional development banks, the two groups are shown to have similar patterns, as presented in Figure 5.5 and Figure 5.6. A slight disparity is shown in 1998-1998, in which private banks is more efficient in term of the intermediation approach than revenue based approach, whereas regional development banks show a reverse position. The similarities in trends can be attributed to similarities in the nature of their business. In fact, such banks compete for the same customers.

Although the portraits of joint venture and foreign banks indicate some differences between them and the other groups, Figure 5.7 shows that the joint venture banks exhibit similar fluctuations during the period of analysis. Under the intermediation approach, the trend of technical efficiency among joint venture banks appears flat at above 70%, but it appears to decline under the revenue approach. The same trend is also observed for foreign banks. However, later in the period the efficiency of foreign banks under the intermediation approach improves much more markedly relative to the efficiency of other banks and relative to its own estimates under the revenue approach.

In brief, the technical efficiency of all groups reveals a high fluctuation during the study period except for state owned banks. This finding suggests that the regulatory changes and liberalisation of the banking sector in Indonesia have had a different effect for each group. The nature of the bank group’s business operation appears to influence their performance in response to the change in regulations. However, the banks in the all groups comprise different size of banks, which encompass large, medium and small banks. An exception occurs in the case of state owned banks, a group that includes only four banks of primarily large and medium size. The next subsection presents results for the technical efficiency of banks based on size category.

5.5.3 The Technical Efficiency of Banks by Size Categories

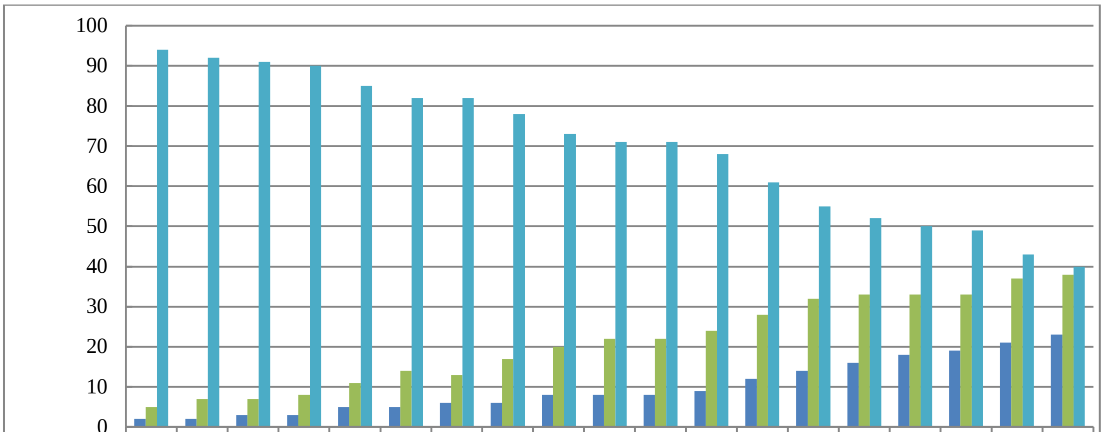
The previous subsection demonstrates the substantial disparities in efficiency estimates among the groups of banks. Efficiency in those groups could be attributed to a broad range of sources. Hence, it is worth tracing the sources of efficiency based on bank size. Given the individual bank efficiency estimates, banks are classified into different size categories to trace the sources of efficiency.

The literature shows that the criteria for classifying banks in terms of size are varied, but bank size is typically classified based on equity capital, assets, consumer deposits, total loans or the number of employees. Following the practice that has been used by Bank Indonesia, banks are divided into three categories:

- Large banks total assets > IDR 25 trillion
- Medium banks $25 \geq$ total assets $\geq$ IDR 4 trillion
- Small banks total assets < IDR 4 trillion

The yearly number of banks over the period of investigation in each size category (i.e., large, medium and small) is displayed in Figure 5.9. In addition, Table 5.8 presents the total assets per bank group for each year during the 1993-2011.

Figure 5.9: The Number of Banks by Size Category, 1993 - 2011



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Large	2	2	3	3	5	5	6	6	8	8	8	9	12	14	16	18	19	21	23
Medium	5	7	7	8	11	14	13	17	20	22	22	24	28	32	33	33	33	37	38
Small	94	92	91	90	85	82	82	78	73	71	71	68	61	55	52	50	49	43	40

Source: Author's calculation.

Figure 5.9 clearly shows that the size groups do not contain equal numbers of banks. Rather, small banks are predominant (69% of all banks on average), followed by medium and large banks (21% and 10% of all banks), respectively. However, this pattern of domination is not observed in the size of business operations. As shown in Table 5.8, the rank of domination is inverted, with large banks constituting an average of 65% of the total sample, followed by medium banks (25%) and small banks (10%). The supremacy of large banks in the Indonesian banking industry is also noted by Sufian (2009)

Table 5.8: Total Assets of Banks by Size Category (IDR trillion)

Year	Large	Medium	Small	All banks
1993	52.84	57.87	38.27	148.98
1994	56.17	79.85	39.87	175.89
1995	85.63	73.98	45.68	205.28
1996	103.42	98.68	51.51	253.61
1997	212.26	102.41	51.38	366.05
1998	216.95	126.51	55.48	398.94
1999	525.88	109.40	62.78	698.06
2000	626.34	198.78	65.87	890.98
2001	703.58	205.94	70.53	980.04
2002	716.63	224.16	71.89	1,012.68
2003	747.68	250.94	81.41	1,080.03
2004	814.60	280.53	83.29	1,178.42
2005	986.15	317.15	75.59	1,378.89
2006	1,166.38	358.36	71.41	1,596.15
2007	1,430.60	357.14	71.48	1,859.23
2008	1,753.69	367.93	71.27	2,192.89
2009	1,976.87	371.50	78.15	2,426.52
2010	2,410.00	417.52	67.34	2,894.86
2011	2,939.68	478.90	73.97	3,492.55

Source: Author’s calculation.

The remarkable number of small banks during the initial period clearly reflects the effect of banking reforms in 1988, which eased the requirements for establishing a bank. Nevertheless, the restructuring and consolidation programmes that were undertaken after the AFC in 1997 resulted in a steady decline in the number of small banks, while the number of medium and large banks increased steadily. Declining trends are also observed in the total asset shares of small and medium banks, whereas large banks are shown to have a steadily increasing share of total assets over the period of analysis.

Table 5.9 and Table 5.10 present the annual mean efficiency levels estimated by bank size categories for Model A and Model B, respectively. Columns 2 to 4 present the original efficiency estimates for the groups of large, medium and small banks, respectively. Bias-corrected estimates and estimates of bias, including lower and upper bounds, are presented in the next columns for the same categories. Some important findings emerge from these tables. *First*, the trend in efficiency estimates is generally declining over the period of investigation. Movements among all size categories under each model are displayed in Figure 5.10 and Figure 5.11. Under Model A, the patterns in the different categories slightly diverge from one another and from the pattern of the industry as a whole. By contrast, under Model B, the different size groups show similar fluctuations that also resemble the industry pattern.

Second, the ranking of categories, from most to least efficient, is similar under the two models. Large banks are found to be the most efficient, with average efficiency levels of 89.1% (Model A) and 71.64% (Model B), followed by medium banks, with average efficiency levels of 75.8% (Model A) and 74.4% (Model B), and finally small banks, with average efficiency levels of 51.9% (Model A) and 66.96% (Model B). The relative efficiency of these two categories is even higher than that for the industry as a whole, especially under Model A, in which the gap is extremely large. This finding noticeably suggests that large banks are able to perform efficiently in terms of both the intermediation function and revenue creation functions.

Given the results from the previous groups and the number of bank categories in each group, it is evident that the sources of efficiency for state owned banks and foreign banks are that they are large and medium banks. Large banks are dominant among state owned banks (90.5%), but they constitute only 17% of foreign banks (in which medium banks dominate, with 33% of the total). Likewise, for the least efficient group, regional development banks, most of the inefficiency is contributed by small banks. Moreover, given that the industry has been dominated by small banks, the industry efficiency patterns appear to follow the efficiency patterns of small banks under Model A (see Figure 5.10).

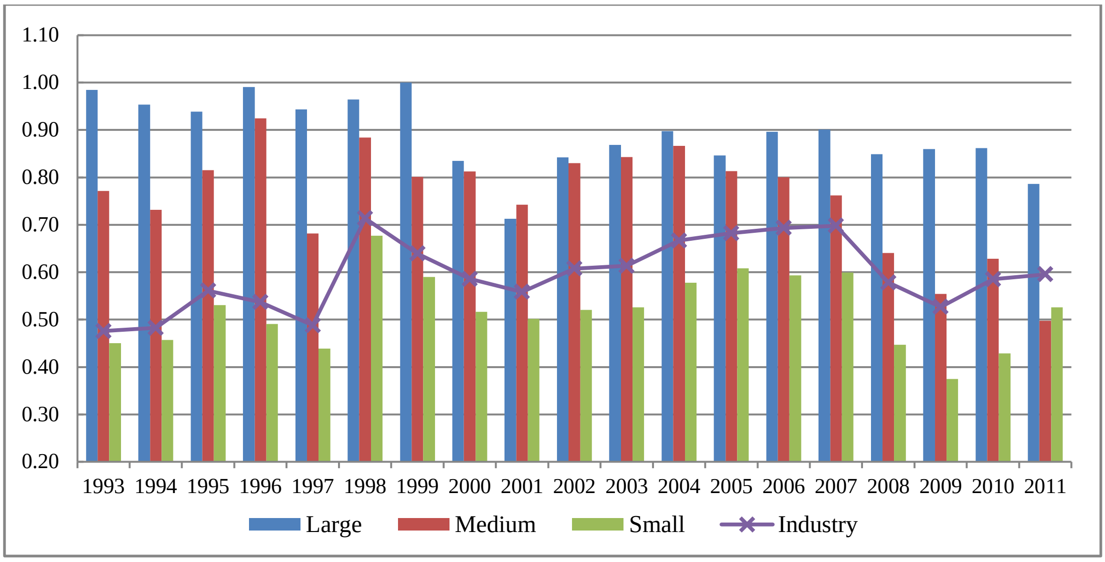
Third, in contrast to the industry pattern, the efficiency levels of large and medium banks are higher under Model A than under Model B. This result is evident from the overall mean efficiency levels of 89.75% under Model A and 75% for large and medium banks, respectively, compared with scores of 86.5% and 71.65%, respectively, under Model B. Nonetheless, in the case of small banks, the efficiency level is similar to that of the industry as a whole and is much higher under Model B (67.21%) than under Model A (41.47%). This finding is noteworthy, given that industry-level efficiency is shown to be higher under Model B than under Model A.

Table 5.9: Annual Mean of DEA Bootstrapping by Bank Size Category, 1993-2011 (Model A)

Year	Efficiency			Bias-corrected mean			Bias			Lower bound			Upper bound		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
1993	1.0000	0.7613	0.4495	1.0000	0.6381	0.3949	0.0000	0.1232	0.0546	1.0000	0.5225	0.3108	1.0000	0.7681	0.4537
1994	0.9301	0.7369	0.4536	0.8651	0.5829	0.3701	0.0650	0.1540	0.0835	0.8601	0.4739	0.2643	0.9384	0.7452	0.4586
1995	0.9180	0.8139	0.5299	0.8552	0.7101	0.4613	0.0628	0.1038	0.0686	0.8360	0.6278	0.3657	0.9204	0.8186	0.5335
1996	1.0000	0.9108	0.4882	1.0000	0.8551	0.4418	0.0000	0.0557	0.0464	1.0000	0.8217	0.3764	1.0000	0.9156	0.4917
1997	0.9947	0.6474	0.4376	0.9895	0.4668	0.3781	0.0051	0.1806	0.0594	0.9893	0.3215	0.2960	0.9966	0.6522	0.4411
1998	0.9641	0.8515	0.6748	0.9396	0.8116	0.6475	0.0245	0.0400	0.0273	0.9281	0.7480	0.6016	0.9656	0.8533	0.6770
1999	1.0000	0.8121	0.5856	1.0000	0.7566	0.5518	0.0000	0.0555	0.0337	1.0000	0.6788	0.4948	1.0000	0.8151	0.5881
2000	0.8812	0.7985	0.5167	0.8683	0.7581	0.4698	0.0129	0.0403	0.0469	0.8348	0.6808	0.3762	0.8814	0.7998	0.5188
2001	0.7525	0.6849	0.5024	0.6674	0.5850	0.4526	0.0851	0.1000	0.0497	0.5338	0.4520	0.3577	0.7554	0.6897	0.5055
2002	0.8026	0.8492	0.5107	0.7592	0.7917	0.4654	0.0435	0.0576	0.0452	0.6931	0.7307	0.3663	0.8043	0.8510	0.5125
2003	0.8354	0.8593	0.5121	0.7987	0.8119	0.4616	0.0367	0.0474	0.0505	0.7309	0.7530	0.3669	0.8371	0.8615	0.5141
2004	0.8958	0.8678	0.5655	0.8565	0.8206	0.5205	0.0393	0.0472	0.0450	0.7918	0.7631	0.4340	0.8979	0.8699	0.5675
2005	0.8404	0.7720	0.6099	0.7985	0.7167	0.5718	0.0419	0.0553	0.0381	0.7344	0.6334	0.4995	0.8415	0.7739	0.6116
2006	0.9242	0.7764	0.5864	0.8907	0.7252	0.5478	0.0335	0.0512	0.0386	0.8516	0.6445	0.4697	0.9255	0.7782	0.5878
2007	0.9020	0.7554	0.5996	0.8701	0.7119	0.5635	0.0319	0.0435	0.0361	0.8259	0.6415	0.4922	0.9031	0.7569	0.6008
2008	0.8710	0.6323	0.4377	0.8138	0.5593	0.3887	0.0572	0.0730	0.0490	0.7607	0.4577	0.2981	0.8747	0.6357	0.4400
2009	0.8822	0.5586	0.3674	0.8157	0.4858	0.3262	0.0666	0.0728	0.0412	0.7645	0.3615	0.2422	0.8876	0.5621	0.3694
2010	0.8746	0.6161	0.4170	0.8143	0.5620	0.3700	0.0602	0.0541	0.0469	0.7519	0.4767	0.2817	0.8780	0.6193	0.4190
2011	0.7840	0.5455	0.5349	0.7167	0.5093	0.4854	0.0673	0.0362	0.0495	0.6250	0.4402	0.4032	0.7869	0.5479	0.5370
Mean	0.8975	0.7500	0.5147	0.8589	0.6768	0.4668	0.0386	0.0732	0.0479	0.8164	0.5910	0.3841	0.8997	0.7534	0.5173

Source: Author’s calculation.

Figure 5.10: Annual Mean Efficiency Estimates by Bank Size Category, 1993-2011 (Model A)



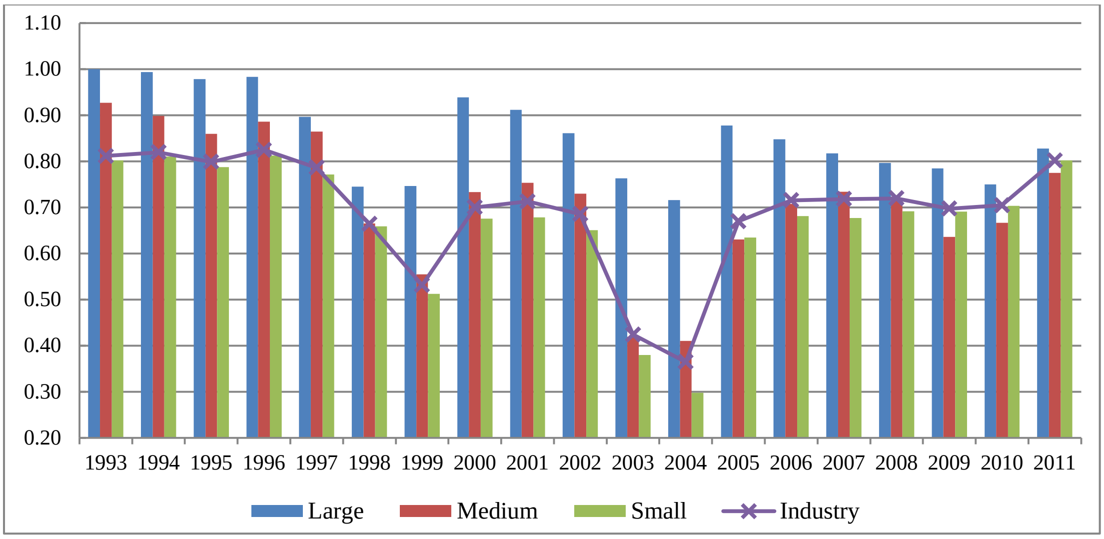
Source: Author's DEA results (Table 5.9).

Table 5.10: Annual Mean of DEA Bootstrapping by Bank Size Category, 1993-2011 (Model B)

Year	Efficiency			Bias-corrected mean			Bias			Lower bound			Upper bound		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
1993	1.0000	0.8943	0.8033	1.0000	0.8677	0.7773	0.0000	0.0266	0.0260	1.0000	0.8445	0.7325	1.0000	0.8951	0.8044
1994	1.0000	0.8879	0.8109	1.0000	0.8560	0.7832	0.0000	0.0319	0.0277	1.0000	0.8115	0.7389	1.0000	0.8888	0.8116
1995	0.9716	0.8740	0.7876	0.9579	0.8481	0.7630	0.0137	0.0259	0.0246	0.9432	0.7974	0.7204	0.9722	0.8749	0.7888
1996	0.9729	0.9289	0.8108	0.9653	0.9192	0.7890	0.0076	0.0097	0.0218	0.9458	0.9013	0.7500	0.9732	0.9293	0.8116
1997	0.9608	0.8321	0.7702	0.9470	0.8129	0.7426	0.0139	0.0192	0.0276	0.9288	0.7823	0.7015	0.9617	0.8332	0.7717
1998	0.7455	0.7253	0.6490	0.7065	0.6776	0.6024	0.0390	0.0477	0.0465	0.6254	0.6138	0.5279	0.7464	0.7287	0.6527
1999	0.7465	0.5519	0.5128	0.6508	0.4196	0.4366	0.0958	0.1322	0.0762	0.5436	0.2861	0.3377	0.7508	0.5613	0.5188
2000	0.9090	0.7689	0.6757	0.8629	0.7300	0.6367	0.0461	0.0390	0.0390	0.8179	0.6603	0.5652	0.9095	0.7703	0.6776
2001	0.9567	0.7257	0.6830	0.9362	0.6736	0.6433	0.0205	0.0521	0.0398	0.9133	0.5976	0.5726	0.9573	0.7275	0.6847
2002	0.8487	0.7363	0.6517	0.8169	0.6981	0.6198	0.0318	0.0382	0.0319	0.7776	0.6410	0.5600	0.8505	0.7385	0.6538
2003	0.7696	0.4298	0.3837	0.7284	0.3560	0.3075	0.0412	0.0738	0.0762	0.6546	0.2506	0.1965	0.7735	0.4353	0.3879
2004	0.7266	0.4092	0.3015	0.6481	0.3298	0.2209	0.0785	0.0794	0.0806	0.5348	0.2497	0.0970	0.7362	0.4175	0.3075
2005	0.9030	0.6498	0.6334	0.8616	0.6137	0.5819	0.0414	0.0361	0.0516	0.8143	0.5485	0.4959	0.9044	0.6514	0.6354
2006	0.9167	0.6798	0.6850	0.8892	0.6532	0.6486	0.0275	0.0266	0.0363	0.8522	0.5999	0.5829	0.9184	0.6810	0.6864
2007	0.8695	0.7176	0.6799	0.8424	0.6907	0.6439	0.0271	0.0268	0.0360	0.7952	0.6368	0.5797	0.8705	0.7187	0.6813
2008	0.7949	0.7133	0.6971	0.7572	0.6810	0.6572	0.0377	0.0323	0.0399	0.7115	0.6265	0.5887	0.7971	0.7151	0.6991
2009	0.7725	0.6517	0.6992	0.7399	0.6173	0.6634	0.0326	0.0343	0.0358	0.7006	0.5547	0.6016	0.7748	0.6536	0.7014
2010	0.7400	0.6545	0.7310	0.6974	0.6120	0.6905	0.0426	0.0425	0.0405	0.6415	0.5470	0.6318	0.7422	0.6567	0.7334
2011	0.8314	0.7829	0.8038	0.8074	0.7608	0.7813	0.0241	0.0221	0.0225	0.7713	0.7236	0.7407	0.8325	0.7840	0.8049
Mean	**0.8650**	**0.7165**	**0.6721**	**0.8324**	**0.6746**	**0.6310**	**0.0327**	**0.0419**	**0.0411**	**0.7880**	**0.6144**	**0.5643**	**0.8669**	**0.7190**	**0.6744**

Source: Author's calculation.

Figure 5.11: Annual Mean Efficiency Estimates by Bank Size Category, 1993-2011 (Model B)



Source: Author's DEA results (Table 5.10).

Furthermore, the number of efficient banks in each size category supports the sequence of efficiency levels observed among bank size categories. Table 5.11 shows the number of efficient banks under each model and in each size category. The large banks have the highest percentage of efficient banks, followed by medium and small banks. In particular, the percentages of efficient banks are 56.3% and 48% for large banks, 30% and 21.8% for medium banks, and 9.7% and 12% for small banks under models A and B, respectively. Similarly, the trend is also decreasing towards the end of the sample period, especially for large and medium banks. Indeed, the trend among small banks tends to be constant and then improves by the end of the period.

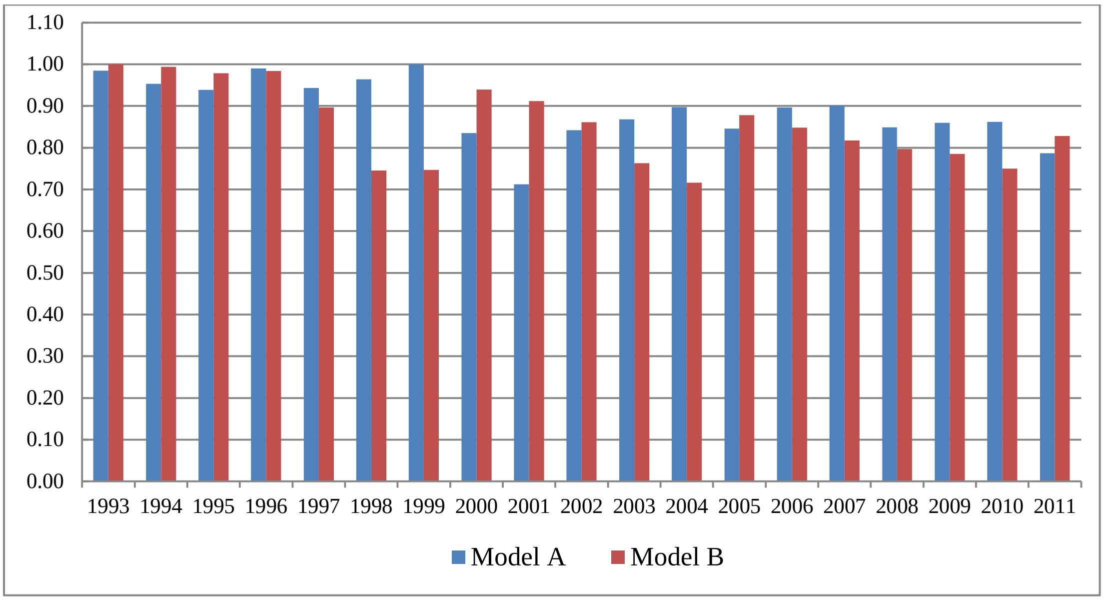
Nonetheless, when considering efficiency by size categories, there are notable differences across Model A and Model B among the three categories. Under both models, large banks show a similar level and pattern of efficiency during the study period. As displayed in Figure 5.12, the only significant gap between the two models occurs from 1998 to 2001, in which Model A outweighs Model B in the first two years and Model B outweighs Model A in the last two years. However, the superiority of large banks in their average efficiency exhibits a decreasing trend towards the end of the period under both models, which is similar to the trend among medium banks. Another similarity between large and medium banks is that efficiency under Model A is higher for both categories than under Model B.

Table 5.11: The Number of Efficient Banks by Bank Size Category

Year	Large			Medium			Small		
	No. of Bank	No EB Model A	No EB Model B	No. of Bank	No EB Model A	No EB Model B	No. of Bank	No EB Model A	No EB Model B
1993	3	2	3	3	1	1	95	10	13
1994	3	2	2	4	1	2	94	5	14
1995	4	3	3	5	1	2	92	8	15
1996	5	4	4	5	2	2	91	12	14
1997	6	4	3	8	2	4	87	6	9
1998	5	3	3	11	7	2	85	15	13
1999	6	6	3	12	5	1	83	10	8
2000	8	6	5	15	9	3	78	8	10
2001	10	4	6	15	5	2	76	6	8
2002	10	6	4	18	8	3	73	6	9
2003	10	6	4	17	7	0	74	5	5
2004	11	5	4	19	8	1	71	8	3
2005	15	7	6	19	4	3	67	3	5
2006	17	8	5	24	6	6	60	5	6
2007	19	9	7	26	6	6	56	5	4
2008	20	6	5	27	3	4	54	5	6
2009	22	8	6	26	2	3	53	5	8
2010	24	9	6	27	1	2	50	4	8
2011	30	9	7	28	2	6	43	7	8

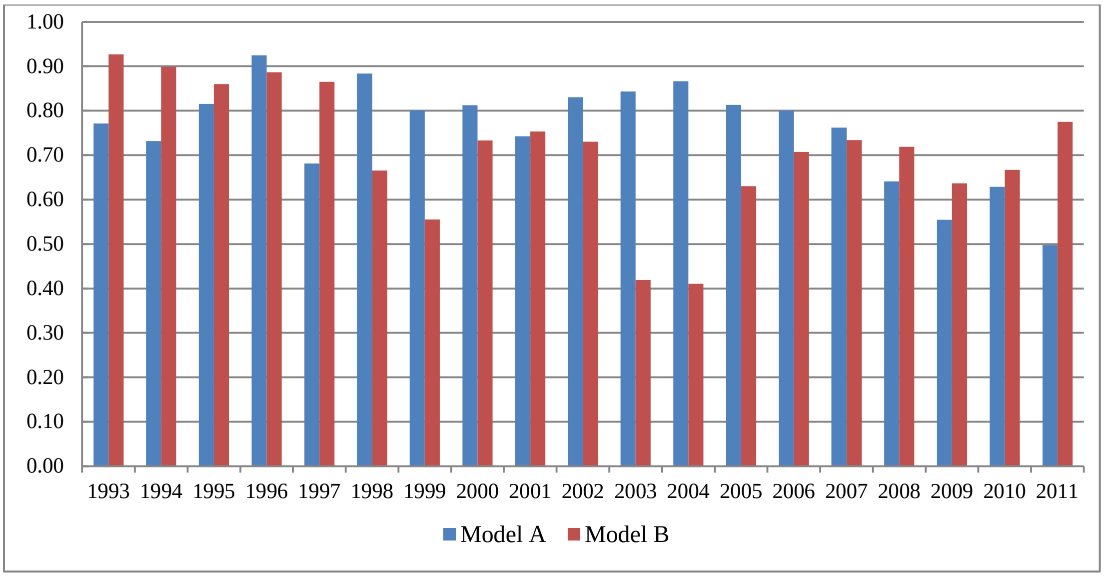
Source: Author's calculation. EB denotes efficient bank.

Figure 5.12: Annual Mean of the Efficiency Estimates of Large Banks



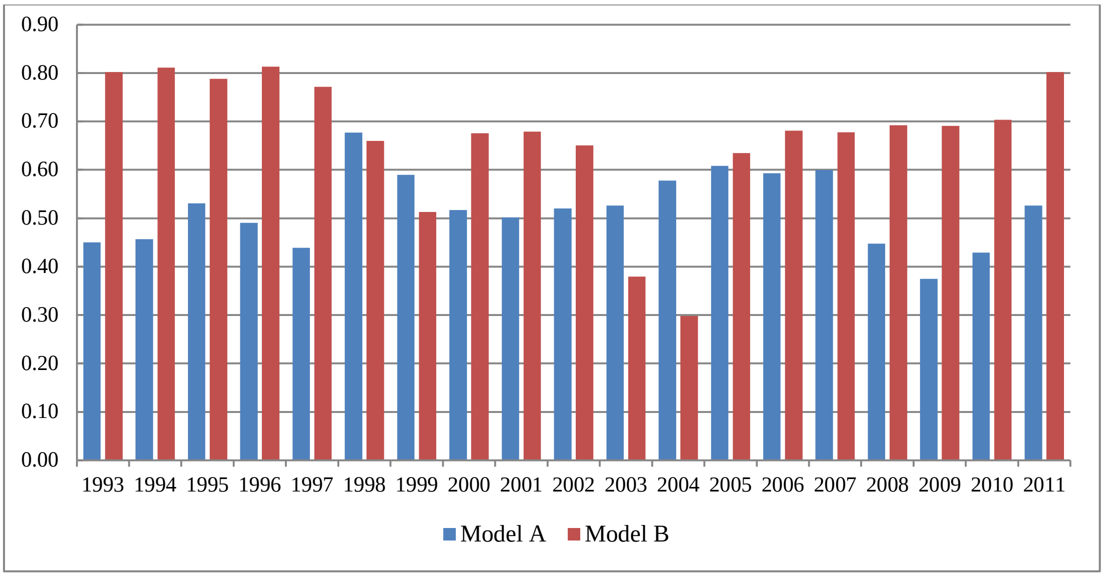
Source: Author's DEA result.

Figure 5.13: Annual Mean of the Efficiency Estimates of Medium Banks



Source: Author's DEA result.

Figure 5.14: Annual Mean of the Efficiency Estimates of Small Bank



Source: Author's DEA result.

Medium banks exhibit more frequent divergence between the two models than do large banks during the sample period, especially in 2003 and 2004. Small banks also exhibit large and even dramatic disparities in most periods. The difference between the small banks, the medium and large banks is that efficiency in Model B largely exceeds that in Model A for the small banks, particularly at the beginning and end of the period, whereas the trend under model A is relatively constant throughout the period.

One could conclude that industry efficiency is primarily determined by the efficiency of small banks. It is evident that the periods of large disparities occur at the beginning and end of the sample period, when model B indicates better performance. Moreover, the primary source of improvement, as indicated by Model A during the sample period, is contributed by the small banks. This finding may not be surprising, given that the industry remains dominated by small banks. The deregulation and reforms following the AFC appear to have improved the intermediation performance of the banking sector.

5.6 A Comparison with Earlier Studies

As noted in the review chapter, the number of efficiency studies of the Indonesian banking sector is limited, and the results are varied. Although the efficiency estimates of this study cannot be strictly compared to previous studies as a result of differences in the study periods, sample sizes, choices of input and output variables, and model specifications, a rough comparison can provide an overall view of the trend of industry performance.

At the industry level, the efficiency results of this study confirm the results of Zhang and Matthews (2012) regarding the lowest annual mean efficiency during the study period, the wide range of efficiency levels within the industry and the higher efficiency levels measured under the revenue approach compared with those measured under the intermediation approach. These authors report that the annual mean cost efficiency of Indonesian banking ranges from 28.51% to 45.17% under the intermediation approach and from 30% to 50.84% under the income approach during the 1992-2007 period. Widely divergent annual mean efficiency levels are also found in the work of Hadad et al. (2010a). The better performance of the industry that is observed under the revenue approach than the intermediation approach is also implied by Sufian (2010), who finds the scores of intermediation-based efficiency ranges from 66.8% to 94.3% and revenue-based efficiency starts from 71% to 90.4%. Other Indonesian studies report a higher efficiency level compare to this study such as Harada and Ito (2005) (80% to 94%); Omar, Majid, and Rulindo (2007) (86.2% to

91.2%); and Hadad et al. (2008a) (70% to 82%). However, these studies use small samples and short sample periods.

In terms of the efficiency of bank groups, the findings in this study are similar to those of Hadad et al. (2008b) and Hadad et al. (2012), who report that state owned banks are the best performers and that regional development banks constitute the least efficient group. In these studies, the same rankings are found for joint venture banks, foreign banks and national private banks in the second, third and fourth place, respectively.

The results in various studies based on bank size are mixed. As in this study, most Indonesian bank efficiency studies find that large banks are the most efficient. An exception, however, is the work of Margono, Sharma, and Melvin (2010), who report that medium banks are the most efficient, followed by large banks and small banks. These researchers also find that joint ventures and foreign banks are more efficient than publicly owned banks. This finding may be valid since their analysis covers the period of 1993-2000, in which domestic banks were still struggling in the aftermath of the AFC, whereas foreign banks were less affected.

The results for medium and small banks in previous studies are varied. When using the revenue approach, Sufian (2010) finds similar results as found in this study. Conversely, under the intermediation approach, the author finds small banks to be the most efficient banks, followed by medium and large banks. Medium banks are reported as being the least efficient in 2007 by Hadad et al. (2008b), whilst Margono, Sharma, and Melvin (2010) find that medium banks are the most efficient, followed by large banks. These variations in study results show that industry efficiency is not stable across different time periods, assumptions and datasets.

Despite the fluctuations in efficiency during the study period, improvements are generally observed in most of the above-cited studies, except in the work of Omar, Majid, and Rulindo (2007), who present evidence of a decline in efficiency (from 91.2% to 86.2%) during the 2002-2003 period. However, their study examines only 21 national private banks.

As noted in the literature review of Chapter 3, studies of the impact of regulatory changes on bank efficiency in various countries show mixed results. In this study, results show an improvement in the efficiency of Indonesian banks after deregulation which is similar to that found by Hadad et al. (2010) the case of intermediation approach. The enormous differences in efficiency between large and small banks is consistent with the findings of Drake and Hall (2003). Furthermore, the positive relationship between bank size and efficiency is similar to that reported by Leightner and Lovell (1998).

5.7 Conclusions

This chapter provides an empirical analysis of the technical efficiency of the Indonesian banking sector during the 1993-2011 period. The results are obtained by conducting an input-oriented DEA complemented with the bootstrapped DEA method under an assumption of VRS. Two separate sets of input and output variables under both the intermediation approach (Model A) and the revenue approach (Model B) are employed to measure the efficiency of intermediation activities and revenue-maximising bank business operations.

The empirical results reveal that the banking sector is less than fully efficient under both approaches. In terms of intermediation approach, the average technical efficiency over the period of analysis is 59.4%, with values ranging from 47% to 71%. The overall trend indicates improvement, although fluctuations occurred. The average efficiency of the industry under the revenue approach is found to be 69.2%, with values ranging from 36.5% to 81.9%, which are higher levels of efficiency than is shown under the intermediation approach. These results imply that inputs can be reduced by an average of 40.6% and 30.8% under the intermediation and revenue approaches, respectively, relative to the current best practices. The results of the bias-corrected estimations fall below the estimated efficiency levels, but reproduce the same pattern as the original estimates. The bias ranges from 0.03 to 0.09 under the intermediation approach and from 0.02 to 0.08 under the revenue approach.

Based on the bank group results, the most and the least efficient group are relatively similar under both models, which refer to state owned banks and regional development banks, respectively. The rest of groups are positioned in the middle ranks with a various order under the models. Results on bank size offer similar suggestions with typical findings in bank efficiency studies of larger banks tend to be more efficient.

Thus, this chapter provides an empirical measure of technical efficiency of Indonesian banks for the period of 1993-2011. To have the broader picture of banks' performance during this study period the next chapter presents the measure of productivity growth of banks by using the MPI.

Chapter 6

Decomposing the Productivity Growth of the Indonesian Banking Sector Using the Bootstrap MPI

6.1 Introduction

In the previous chapter, the efficiency of the banking sector in Indonesia was investigated using the DEA bootstrapping approach. The result shows that generally, the efficiency of Indonesian banking has slowly improved over the period of analysis, particularly when measured using the intermediation approach. The measurement was conducted using the non-parametric DEA method, in which the frontier is assumed to be stable over the period. However, this case does not appear to apply in the real world, because improvements in technology could shift the efficiency frontier. The shift of the frontier could result from technological improvement or regulatory change and should be differentiated from technical efficiency gains, which are characterised by units moving closer to the frontier and are referred to as the 'catching-up effect'.[22]

It is imperative to measure productivity growth in the banking industry, given that the industry has often confronted regulatory change over time, in addition to its crucial role in the economy and financial system. It must also be considered that regulatory change does not always lead to improvements in productivity. Moreover, the decomposition of productivity growth offers further insight into the sources of productivity growth (decline) in lieu of the effect of regulatory change. The effects of regulatory change can emerge in an upward shift of production technology frontier (technological gain) or in a movement towards the production technology frontier (technical efficiency gain). Hence, a comprehensive analysis of the source of productivity change is supported by decomposing productivity growth.

This chapter empirically investigates the productivity change in Indonesian banks by using the bootstrapped Malmquist productivity index (MPI) proposed by Simar and

[22] The change of regulation could shift the frontier through limiting or relaxing the use of technology. For instance, if regulator imposes a specific percentage on loan expansions, banks might be unable to maximise their lending ability which in turn moves their production frontier down.

Wilson (1999a). The application of bootstrap methods in this chapter ensures consistency with the previous chapter regarding the statistical sense of results. This method allows for the assessment of the “null hypothesis” of no efficiency change, no technological change and no productivity gains or losses, which implies that the measures are not significantly different from unity (Tortosa-Ausina et al. 2008). The value of unity (one) is used as the base value to signify no change in productivity measures from a base year to the next. The MPI provides measures of total factor productivity (TFP) change, which is decomposed into the product of efficiency change (EC), also commonly referred to as technical efficiency change or ‘catching up’, and technological change (TC) or ‘frontier shift’. Technical efficiency change is further decomposed into the product of pure efficiency change (PEC) and the scale efficiency change (SEC), and technological change is further decomposed into the product of pure technological change (PTC) and the scale of technology change (STC). This decomposition presents information regarding the sources of productivity change in the Indonesian banking industry.

The remainder of this chapter is constructed as follows. The next section explains the formulation of the bootstrap MPI (Section 6.2). Section 6.3 describes the decomposition of productivity growth. Section 6.4 presents the empirical results of TFP growth and its decomposition. Section 6.4 is divided into three subsections to provide the results by overall industry, by group of banks and by bank size. The final section (Section 6.5) concludes with a summary of the major findings of this chapter.

6.2 Bootstrapping the MPI

Following their work in 1998 on the efficiency bootstrapping method, Simar and Wilson (1999a) develop the methodology for bootstrapping MPI. The previous chapter presented bootstrap methodology for efficiency scores can be adapted to bootstrap Malmquist indices. In this case, however, the time-dependence structure of the data must be considered. Simar and Wilson (1998b) note the problems with bootstrapping in DEA model and suggest the use of the bootstrap procedure. In addition to estimating the Malmquist indices, this study uses panel data in lieu of a single cross-section of data with the possibility of temporal correlation. In adapting the bootstrapping procedure for Malmquist indices, Simar and Wilson (1999a) advise employing a consistent approach with a bivariate kernel density estimator using the covariance matrix of data from adjacent years.

This process can be summarised as follows:

1. Calculate the MPI $\widehat{M}_i(t_1, t_2)$ for each bank $(i = 1, \dots, N)$ at time (t_1 and t_2) by solving the linear programming models in Equations 4.31 to 4.34 in Chapter 4.
2. Construct a pseudo-dataset $\{(x_{it}^*, y_{it}^*); i = 1, \dots, N; t = 1,2\}$ to form the reference bootstrap technology using the bivariate kernel density estimation and the reflection method proposed by Simar and Wilson (1999a).
3. Calculate the bootstrap estimate of the Malmquist index $\widehat{M}_i(t_1, t_2)$ for each bank using the original estimators for the pseudo-sample obtained in step 2.
4. Repeat steps 2 and 3 a large number, *B*, times (in this study, *B* = 2,000 times), to facilitate a set of estimates for each bank.
5. Construct the confidence intervals for the Malmquist indices accordingly.

As explained in the previous chapter, these bootstrap estimates can be used to construct statistical inference on the productivity indices. Given that the distribution of $\widehat{M}_i(t_1, t_2) - M_i(t_1, t_2)$ is unknown, it can be approximated by the distribution of $\widehat{M_i^*}(t_1, t_2) - \widehat{M}_i(t_1, t_2)$ where $\widehat{M_i^*}(t_1, t_2)$ is the bootstrap estimate of the index and $\widehat{M}_i(t_1, t_2)$ is the original estimate of the MPI. Thus, a_α and b_α explain the confidence interval as

$$Pr\left(-b_\alpha \leq \widehat{M}_i(t_1, t_2) - M_i(t_1, t_2) \leq -a_\alpha\right) = 1 - \alpha. \qquad 6.1$$

This term can thus be approximated by estimating the values a_α^* and b_α^* and given by the following:

$$Pr(-b_\alpha^* \leq \widehat{M_i^*}(t_1, t_2) - \widehat{M}_i(t_1, t_2) \leq -a_\alpha^*) = 1 - \alpha. \qquad 6.2$$

The confidence intervals are obtained by sorting the values $\widehat{M}_i^*(t_1, t_2) - \widehat{M}_i(t_1, t_2)$ for $b = 1, \ldots, B$ in increasing order and by deleting $\left({}^{\alpha}/_{2}\ x\ 100\right)\%$ of the rows at either end of the sorted list. After $-\hat{b}_\alpha^*$ and $-\hat{a}_\alpha^*$ are set according to the endpoint of the sorted array, the estimated $(1 - \alpha)$ percentage confidence interval for productivity is as follows:

$$\widehat{M}_i^*(t_1, t_2) + a_\alpha^* \leq M_i(t_1, t_2) \leq \widehat{M}_i(t_1, t_2) + b_\alpha^* \qquad 6.3$$

Given the result in the confidence interval, then it is possible to determine whether the estimated MPI is significantly different from unity.

Functioning similarly as in the previous chapter, another method for obtaining a statistical inference of the productivity indices is through the development of the bias estimate. Using the step in the bootstrap estimate (Step 4), the finite-sample bias in the original estimator of the Malmquist indices ($\widehat{M}_i(t_1, t_2)$) can be corrected. By definition, the bootstrap bias estimate of the original estimator of Malmquist indices is as follows:

$$\widehat{bias}_i\left[\widehat{M}_i(t_1, t_2)\right] = B^{-1} \sum_{b=1}^{B} \widehat{M}_i^*(t_1, t_2)(b) - \widehat{M}_i(t_1, t_2) \qquad 6.4$$

Hence, the empirical bias-corrected estimate for of $M_i(t_1, t_2)$ can be computed as follows:

$$\begin{aligned} \widetilde{M}_i(t_1, t_2) &= \widehat{M}_i(t_1, t_2) - \widehat{bias}_i\left[\widehat{M}_i(t_1, t_2)\right] \\ &= 2\widehat{M}_i(t_1, t_2) - B^{-1} \sum_{b=1}^{B} \widehat{M}_i^*(t_1, t_2)(b) \qquad 6.5 \end{aligned}$$

Nevertheless, as discussed by Simar and Wilson (2000b), the above estimation may be less reliable if the bias-corrected estimator result has a higher mean-square error compared with the original estimator. Therefore, the correction should be considered only if the following holds true:

$$\hat{\sigma}^2 < \frac{1}{3}\left(\widehat{bias}_i\left[\widehat{M}_i^*(t_1, t_2)\right]\right)^2 \quad 6.6$$

The above procedures are performed using the commands *malmquist.components* and *malmquist* in the FEAR software programme developed by Wilson (2008).

6.3 Decomposition of Productivity Growth

The Malmquist TFP index is developed by Färe et al. (1992) which is the combination of the efficiency measurement idea of Farrell (1957) and the measurement of productivity of Caves, Christensen, and Diewert (1982). The authors also decompose the TFP index into efficiency change and technical change components. Subsequently, Färe et al. (1994) demonstrate a further decomposition of efficiency change into pure efficiency change and change in scale efficiency, which has been widely employed in many empirical studies of productivity change.

Simar and Wilson (1998a) argue that it is pointless to draw inferences from the results if the statistical interpretation is not provided. These researchers also provide the decomposition of the Malmquist index in which they estimate the change in technology by the change in the variable return to scale (VRS) estimate and decompose the technological changes into pure technological change and change in the scale of efficiency. This latter method (Simar and Wilson 1998a) of Malmquist index and its decomposition, which is pure efficiency changes, scale efficiency change, pure technology change and change in the scale of technology, is adopted in this study to provide a more comprehensive and robust analysis of productivity change. To the best of author knowledge, this study is the first attempt to employ this method in the Indonesian banking industry.

The MPI is estimated using the same dataset used in the previous chapter, which includes yearly panel data on 101 Indonesian commercial banks. Similarly, the same combination of input and output variables separated into two models, Model A and Model B, is also employed to measure productivity change and its decomposition over 18 pairs of year, from 1993 to 2011. The estimation is held under the assumption that the banking sector operates under VRS.

By definition, DEA efficiency scores are assigned numerical values between zero and one (or 0% and 100%) for the efficiency level of a bank relative to others. In which, the value close to zero indicates an inefficient bank and close to one indicates more efficient bank. In contrast, the Malmquist indices assign numerical values in which a value greater than one (unity) indicates positive productivity growth or productivity progress, whereas a value less than unity denotes a productivity decline or productivity regress. In the efficiency level, the value of one indicates the most efficient bank in a year, whereas in Malmquist indices it denotes no change in bank productivity from a base year to another year.

6.4 Empirical Results

6.4.1 The Aggregated Banking Industry

This section presents the results based on the input oriented of MPI for the entire industry. Following the step described earlier, the MPI (the TFP index) and its components are computed for individual banks for each adjacent year during the study horizon (1993-2011). The annual mean of the empirical estimates of TFP index for the entire industry and its components of efficiency change and technological change indices are presented in Table 6.1 and Table 6.2 for Model A and Model B, respectively. These estimates include the subcomponents of efficiency change and technological change; thus, pure efficiency change, scale efficiency change, pure technological change and the scale of technology are also reported in each of these tables.

As noted in the previous chapter, the individual bank time-variant results are not presented here because of space limitations but can be obtained upon request. In addition, for ease of observation, the result of the Malmquist indices in both models is illustrated in Figure 6.1. Accordingly, the decompositions of TFP index are displayed in Figure 6.2 and Figure 6.3 for Model A and Model B, respectively.

Table 6.1: Model A – TFP, Efficiency and Technological Indices (1993-2011)

Year	TFP	Efficiency Change (EC)	Technological Change TC)	Pure Efficiency (PE)	Scale Efficiency (SE)	Pure Technology (PT)	Scale of Technology (ST)
1993-94	1.0052	0.8375	1.2002	0.9010	0.9296	1.1873	1.0141
	(0.0467)	(0.0452)	(0.0222)	(0.0421)	(0.0246)	(0.0292)	(0.0273)
1994-95	1.1357	0.6525	1.7404	0.8304	0.7858	1.4902	1.1694
	(0.0623)	(0.0287)	(0.0586)	(0.0284)	(0.0199)	(0.0469)	(0.0460)
1995-96	1.0100	1.5673	0.6444	1.1527	1.3597	0.9147	0.7029
	(0.0360)	(0.0732)	(0.0296)	(0.0473)	(0.0752)	(0.0374)	(0.0223)
1996-97	0.9204	0.8499	1.0830	1.0550	0.8056	0.8401	1.3090
	(0.0322)	(0.0424)	(0.0452)	(0.0668)	(0.0279)	(0.0337)	(0.0659)
1997-98	0.8354	0.5435	1.5370	0.6436	0.8444	1.2782	1.1989
	(0.0579)	(0.0357)	(0.0479)	(0.0299)	(0.0258)	(0.0590)	(0.0352)
1998-99	0.9594	1.7280	0.5552	1.1471	1.5064	0.8167	0.6728
	(0.0591)	(0.1035)	(0.0217)	(0.0519)	(0.0927)	(0.0473)	(0.0219)
1999-00	1.1267	0.8783	1.2828	1.0978	0.8000	1.0140	1.2750
	(0.0469)	(0.0431)	(0.0403)	(0.0427)	(0.0333)	(0.0369)	(0.0457)
2000-01	1.0414	1.0472	0.9944	1.0561	0.9916	0.9639	1.0319
	(0.0346)	(0.0460)	(0.0152)	(0.0398)	(0.0304)	(0.0167)	(0.0186)
2001-02	1.0502	0.9119	1.1516	0.8977	1.0159	1.1254	1.0239
	(0.0352)	(0.0288)	(0.0109)	(0.0275)	(0.0408)	(0.0267)	(0.0183)
2002-03	1.1103	1.1566	0.9600	0.9935	1.1642	1.0624	0.9030
	(0.0593)	(0.0634)	(0.0045)	(0.0259)	(0.0564)	(0.0148)	(0.0118)
2003-04	0.9933	0.7701	1.2898	0.8919	0.8634	1.1070	1.1656
	(0.0200)	(0.0412)	(0.0613)	(0.0255)	(0.0360)	(0.0339)	(0.0605)
2004-05	0.9907	0.7288	1.3594	0.9563	0.7620	1.0247	1.3278
	(0.0332)	(0.0234)	(0.0506)	(0.0211)	(0.0175)	(0.0333)	(0.0378)
2005-06	0.9759	1.0382	0.9400	0.9896	1.0490	0.9512	0.9888
	(0.0123)	(0.0203)	(0.0119)	(0.0194)	(0.0143)	(0.0118)	(0.0138)
2006-07	0.9859	1.0579	0.9320	0.9906	1.0679	1.0034	0.9282
	(0.0202)	(0.0216)	(0.0167)	(0.0146)	(0.0177)	(0.0164)	(0.0147)
2007-08	1.0209	1.4207	0.7186	1.2825	1.1077	0.8106	0.8853
	(0.0181)	(0.0250)	(0.0072)	(0.0317)	(0.0236)	(0.0169)	(0.0135)
2008-09	1.0247	1.1129	0.9207	1.1271	0.9874	0.8883	1.0399
	(0.0216)	(0.0263)	(0.0105)	(0.0364)	(0.0176)	(0.0154)	(0.0155)
2009-10	0.9440	0.9075	1.0402	0.8722	1.0405	1.0661	0.9756
	(0.0155)	(0.0141)	(0.0078)	(0.0164)	(0.0225)	(0.0171)	(0.0157)
2010-11	0.9867	0.8941	1.1036	0.9706	0.9212	1.0052	1.0975
	(0.0333)	(0.0243)	(0.0289)	(0.0237)	(0.0175)	(0.0306)	(0.0170)
Mean	**1.0039**	**0.9648**	**1.0406**	**0.9812**	**0.9833**	**1.0183**	**1.0228**

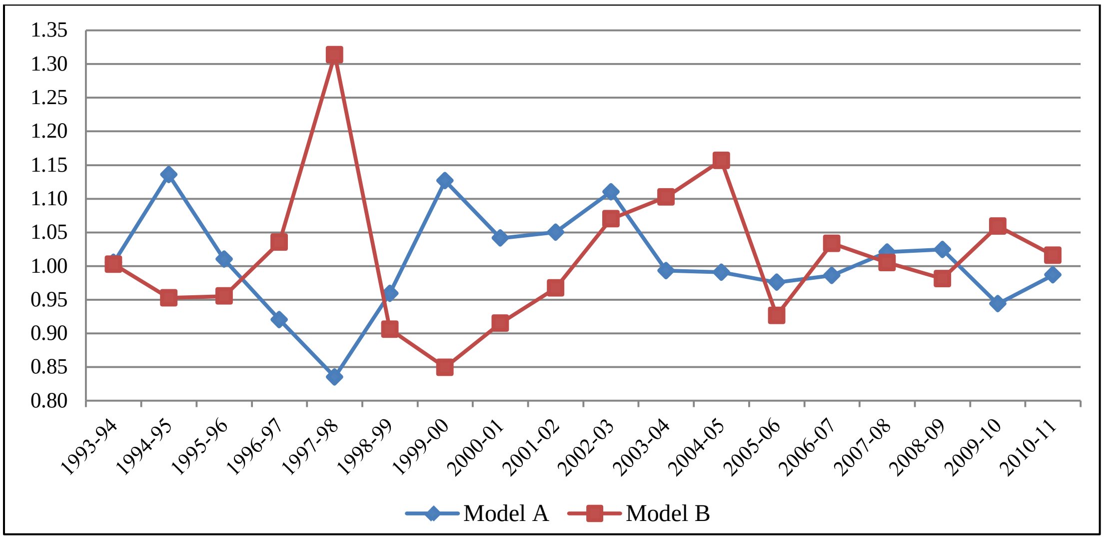
Sources: Author's calculations. Note: TFP denotes total factor productivity. The standard errors are in the parentheses.

Table 6.2: Model B - TFP, Efficiency and Technological Indices (1993-2011)

Year	TFP	Efficiency Change (EC)	Technological Change TC)	Pure Efficiency (PE)	Scale Efficiency (SE)	Pure Technology (PT)	Scale of Technology (ST)
1993-94	1.0028	0.9978	1.0050	0.9874	1.0106	1.0234	0.9821
	(0.0159)	(0.0155)	(0.0028)	(0.0122)	(0.0162)	(0.0283)	(0.0213)
1994-95	0.9527	0.9694	0.9828	1.0367	0.9351	0.9316	1.0537
	(0.0408)	(0.0498)	(0.0097)	(0.0272)	(0.0151)	(0.0080)	(0.0081)
1995-96	0.9554	0.9485	1.0073	0.9589	0.9892	1.0068	0.9999
	(0.0159)	(0.0143)	(0.0061)	(0.0124)	(0.0080)	(0.0076)	(0.0073)
1996-97	1.0354	1.0762	0.9620	1.0587	1.0166	0.9664	0.9951
	(0.0249)	(0.0251)	(0.0172)	(0.0203)	(0.0126)	(0.0161)	(0.0070)
1997-98	1.3137	1.5266	0.8606	1.2709	1.2012	0.9417	0.9064
	(0.2796)	(0.2287)	(0.0296)	(0.1187)	(0.1921)	(0.0355)	(0.0174)
1998-99	0.9062	1.1940	0.7589	1.2901	0.9255	0.7258	1.0581
	(0.0809)	(0.1127)	(0.0185)	(0.1393)	(0.0528)	(0.0219)	(0.0285)
1999-00	0.8496	0.6689	1.2703	0.6896	0.9699	1.2840	0.9891
	(0.0599)	(0.0316)	(0.0240)	(0.0331)	(0.0202)	(0.0520)	(0.0185)
2000-01	0.9151	0.9451	0.9683	0.9846	0.9599	0.9326	1.0378
	(0.0235)	(0.0243)	(0.0117)	(0.0218)	(0.0096)	(0.0149)	(0.0146)
2001-02	0.9672	1.0089	0.9586	1.0524	0.9587	0.9165	1.0448
	(0.0260)	(0.0341)	(0.0189)	(0.0342)	(0.0121)	(0.0203)	(0.0158)
2002-03	1.0701	2.6939	0.3972	1.8730	1.4383	0.5514	0.7165
	(0.0272)	(0.1392)	(0.0355)	(0.1126)	(0.0786)	(0.0408)	(0.0199)
2003-04	1.1026	1.5174	0.7266	1.2689	1.1958	0.8252	0.8793
	(0.0644)	(0.0764)	(0.0083)	(0.1046)	(0.0394)	(0.0226)	(0.0411)
2004-05	1.1568	0.2816	4.1079	0.4301	0.6547	2.7193	1.5318
	(0.5875)	(0.0464)	(0.2236)	(0.0395)	(0.0305)	(0.3301)	(0.1153)
2005-06	0.9267	0.9086	1.0199	0.9266	0.9805	0.9827	1.0385
	(0.0172)	(0.0171)	(0.0084)	(0.0160)	(0.0111)	(0.0105)	(0.0096)
2006-07	1.0336	0.9736	1.0616	0.9923	0.9812	1.0542	1.0061
	(0.0115)	(0.0102)	(0.0054)	(0.0088)	(0.0075)	(0.0167)	(0.0087)
2007-08	1.0052	0.9642	1.0425	1.0058	0.9586	1.0164	1.0252
	(0.0208)	(0.0204)	(0.0103)	(0.0204)	(0.0128)	(0.0148)	(0.0135)
2008-09	0.9813	1.2250	0.8010	1.0519	1.1646	0.9263	0.8646
	(0.0152)	(0.0187)	(0.0123)	(0.0170)	(0.0172)	(0.0195)	(0.0127)
2009-10	1.0593	1.0482	1.0106	0.9893	1.0595	1.0630	0.9531
	(0.0182)	(0.0188)	(0.0208)	(0.0171)	(0.0126)	(0.0210)	(0.0296)
2010-11	1.0161	0.7466	1.3610	0.8552	0.8729	1.2160	1.1207
	(0.0176)	(0.0176)	(0.0176)	(0.0191)	(0.0161)	(0.0685)	(0.0225)
Mean	**1.0090**	**1.0043**	**1.0046**	**1.0013**	**1.0030**	**1.0046**	**1.0006**

Sources: Author's calculations. Note: TFP denotes total factor productivity. The standard errors are in the parentheses.

Figure 6.1: Annual Mean of TFP Index, 1993-2011

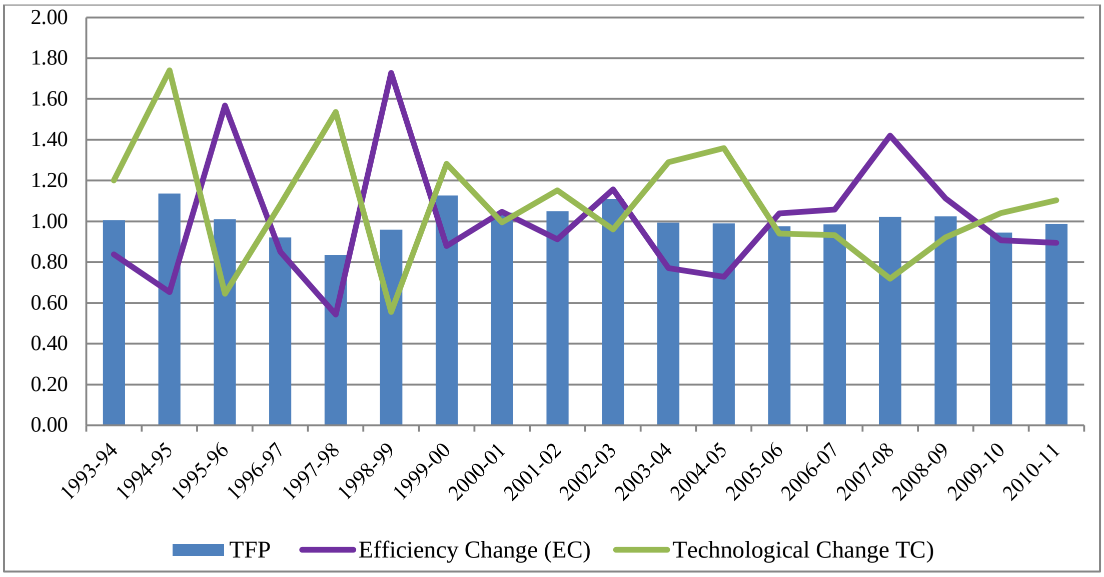


Source: Author's TFP results (Table 6.1 and Table 6.2)

Generally, the results of both models show that the industry has exhibited progress in TFP based on the annual mean over the considered period. Specifically, Model B appears to have a slightly higher mean TFP growth (0.9%) than Model A (0.39%). The growth in Model A is largely driven by gains in technological change with an annual average of 4.06%, whereas efficiency change contributes negatively to TFP growth by -3.52%. In Model B, although both components make a positive contribution to TFP index, the technological component is shown to be slightly higher (0.46%) than the efficiency change (0.43%).

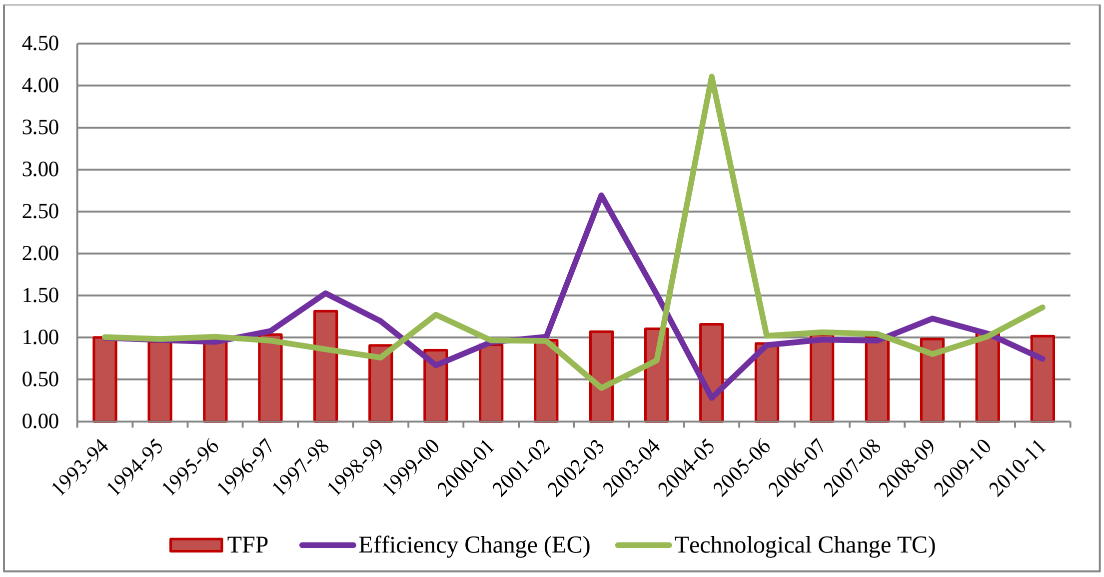
This result suggests that productivity growth under both models largely results from the frontier shift rather than from catching up. This association is even more evident in the intermediation function (Model A) of the banking industry. These results confirm the findings of Omar, Majid, and Rulindo (2007) and Hadad et al. (2008a) regarding technological change as the main source of TFP growth in Indonesian banks. The first study, employing a stochastic frontier model, finds a positive contribution of technological change to improvement in TFP. By contrast, the latter study, employing the DEA-Malmquist index, discovers the opposite pattern: the negative in technological change drives the TFP results downward. Although these studies cover a relatively small number of Indonesian banks and a short period of study (e.g., Hadad et al. used monthly data over a two-year period), they are still comparable to the results of this study.

Figure 6.2: Decomposition of TFP Index – Model A



Source: Author's calculation

Figure 6.3: Decomposition of TFP Index – Model B



Source: Author's calculation

The result of the major contribution from outward shift in the production frontier also coincides with the finding of Chang et al. (2012) for Chinese banks and Fujii, Managi, and Matousek (2014) for Indian banks. However, it is inconsistent with the findings in some international studies such as of Isik and Hassan (2003b) for Turkish banks, Lee, Worthington, and Leong (2010) for Singaporean banks, and Sufian (2011) for Malaysian banks.

The higher overall mean TFP in Model B is affected by a remarkable growth in productivity during some periods. For instance, in 1997/1998 under Model B, the TFP increases by 31.37%, and in 2004/2005, it increases by 15.68%. In contrast, the highest growth in Model A occurred in 1994/1995 and 1999/2000, by only 13.57% and 12.67%, respectively. The more stable performance of Model B compared with Model A appears to follow the efficiency results in the previous chapter.

When decreases in TFP are examined, Table 6.1 shows that the declines in TFP in Model A also occur during three main broad periods. These periods are from 1996/1997 to 1998/1999, from 2003/2004 to 2006/2007 and from 2009/2010 to 2010/2011. These three periods are centred on the economic turbulence caused by the Asian financial crisis of 1997, bank privatisation and the global financial crisis. The period of 1997/1998 is marked as the greatest degree of productivity decline for the entire period, which implies that the AFC has had a severe negative impact on the productivity of banks' intermediating funds from depositors to borrowers. This result supports the common premise that an economic downturn results in decreased performance of the banking industry. The declines in Model B, as shown in Table 6.2, are observed in eight pairs of years: 1994/1995 (-4.73%), 1995/1996 (-4.46%), 1998/1999 (-9.38%), 1999/2000 (-15.04), 2000/2001 (-8.49%), 2001/2002 (-3.28%), 2005/2006 (-7.33%) and 2008/2009 (-1.87%).

Similar to the efficiency results, the opposite pattern of outcomes from these two models also appears in the TFP results. However, unlike Model A, the substantial decline in Model B occurs after the crisis or during the recovery periods (1998/1999 to 2000/2001). This is possibly as a result of the bad loans mounted during the AFC, the unpaid loan interest accumulates, thus deteriorating bank productivity in generating revenue.

On a year-on-year basis, the decomposition components of technical change and technical efficiency are observed to have an inverse relationship. Indeed, under Model A, this inverse relationship is even more evident during the entire period of this study. This observation suggests that when technological change increases, efficiency change decreases. Hence, when the use of technology and equipment improves, the management best practices or organisational performance decline, and vice versa. By contrast, in the case of Model B, although the opposite movement is also apparent, it does not hold for the entire period. In the 1994/1995 and 2000/2001, both efficiency change and technological change contribute negatively to the decline in the TFP change, whereas in 2009/2010, both components contribute positively to the TFP gain. A similar pattern also evident in Tortosa-Ausina et al. (2008) and Chang et al. (2012).

A broader explanation of the change in TFP components is obtained from the further decomposition of efficiency change and technological change. Employing the four components described in the previous section, the components of productivity changes over the period of analysis can be traced. Columns 5 to 8 of Table 6.1 and Table 6.2 show the estimate of changes in pure efficiency, scale efficiency, pure technology and the scale of technology, respectively. The decomposition under the two models shows differing results regarding the source of productivity growth. In Model A, pure efficiency and scale efficiency deteriorate by an average of -1.88% and -1.67%, respectively, which fully decomposes the decline in efficiency change. Pure technology and the scale of technology improve by 1.83% and 2.28%, respectively, which certainly leads to the increase in technological change. However, the annual observations reveal substantial variation between efficiency change and technological change. The remarkable technological growth during the initial period is associated with pure technology, whereas losses in the scale of technology contributed to the deep decline in technological change in 1998/1999.

As presented in Columns 5 to 8 of Table 6.2, the results of Model B reveal that based on the overall mean, all subcomponents contribute positively to the improvement of efficiency and technological change. The main component of efficiency gain is scale efficiency (0.30%), whereas pure efficiency contributes 0.13%. Additionally, the main component of technological gain is pure technology in contributing 0.46%, whereas the contribution of scale of technology is only 0.06%. During the period, some remarkable gains have been recorded from PE and PT, and each contributes to the higher degree of efficiency changes observed in 2002/2003 (PE gains 87.3%) and of technological change in 2004/2005 (PT gains 171.93%).

Table 6.3: Summary of Bootstrap Results for TFP, Efficiency and Technological Change (Model A)

Year		TFP Change				Efficiency Change (EC)				Technological Change (TC)			
		Original estimate	Number of bank significance at			Original estimate	Number of bank significance at			Original estimate	Number of bank significance at		
			10%	5%	1%		10%	5%	1%		10%	5%	1%
1993-94	Growth	43	-	37	3	24	-	24	-	80	-	80	-
	Stagnation	-	-	-	-	1	-	-	-	-	-	-	-
	Decline	58	-	44	8	76	-	76	-	21	-	21	-
1994-95	Growth	67	-	52	11	7	-	7	-	101	-	101	-
	Stagnation	-	-	-	-	1	-	-	-	-	-	-	-
	Decline	34	-	23	10	93	-	93	-	-	-	-	-
1995-96	Growth	55	-	55	-	84	-	84	-	16	-	16	-
	Stagnation	-	-	-	-	1	-	-	-	-	-	-	-
	Decline	46	-	46	-	16	-	16	-	85	-	85	-
1996-97	Growth	49	-	48	-	39	-	39	-	56	-	56	-
	Stagnation	-	-	-	-	1	-	-	-	-	-	-	-
	Decline	52	-	51	-	61	-	61	-	45	-	45	-
1997-98	Growth	27	-	27	-	14	-	13	-	94	-	94	-
	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	74	-	74	-	85	-	47	18	7	-	7	-
1998-99	Growth	37	-	32	2	87	-	86	-	8	-	8	-
	Stagnation	-	-	-	-	3	-	-	-	-	-	-	-
	Decline	64	-	50	6	11	-	11	-	93	-	51	19
1999-00	Growth	66	-	63	0	34	-	34	-	80	-	80	-
	Stagnation	-	-	-	-	5	-	-	-	-	-	-	-
	Decline	35	-	32	2	62	-	62	-	21	-	21	-
2000-01	Growth	57	-	52	3	43	-	43	-	67	-	67	-
	Stagnation	-	-	-	-	3	-	-	-	-	-	-	-
	Decline	44	-	33	8	55	-	54	-	34	-	34	-
2001-02	Growth	62	-	47	3	30	-	30	-	101	-	101	-
	Stagnation	-	-	-	-	3	-	-	-	-	-	-	-
	Decline	39	-	25	8	68	-	68	-	-	-	-	-
2002-03	Growth	68	-	54	4	78	-	78	-	19	-	19	-
	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	33	-	20	10	21	-	21	-	82	-	82	-
2003-04	Growth	62	-	58	1	38	-	38	-	67	-	67	-
	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	39	-	39	-	61	-	61	-	34	-	34	-
2004-05	Growth	47	-	47	-	10	-	10	-	88	-	88	-
	Stagnation	-	-	-	-	3	-	-	-	-	-	-	-
	Decline	54	-	51	-	88	-	62	6	13	-	13	-
2005-06	Growth	45	-	42	-	57	-	56	-	39	-	39	-
	Stagnation	-	-	-	-	4	-	-	-	-	-	-	-
	Decline	56	-	53	1	40	-	40	-	62	-	62	-
2006-07	Growth	47	-	47	-	59	-	59	-	39	-	39	-
	Stagnation	-	-	-	-	6	-	6	-	-	-	-	-
	Decline	54	-	53	-	36	-	36	-	62	-	59	-
2007-08	Growth	58	-	51	3	94	-	93	1	-	-	-	-
	Stagnation	-	-	-	-	3	-	-	-	-	-	-	-
	Decline	43	-	35	3	4	-	4	-	101	-	100	-
2008-09	Growth	51	-	47	-	71	-	71	-	27	-	27	-
	Stagnation	-	-	-	-	4	-	-	-	-	-	-	-
	Decline	50	-	42	5	26	-	26	-	74	-	74	-
2009-10	Growth	36	-	34	0	22	-	22	-	80	-	80	-
	Stagnation	-	-	-	-	5	-	-	-	-	-	-	-
	Decline	65	-	60	2	74	-	74	-	21	-	21	-
2010-11	Growth	39	-	38	1	28	-	28	-	70	-	70	-
	Stagnation	-	-	-	-	4	-	-	-	-	-	-	-
	Decline	62	-	60	-	69	-	68	-	31	-	31	-

Sources: Author's compilation from the individual bank results of the Malmquist index.

Table 6.4: Summary of Bootstrap Results for TFP, Efficiency and Technological Change (Model B)

Year		TFP Change				Efficiency Change (EC)				Technological Change (TC)			
		Original estimate	Number of bank significance at			Original estimate	Number of bank significance at			Original estimate	Number of bank significance at		
			10%	5%	1%		10%	5%	1%		10%	5%	1%
	Growth	52	-	52	-	47	-	47	-	45	-	45	-
1993-94	Stagnation	-	-	-	-	4	-	-	-	-	-	-	-
	Decline	49	-	48	-	50	-	50	-	56	-	56	-
	Growth	31	-	31	-	28	-	28	-	49	-	49	-
1994-95	Stagnation	-	-	-	-	4	-	-	-	-	-	-	-
	Decline	70	-	68	2	69	-	69	-	52	-	52	-
	Growth	43	-	37	3	42	-	42	-	54	-	54	-
1995-96	Stagnation	-	-	-	-	5	-	-	-	-	-	-	-
	Decline	58	-	52	4	54	-	54	-	47	-	47	-
	Growth	68	-	64	3	60	-	60	-	61	-	61	-
1996-97	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	33	-	30	2	39	-	39	-	40	-	40	-
	Growth	60	-	58	1	81	-	67	-	25	-	23	-
1997-98	Stagnation	-	-	-	-	1	-	1	-	-	-	-	-
	Decline	41	-	41	-	19	-	19	-	76	-	36	18
	Growth	43	-	40	-	59	-	59	-	16	-	16	-
1998-99	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	58	-	57	-	40	-	40	-	85	-	85	-
	Growth	44	-	40	2	13	-	11	-	93	-	93	-
1999-00	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	57	-	55	1	86	-	79	2	8	-	8	-
	Growth	29	-	28	1	35	-	35	-	49	-	49	-
2000-01	Stagnation	-	-	-	-	3	-	-	-	-	-	-	-
	Decline	72	-	67	1	63	-	63	-	52	-	52	-
	Growth	53	-	45	5	32	-	32	-	84	-	84	-
2001-02	Stagnation	-	-	-	-	3	-	-	-	-	-	-	-
	Decline	48	-	45	-	66	-	66	-	17	-	17	-
	Growth	75	-	74	-	90	-	67	-	7	-	7	-
2002-03	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	26	-	24	1	9	-	9	-	94	-	13	54
	Growth	75	-	74	-	91	-	91	-	-	-	-	-
2003-04	Stagnation	-	-	-	-	2	-	-	-	-	-	-	-
	Decline	26	-	24	1	8	-	8	-	101	-	101	-
	Growth	69	-	62	3	3	-	1	1	101	-	98	-
2004-05	Stagnation	-	-	-	-	-	-	-	-	-	-	-	-
	Decline	32	-	28	-	98	-	52	30	-	-	-	-
	Growth	32	-	29	-	23	-	22	-	62	-	62	-
2005-06	Stagnation	-	-	-	-	4	-	-	-	-	-	-	-
	Decline	69	-	67	1	74	-	74	-	39	-	39	-
	Growth	69	-	68	-	40	-	40	-	98	-	98	-
2006-07	Stagnation	-	-	-	-	6	-	-	-	-	-	-	-
	Decline	32	-	32	-	55	-	55	-	3	-	3	-
	Growth	52	-	50	1	31	-	31	-	88	-	88	-
2007-08	Stagnation	-	-	-	-	4	-	-	-	-	-	-	-
	Decline	49	-	45	1	66	-	66	-	13	-	13	-
	Growth	40	-	36	1	86	-	86	-	8	-	8	-
2008-09	Stagnation	-	-	-	-	5	-	-	-	-	-	-	-
	Decline	61	-	54	4	10	-	10	-	93	-	93	-
	Growth	68	-	66	-	63	-	63	-	41	-	41	-
2009-10	Stagnation	-	-	-	-	5	-	-	-	-	-	-	-
	Decline	33	-	32	1	33	-	33	-	60	-	60	-
	Growth	48	-	48	-	7	-	7	-	101	-	100	-
2010-11	Stagnation	-	-	-	-	5	-	-	-	-	-	-	-
	Decline	53	-	53	-	89	-	87	-	-	-	-	-

Sources: Author's compilation from the individual bank results of the Malmquist index

Given the heterogeneous nature of Indonesian banks and the aim of obtaining a comprehensive understanding of TFP and its components, it is imperative to observe the growth of each component in every pair of years by each bank. However, as mentioned earlier the individual banks' time-variant results are not presented here. Rather, a summary of the findings is provided in Table 6.3 for Model A and in Table 6.4 for Model B. These tables also include a summary of the bootstrap results, including the results for 90%, 95% and 99% confidence intervals. The summaries show the number of banks that have productivity growth (above unity), no change or stagnation (unity) and decline (below unity) in each year, including the number of banks for which changes are significant in respective measures.

The results show that both models demonstrate that a number of banks exhibit productivity regress and progress and that they are interchangeable with respect to which demonstrate greater progress. Although the general mean results conclude that industry productivity is improved under both models, the number of periods showing a greater amount of TFP growth is only half of the 18 total periods in Model A, whereas under Model B, positive growth appears to be confirmed in 10 out of 18 periods. Briefly, in only slightly more than half the periods, the number of banks that have positive productivity is greater in Model B than in Model A.

Turning to the application of the bootstrap method, productivity change and its decomposition estimates (efficiency change and technological change) are assessed for their significance to specify whether the measures are significantly different from unity. Although a bank exhibits a TFP growth or decline, the measure is meaningless without a statistical inference. As noted by Simar and Wilson (1999a, 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'. As shown in Table 6.3 and Table 6.4, most of the individual bank results are significant at the 5% and a small number at the 1% confidence level.

During the period of analysis, on average, 94% and 96% of the banks' individual results of TFP change are significant, ranging from 82.2% to 100% and from 91% to

99% for Models A and B, respectively. Therefore, the results are relatively reliable to signify the productivity measures. These results are similar to those of Arjomandi, Valadkhani, and Harvie (2011) but inconsistent with those of Tortosa-Ausina et al. (2008) and Lee, Worthington, and Leong (2010), where most of their sample of bank TFP scores are insignificant.

6.4.2 Bank Group

As with the presentation and analysis in the previous chapter, the investigation of productivity growth for the Indonesian banks is also extended on the five groups of banks. The estimates of the Malmquist productivity indices, including efficiency change and technological change, are presented in Table 6.5 for Model A and in Table 6.6 for Model B. The further decomposition of efficiency and technological change into four components for both models is provided in Appendix Table 6.1 through 6.4. The key aspect of this part of discussion is to analyse which group is the main contributor to productivity growth in the Indonesian banking sector. Additionally, Figure 6.4 and Figure 6.5 are provided to illustrate the differentiation and movement of the results among groups of bank during the period from 1993 to 2011. Also, Figure 6.6 illustrates the decomposition of TFP change by group of banks for both models.

Overall, all groups of banks are shown to have positive productivity growth over the period of study, except foreign banks (-3.57%) in Model A and regional development banks (-0.63%) in Model B. The decline in foreign banks derives mainly from the negative efficiency change, whilst in regional banks both components drag down the TFP. The overall mean in Model A indicates that the joint venture banks show the highest growth (3.95%), followed by state owned banks (1.38%), regional development banks (0.43%) and private national banks (0.11%).

By contrast, Model B shows the state owned bank group as showing the highest growth in TFP (1.98%), followed by joint-venture banks (1.12%), private national banks (0.93%) and foreign banks (no change). With regard to the lower results for foreign banks compared with domestic banks, the findings of this study are consistent with those of Sufian (2011) and Fujii, Managi, and Matousek (2014) but run contrary with those of Rebelo and Mendes (2000) and Chang et al. (2012) regarding the performance of state banks. This study supports the findings of George Assaf, Barros, and Matousek (2011) with respect to the low productivity growth of *Shinkin* in Japan, which have similar features with regional development banks group in Indonesia.

Technological change contributes positively to the overall mean TFP index for most of the groups in both models, which is consistent with the results in the previous chapter. Also, the decline in the average efficiency index occurs in all groups in Model A, aside from joint venture banks. On the other side, the positive growth of efficiency index in Model B is only supported by state, private and joint-venture banks. The improvement in technology increases the productivity of banks, except for foreign banks, which experience an average change in efficiency of -3.57%. Remarkable technology improvements are recorded for regional banks and private national banks (4.89% and 4.33%, respectively). These results may be observed because most of the banks in these groups are in the stage of developing the technology that is commonly utilised in the banking business, such as ATMs, mobile banking and internet banking.

Table 6.5: MPI Estimates of Annual Mean TFP, Efficiency and Technological Indices by Bank Group, 1993-2011 (Model A)

Year	TFP change					Efficiency Change (EC)					Technological change (TC)				
	SOB	PNB	RDB	JVB	FB	SOB	PNB	RDB	JVB	FB	SOB	PNB	RDB	JVB	FB
1993-94	1.0067	0.9571	1.1003	1.0645	0.9792	0.8681	0.7336	0.9340	1.0789	1.0029	1.1596	1.3047	1.1780	0.9866	0.9765
	(0.0436)	(0.0411)	(0.1586)	(0.1298)	(0.0487)	(0.1101)	(0.0429)	(0.1351)	(0.1423)	(0.1091)	(0.1638)	(0.0219)	(0.0400)	(0.0872)	(0.0696)
1994-95	1.1344	1.1594	0.9890	1.5993	1.0094	0.7405	0.7207	0.4734	0.8375	0.6346	1.5320	1.6087	2.0891	1.9096	1.5907
	(0.1207)	(0.0743)	(0.0244)	(0.4197)	(0.1958)	(0.0577)	(0.0397)	(0.0304)	(0.0731)	(0.1440)	(0.0748)	(0.0503)	(0.1115)	(0.3895)	(0.0971)
1995-96	1.0165	1.0144	0.9889	0.9215	1.1525	1.4570	1.7811	1.6312	1.0266	1.0917	0.6977	0.5695	0.6062	0.8976	1.0557
	(0.0702)	(0.0328)	(0.0368)	(0.0758)	(0.3343)	(0.1855)	(0.0988)	(0.1411)	(0.2042)	(0.2308)	(0.1377)	(0.0288)	(0.0472)	(0.1336)	(0.0998)
1996-97	0.8871	0.9672	1.0839	0.7579	0.5506	0.9569	0.7923	0.9045	0.8431	1.0337	0.9271	1.2207	1.1984	0.8989	0.5326
	(0.1133)	(0.0250)	(0.0767)	(0.1366)	(0.1826)	(0.1022)	(0.0383)	(0.1033)	(0.1165)	(0.2610)	(0.1099)	(0.0601)	(0.0855)	(0.1186)	(0.0771)
1997-98	1.3377	0.7191	0.7950	1.0145	1.1848	1.1496	0.4428	0.4793	0.8700	0.7005	1.1637	1.6240	1.6586	1.1661	1.6913
	(0.1160)	(0.0484)	(0.0542)	(0.0973)	(0.5104)	(0.2017)	(0.0419)	(0.0633)	(0.1020)	(0.1355)	(0.1251)	(0.0500)	(0.0745)	(0.0414)	(0.3603)
1998-99	1.9119	0.9324	0.9172	1.0093	0.8947	2.8210	1.8590	1.8637	1.2730	1.0286	0.6777	0.5016	0.4921	0.7928	0.8698
	(0.3751)	(0.0717)	(0.1483)	(0.1439)	(0.1133)	(0.4392)	(0.1280)	(0.2673)	(0.1726)	(0.1047)	(0.1047)	(0.0205)	(0.0181)	(0.0991)	(0.0774)
1999-00	1.0983	1.1910	1.0096	1.1750	1.0636	0.8387	0.8723	0.8186	0.9365	1.0565	1.3094	1.3653	1.2334	1.2547	1.0068
	(0.1043)	(0.0729)	(0.0907)	(0.1248)	(0.0789)	(0.1906)	(0.0719)	(0.0752)	(0.0401)	(0.0780)	(0.2945)	(0.0625)	(0.0463)	(0.1454)	(0.0207)
2000-01	0.7703	1.1370	0.8655	1.2735	0.9486	0.8331	1.1414	0.7898	1.5220	1.0089	0.9246	0.9961	1.0960	0.8367	0.9402
	(0.0676)	(0.0453)	(0.0421)	(0.1715)	(0.0545)	(0.1400)	(0.0618)	(0.0364)	(0.2052)	(0.0904)	(0.0666)	(0.0227)	(0.0085)	(0.0464)	(0.0447)
2001-02	1.0697	1.0169	1.0788	0.9720	1.2737	0.9450	0.8868	0.9576	0.8065	1.0587	1.1319	1.1466	1.1265	1.2052	1.2031
	(0.1012)	(0.0457)	(0.0333)	(0.0454)	(0.2586)	(0.1045)	(0.0405)	(0.0287)	(0.0418)	(0.1896)	(0.0264)	(0.0080)	(0.0159)	(0.0245)	(0.0998)
2002-03	0.9542	1.1214	1.1176	1.1994	1.0089	0.9979	1.1757	1.1850	1.1897	1.0156	0.9562	0.9538	0.9431	1.0081	0.9935
	(0.0480)	(0.1099)	(0.0273)	(0.1217)	(0.0525)	(0.0474)	(0.1183)	(0.0286)	(0.1027)	(0.0529)	(0.0157)	(0.0055)	(0.0058)	(0.0165)	(0.0219)
2003-04	0.9037	1.0008	1.0375	0.9522	0.9201	0.5441	0.7454	0.9545	0.5872	0.8102	1.6609	1.3426	1.0870	1.6215	1.1356
	(0.0379)	(0.0294)	(0.0232)	(0.0628)	(0.1107)	(0.1493)	(0.0678)	(0.0495)	(0.0810)	(0.1264)	(0.3187)	(0.0946)	(0.0713)	(0.1966)	(0.1557)
2004-05	0.9354	1.0199	0.9452	1.0109	0.9537	0.6437	0.6828	0.7108	0.9706	0.9161	1.4531	1.4937	1.3297	1.0415	1.0410
	(0.0240)	(0.0595)	(0.0206)	(0.0469)	(0.0763)	(0.0422)	(0.0355)	(0.0274)	(0.0649)	(0.0652)	(0.0924)	(0.0838)	(0.0421)	(0.1115)	(0.0434)
2005-06	0.9775	0.9772	0.9554	1.0663	0.9392	1.1295	1.0943	0.9380	1.0918	0.9191	0.8654	0.8930	1.0185	0.9767	1.0218
	(0.0140)	(0.0166)	(0.0165)	(0.0600)	(0.0545)	(0.0409)	(0.0292)	(0.0291)	(0.0747)	(0.0454)	(0.0389)	(0.0158)	(0.0157)	(0.0359)	(0.0418)
2006-07	0.9371	0.9255	1.1394	0.9580	1.0153	1.0310	1.0503	1.1628	0.9591	0.9480	0.9089	0.8812	0.9799	0.9989	1.0710
	(0.0136)	(0.0265)	(0.0372)	(0.0528)	(0.0708)	(0.0659)	(0.0316)	(0.0401)	(0.0446)	(0.0594)	(0.0606)	(0.0259)	(0.0266)	(0.0394)	(0.0217)
2007-08	0.9795	1.0150	1.0755	1.0130	0.9390	1.4072	1.4625	1.4297	1.3921	1.2084	0.6961	0.6940	0.7522	0.7276	0.7770
	(0.0273)	(0.0195)	(0.0276)	(0.1097)	(0.0928)	(0.0208)	(0.0288)	(0.0371)	(0.1522)	(0.0989)	(0.0223)	(0.0092)	(0.0143)	(0.0243)	(0.0181)
2008-09	0.9500	1.0054	1.0920	1.1333	0.8878	1.0598	1.0801	1.2437	1.1468	0.9634	0.8963	0.9308	0.8780	0.9883	0.9216
	(0.0338)	(0.0226)	(0.0561)	(0.0767)	(0.0787)	(0.0595)	(0.0246)	(0.0776)	(0.0608)	(0.0785)	(0.0401)	(0.0132)	(0.0220)	(0.0368)	(0.0412)
2009-10	0.7964	0.9683	0.9415	0.8661	0.9719	0.7564	0.9208	0.8918	0.8791	0.9825	1.0529	1.0516	1.0557	0.9853	0.9892
	(0.0649)	(0.0180)	(0.0233)	(0.0663)	(0.0927)	(0.0698)	(0.0133)	(0.0247)	(0.0621)	(0.0906)	(0.0153)	(0.0127)	(0.0089)	(0.0209)	(0.0181)
2010-11	0.9809	0.9922	1.0211	0.9678	0.8894	0.9269	0.8773	0.9116	1.0070	0.8172	1.0582	1.1310	1.1202	0.9611	1.0884
	(0.0144)	(0.0604)	(0.0211)	(0.0485)	(0.0855)	(0.1200)	(0.0408)	(0.0310)	(0.0502)	(0.0577)	(0.1336)	(0.0476)	(0.0298)	(0.0816)	(0.0852)
Mean	**1.0138**	**1.0011**	**1.0043**	**1.0395**	**0.9643**	**0.9888**	**0.9596**	**0.9575**	**1.0000**	**0.9446**	**1.0253**	**1.0433**	**1.0489**	**1.0396**	**1.0208**

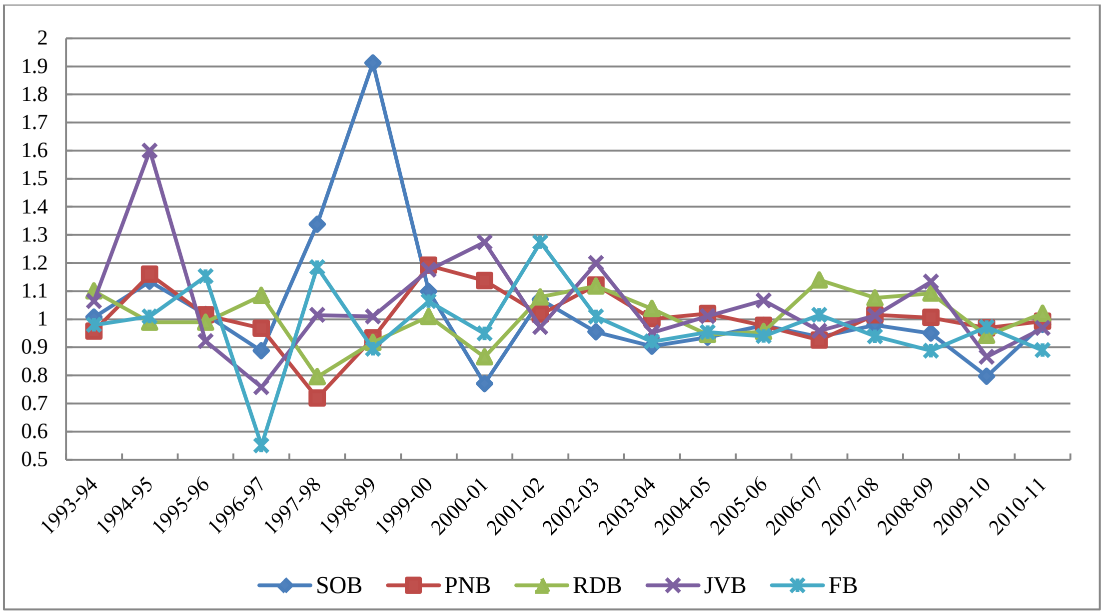
Sources: Author's calculations. Note: SOB, PNB, RDB, JVB and FB are state owned banks, private national banks, regional development banks, joint venture banks and foreign banks, respectively. The standard errors are in the parentheses.

Table 6.6: MPI Estimates of Annual Mean TFP, Efficiency and Technological Indices by Bank Group, 1993-2011 (Model B)

Year	TFP change					Efficiency Change (EC)					Technological change (TC)				
	SOB	PNB	RDB	JVB	FB	SOB	PNB	RDB	JVB	FB	SOB	PNB	RDB	JVB	FB
1993-94	1.0035	1.0136	0.9821	1.0095	0.9903	1.0041	1.0141	0.9757	0.9996	0.9611	0.9995	0.9995	1.0066	1.0100	1.0304
	(0.0509)	(0.0279)	(0.0153)	(0.0247)	(0.0436)	(0.0541)	(0.0266)	(0.0172)	(0.0307)	(0.0440)	(0.0050)	(0.0041)	(0.0037)	(0.0109)	(0.0086)
1994-95	0.9954	0.9923	0.9024	0.8986	0.9120	1.0344	0.9976	0.8721	1.0409	0.9860	0.9623	0.9947	1.0348	0.8633	0.9249
	(0.0317)	(0.0738)	(0.0372)	(0.0693)	(0.0576)	(0.0541)	(0.0923)	(0.0334)	(0.0574)	(0.0563)	(0.0505)	(0.0117)	(0.0148)	(0.0330)	(0.0308)
1995-96	0.9298	0.9111	1.0047	1.0328	1.0200	0.9256	0.9203	0.9968	0.9728	0.9702	1.0045	0.9900	1.0079	1.0617	1.0514
	(0.0476)	(0.0231)	(0.0165)	(0.0812)	(0.0418)	(0.0561)	(0.0239)	(0.0170)	(0.0439)	(0.0344)	(0.0201)	(0.0041)	(0.0099)	(0.0434)	(0.0209)
1996-97	1.0946	1.0621	1.0638	1.0828	0.7671	1.1831	0.9838	1.1637	1.2109	1.2364	0.9252	1.0796	0.9142	0.8942	0.6204
	(0.0642)	(0.0310)	(0.0219)	(0.1445)	(0.1104)	(0.1993)	(0.0290)	(0.0370)	(0.1216)	(0.0643)	(0.0913)	(0.0102)	(0.0195)	(0.0696)	(0.0684)
1997-98	5.0561	1.0693	1.0254	2.0311	1.3912	4.2776	1.4361	1.2567	1.7415	1.0103	1.1820	0.7446	0.8159	1.1663	1.3770
	(5.7941)	(0.1895)	(0.0529)	(0.5327)	(0.3471)	(4.0987)	(0.2379)	(0.0770)	(0.6247)	(0.1775)	(0.1199)	(0.0170)	(0.0404)	(0.1237)	(0.1053)
1998/-99	0.8192	0.9079	1.1062	0.5901	0.8670	1.3092	1.2292	1.2605	0.7818	1.3300	0.6257	0.7387	0.8776	0.7547	0.6519
	(1.2862)	(0.0897)	(0.1244)	(0.0942)	(0.3871)	(1.9772)	(0.1138)	(0.1862)	(0.1127)	(0.4604)	(0.0985)	(0.0186)	(0.0328)	(0.0924)	(0.0838)
1999-00	0.2958	0.9617	0.7736	0.6977	1.0575	0.2239	0.7315	0.6934	0.5495	0.7226	1.3214	1.3146	1.1156	1.2697	1.4633
	(0.0965)	(0.0755)	(0.0542)	(0.1141)	(0.4191)	(0.0739)	(0.0341)	(0.0629)	(0.0985)	(0.1785)	(0.1039)	(0.0331)	(0.0286)	(0.0563)	(0.1070)
2000-01	0.7044	0.9183	0.8660	1.0773	0.9791	0.7026	0.9202	1.0149	1.0165	0.9545	1.0025	0.9980	0.8533	1.0597	1.0258
	(0.0692)	(0.0334)	(0.0389)	(0.0886)	(0.0673)	(0.0643)	(0.0310)	(0.0582)	(0.0632)	(0.0760)	(0.0282)	(0.0113)	(0.0203)	(0.0483)	(0.0341)
2001-02	1.0038	1.0184	0.9670	0.9883	0.6856	0.9327	0.9528	0.9337	1.3025	1.3669	1.0762	1.0689	1.0356	0.7588	0.5016
	(0.0254)	(0.0287)	(0.0418)	(0.1342)	(0.1612)	(0.0198)	(0.0268)	(0.0314)	(0.1863)	(0.1913)	(0.0071)	(0.0070)	(0.0238)	(0.0945)	(0.1061)
2002-03	1.1510	1.0737	1.1021	0.9267	1.0976	2.2693	3.0037	3.8730	1.5466	1.0348	0.5072	0.3575	0.2846	0.5992	1.0607
	(0.0862)	(0.0394)	(0.0329)	(0.1067)	(0.1350)	(0.5165)	(0.1789)	(0.1716)	(0.3668)	(0.1451)	(0.0743)	(0.0195)	(0.0156)	(0.1778)	(0.1795)
2003-04	1.2154	1.1440	1.0359	1.1306	0.9828	1.5531	1.6029	1.5029	1.4645	1.1616	0.7826	0.7137	0.6893	0.7720	0.8461
	(0.1705)	(0.1191)	(0.0327)	(0.0785)	(0.1022)	(0.2432)	(0.1377)	(0.0543)	(0.0991)	(0.1545)	(0.0342)	(0.0105)	(0.0092)	(0.0308)	(0.0247)
2004-05	1.2202	1.1068	1.0729	1.0296	2.0394	0.4061	0.2728	0.1861	0.3750	0.6880	3.0049	4.0577	5.7659	2.7458	2.9642
	(0.1124)	(0.3028)	(0.1015)	(0.0766)	(6.3164)	(0.1156)	(0.0494)	(0.0272)	(0.0693)	(0.3646)	(0.7656)	(0.2192)	(0.3393)	(0.4678)	(1.6492)
2005-06	0.9219	0.9099	0.9721	1.0954	0.7673	0.9034	0.8719	0.9508	1.0841	0.8615	1.0205	1.0437	1.0224	1.0103	0.8907
	(0.0501)	(0.0130)	(0.0219)	(0.0881)	(0.1334)	(0.0475)	(0.0111)	(0.0262)	(0.0783)	(0.1341)	(0.0242)	(0.0107)	(0.0110)	(0.0262)	(0.0341)
2006-07	1.0575	1.0349	1.0369	1.0197	1.0201	0.9835	0.9909	0.9623	0.9515	0.9224	1.0753	1.0444	1.0776	1.0717	1.1060
	(0.0362)	(0.0124)	(0.0115)	(0.0494)	(0.0936)	(0.0460)	(0.0108)	(0.0119)	(0.0449)	(0.0791)	(0.0184)	(0.0062)	(0.0047)	(0.0119)	(0.0403)
2007-08	0.9476	1.0375	0.9805	0.9936	0.9297	0.8834	0.9568	0.9139	0.9960	1.1748	1.0728	1.0844	1.0729	0.9975	0.7914
	(0.0410)	(0.0281)	(0.0123)	(0.1402)	(0.0447)	(0.0363)	(0.0264)	(0.0115)	(0.1095)	(0.0877)	(0.0160)	(0.0052)	(0.0039)	(0.0419)	(0.0549)
2008-09	0.9994	1.0005	1.0084	0.9586	0.8258	1.2950	1.2915	1.1497	1.2730	1.0003	0.7717	0.7747	0.8771	0.7530	0.8255
	(0.0056)	(0.0232)	(0.0140)	(0.0647)	(0.0421)	(0.0761)	(0.0232)	(0.0337)	(0.0609)	(0.0381)	(0.0407)	(0.0170)	(0.0206)	(0.0342)	(0.0462)
2009-10	1.0621	1.0769	0.9886	1.0546	1.1694	1.0308	1.0506	1.1117	0.9344	1.0055	1.0304	1.0250	0.8893	1.1287	1.1629
	(0.0486)	(0.0262)	(0.0256)	(0.0373)	(0.0919)	(0.0395)	(0.0293)	(0.0314)	(0.0522)	(0.0415)	(0.0530)	(0.0300)	(0.0085)	(0.0651)	(0.0913)
2010-11	0.9655	0.9714	1.0627	1.1184	1.0698	0.7150	0.6849	0.8322	0.8394	0.8268	1.3503	1.4183	1.2770	1.3323	1.2939
	(0.0174)	(0.0226)	(0.0285)	(0.0691)	(0.0815)	(0.0622)	(0.0215)	(0.0367)	(0.0453)	(0.0615)	(0.1056)	(0.0215)	(0.0376)	(0.0587)	(0.0515)
Mean	**1.0198**	**1.0093**	**0.9937**	**1.0112**	**1.0000**	**1.0001**	**1.0025**	**0.9994**	**1.0031**	**0.9957**	**1.0197**	**1.0068**	**0.9943**	**1.0081**	**1.0044**

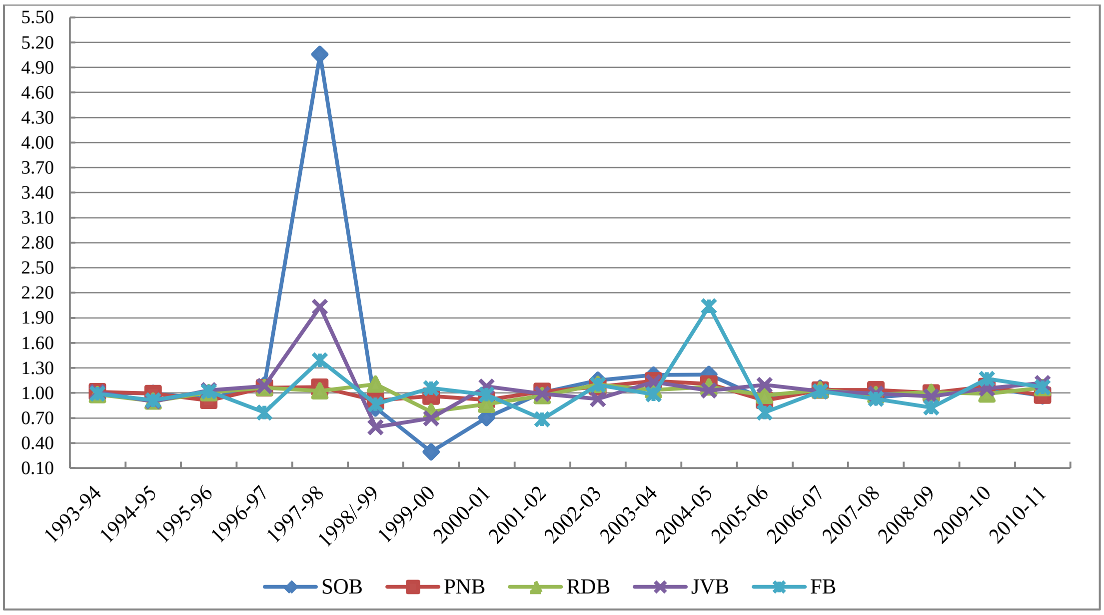
Sources: Author's calculations. Note: SOB, PNB, RDB, JVB and FB are state owned banks, private national banks, regional development banks, joint venture banks and foreign banks, respectively. The standard errors are in the parentheses.

Figure 6.4: MPI Estimates of Annual Mean TFP Index, 1993-2011 (Model A)



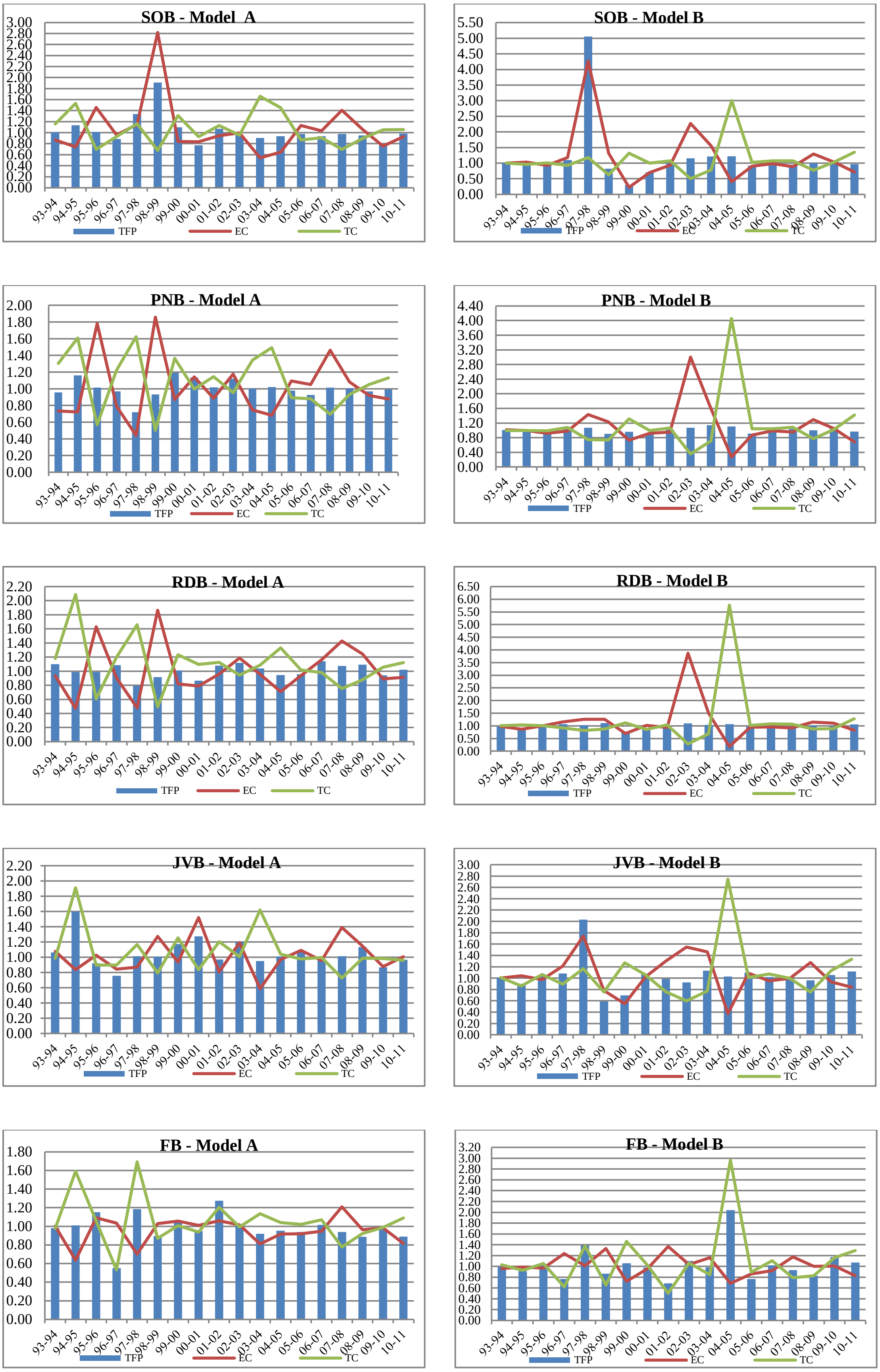
Source: Author’s calculation based on TFP results.

Figure 6.5: MPI Estimates of Annual Mean TFP Index, 1993-2011 (Model B)



Source: Author’s calculation based on TFP results

Figure 6.6: Decomposition of TFP Index by Group



Source : Author’s calculation

6.4.3 Bank Size

The division of banks into three different sizes - large, medium and small - follows the base in Chapter 5. The investigation of productivity growth for different bank sizes is important to obtain a better comprehending the source of industry productivity. The annual results of estimation are summarised and illustrated in Table 6.7 and Figure 6.7 for Model A and in Table 6.8 and Figure 6.8 for Model B. Similarly, further decompositions of efficiency and technological change by bank size are presented in Appendix Table 6.5 and Appendix Table 6.6. Accordingly, Figure 6.9 illustrates the decomposition of TFP for each size category.

Table 6.7 exhibits that the three size categories under Model A generally have a positive TFP growth over the study horizon. However, unlike the finding in Rebelo and Mendes (2000) who find large and small banks have higher productivity, this study finds medium-sized banks have higher growth based on the overall mean of TFP increasing by 1.30% followed by large banks by 0.19% and small banks by 0.05%. During the initial period, from 1993/1994 to 1999/2000, the medium bank group was not the highest, but since 2000/2001, this group category takes the lead in the annual TFP index (except in 2004/2005 and 2009/2010). Additionally, out of 18 annual changes, this category gains positive TFP growth in 12 and is the major contributor to the higher productivity among all banks. Large banks, however, have productivity growth in only seven periods, and this positive growth primarily occurs in the initial period, from 1993/1994 to 1995/1996 and 1997/1998 to 1999/2000. For the remainder of the period the productivity of the large banks falls.

Small banks experience some productivity progress in half of the periods under observation, which is better than that shown by large banks. However, most of the gains of small banks are inferior to the gains observed for either of the two other categories. The superiority of small banks in the TFP index above the other two groups is only apparent in four periods: 1994/1995, 1996/1997, 2004/2005 and 2009/2010. However, the last three periods of superiority are not a positive productivity growth. Rather, these periods merely show smaller productivity declines of small banks than others, importantly marking the period when the economic turbulence occurred.

Table 6.7: MPI Estimates of Annual Mean TFP Index and Its Decomposition by Bank Size Category, 1993-2011 (Model A)

Year	TFP Index			Efficiency Index (EC)			Technological Index (TC)		
	Large	**Medium**	**Small**	**Large**	**Medium**	**Small**	**Large**	**Medium**	**Small**
1993-94	1.0364	0.9494	1.0089	0.7928	0.7310	0.8472	1.3072	1.2987	1.1908
	(0.0180)	(0.0239)	(0.0514)	(0.0868)	(0.0762)	(0.0494)	(0.1204)	(0.0985)	(0.0231)
1994-95	1.0434	1.1116	1.1364	0.6599	0.7345	0.6459	1.5811	1.5136	1.7630
	(0.1446)	(0.0790)	(0.0694)	(0.0515)	(0.0666)	(0.0319)	(0.0971)	(0.1416)	(0.0645)
1995-96	1.0241	0.9825	1.0120	1.4746	1.3590	1.5905	0.6944	0.7230	0.6363
	(0.0470)	(0.0359)	(0.0404)	(0.0675)	(0.1346)	(0.0810)	(0.0617)	(0.0794)	(0.0327)
1996-97	0.7358	0.6867	0.9687	0.9209	0.8260	0.8490	0.7990	0.8313	1.1410
	(0.1050)	(0.1227)	(0.0335)	(0.0984)	(0.2074)	(0.0431)	(0.0372)	(0.1410)	(0.0487)
1997-98	1.0771	1.0136	0.7958	0.8013	0.7063	0.5076	1.3442	1.4351	1.5679
	(0.1399)	(0.2280)	(0.0590)	(0.1702)	(0.1133)	(0.0372)	(0.1142)	(0.1238)	(0.0547)
1998/-99	1.3928	1.0907	0.9148	2.0465	1.5619	1.7343	0.6806	0.6984	0.5275
	(0.3228)	(0.1951)	(0.0611)	(0.2662)	(0.3918)	(0.1118)	(0.0670)	(0.0692)	(0.0229)
1999-00	1.4728	1.1140	1.1064	1.3180	0.9936	0.8287	1.1174	1.1212	1.3351
	(0.2930)	(0.1571)	(0.0449)	(0.2623)	(0.1445)	(0.0389)	(0.0994)	(0.0821)	(0.0474)
2000-01	0.9033	1.0712	1.0496	0.9126	1.1074	1.0470	0.9898	0.9673	1.0025
	(0.1322)	(0.1061)	(0.0359)	(0.1166)	(0.1606)	(0.0447)	(0.0423)	(0.0333)	(0.0186)
2001-02	1.0091	1.0660	1.0501	0.8969	0.9046	0.9159	1.1251	1.1784	1.1464
	(0.0807)	(0.1188)	(0.0337)	(0.0757)	(0.0885)	(0.0300)	(0.0125)	(0.0449)	(0.0067)
2002-03	0.9573	1.1268	1.1238	1.0154	1.1360	1.1802	0.9428	0.9920	0.9522
	(0.0488)	(0.0331)	(0.0837)	(0.0523)	(0.0349)	(0.0894)	(0.0089)	(0.0121)	(0.0046)
2003-04	0.8882	1.0210	0.9983	0.5426	0.7554	0.8121	1.6369	1.3516	1.2293
	(0.0492)	(0.0536)	(0.0218)	(0.0920)	(0.0791)	(0.0524)	(0.2052)	(0.1238)	(0.0750)
2004-05	0.9545	0.9948	0.9961	0.7087	0.8599	0.6792	1.3468	1.1569	1.4666
	(0.0274)	(0.1121)	(0.0203)	(0.0439)	(0.0537)	(0.0259)	(0.0717)	(0.0668)	(0.0735)
2005-06	0.9481	0.9832	0.9788	1.0360	1.0048	1.0586	0.9152	0.9784	0.9247
	(0.0305)	(0.0232)	(0.0166)	(0.0419)	(0.0372)	(0.0287)	(0.0243)	(0.0199)	(0.0172)
2006-07	0.9849	1.0569	0.9437	1.0175	1.0448	1.0792	0.9680	1.0116	0.8745
	(0.0478)	(0.0388)	(0.0258)	(0.0490)	(0.0391)	(0.0309)	(0.0277)	(0.0213)	(0.0267)
2007-08	0.9745	1.0511	1.0183	1.3873	1.4429	1.4182	0.7025	0.7284	0.7180
	(0.0295)	(0.0345)	(0.0266)	(0.0538)	(0.0441)	(0.0372)	(0.0140)	(0.0145)	(0.0098)
2008-09	0.9589	1.0711	1.0205	1.0446	1.1303	1.1287	0.9180	0.9476	0.9041
	(0.0153)	(0.0522)	(0.0254)	(0.0294)	(0.0644)	(0.0303)	(0.0220)	(0.0208)	(0.0141)
2009-10	0.9043	0.9358	0.9714	0.8784	0.9154	0.9152	1.0295	1.0222	1.0613
	(0.0391)	(0.0257)	(0.0220)	(0.0411)	(0.0253)	(0.0160)	(0.0105)	(0.0094)	(0.0153)
2010-11	0.9854	1.0049	0.9705	0.9663	0.9465	0.8101	1.0197	1.0618	1.1980
	(0.0414)	(0.0234)	(0.0783)	(0.0595)	(0.0240)	(0.0437)	(0.0426)	(0.0320)	(0.0581)
Mean	**1.0019**	**1.0130**	**1.0005**	**0.9752**	**0.9822**	**0.9573**	**1.0274**	**1.0313**	**1.0452**

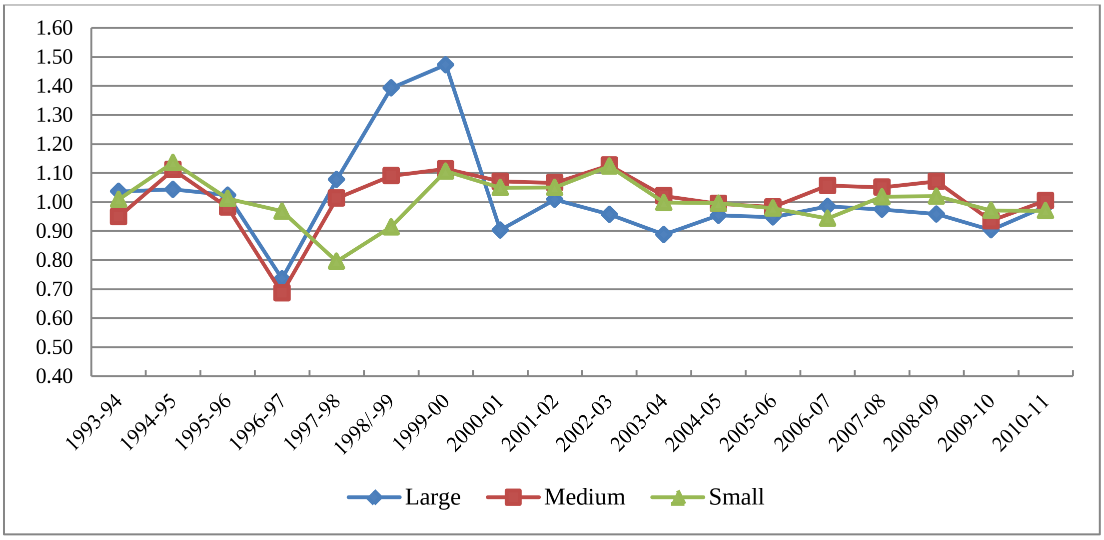
Sources: Author’s calculations. Note: TFP denotes total factor productivity. The standard errors are in the parentheses.

Table 6.8: MPI Estimates of Annual Mean TFP Index and Its Decomposition by Bank Size Category, 1993-2011 (Model B)

Year	TFP Index			Efficiency Index (EC)			Technological Index (TC)		
	Large	**Medium**	**Small**	**Large**	**Medium**	**Small**	**Large**	**Medium**	**Small**
1993-94	1.0553	0.9530	1.0053	1.0629	0.9578	0.9994	0.9929	0.9951	1.0060
	(0.0705)	(0.0406)	(0.0171)	(0.0682)	(0.0425)	(0.0168)	(0.0026)	(0.0040)	(0.0030)
1994-95	0.9490	0.9105	0.9561	0.9999	0.9622	0.9689	0.9491	0.9463	0.9868
	(0.0452)	(0.0921)	(0.0453)	(0.0496)	(0.0977)	(0.0555)	(0.0837)	(0.0742)	(0.0104)
1995-96	0.9224	0.9851	0.9539	0.9097	0.9573	0.9491	1.0140	1.0291	1.0051
	(0.0364)	(0.0362)	(0.0176)	(0.0571)	(0.0301)	(0.0159)	(0.0357)	(0.0251)	(0.0065)
1996-97	1.0816	0.9516	1.0440	1.0074	1.1946	1.0659	1.0737	0.7966	0.9795
	(0.0459)	(0.1003)	(0.0269)	(0.0439)	(0.0664)	(0.0284)	(0.0285)	(0.0844)	(0.0166)
1997-98	4.2220	1.8905	1.1498	4.2533	1.7660	1.3989	0.9926	1.0705	0.8219
	(4.7237)	(0.6012)	(0.1132)	(3.2408)	(0.6692)	(0.1319)	(0.1173)	(0.1015)	(0.0296)
1998-99	0.5050	0.8007	0.9645	0.8152	1.1130	1.2415	0.6195	0.7194	0.7769
	(0.8750)	(0.1668)	(0.0767)	(1.3459)	(0.1852)	(0.1014)	(0.0763)	(0.0387)	(0.0208)
1999-00	0.4201	0.9167	0.8822	0.3115	0.6432	0.7154	1.3487	1.4251	1.2331
	(0.1778)	(0.2147)	(0.0601)	(0.1135)	(0.0838)	(0.0343)	(0.0740)	(0.0820)	(0.0234)
2000-01	0.8631	0.9066	0.9233	0.8550	0.8884	0.9718	1.0095	1.0205	0.9501
	(0.0997)	(0.0595)	(0.0266)	(0.0910)	(0.0615)	(0.0275)	(0.0164)	(0.0239)	(0.0143)
2001-02	1.0285	0.8177	1.0117	0.9604	1.0624	0.9984	1.0710	0.7697	1.0133
	(0.0418)	(0.0789)	(0.0278)	(0.0404)	(0.0931)	(0.0389)	(0.0061)	(0.0630)	(0.0170)
2002-03	1.0111	1.0684	1.0775	1.9058	1.8642	3.1395	0.5305	0.5731	0.3432
	(0.0813)	(0.0730)	(0.0306)	(0.3086)	(0.2748)	(0.1561)	(0.0486)	(0.0961)	(0.0376)
2003-04	1.2079	1.2035	1.0562	1.4911	1.5424	1.5122	0.8101	0.7803	0.6985
	(0.0990)	(0.2601)	(0.0223)	(0.1329)	(0.3006)	(0.0407)	(0.0199)	(0.0183)	(0.0082)
2004-05	1.1505	1.4173	1.0549	0.4208	0.3961	0.2225	2.7338	3.5780	4.7418
	(0.0591)	(2.1062)	(0.0207)	(0.0601)	(0.1530)	(0.0164)	(0.3500)	(0.5749)	(0.2304)
2005-06	0.9401	0.8696	0.9580	0.9367	0.8806	0.9181	1.0036	0.9876	1.0435
	(0.0391)	(0.0397)	(0.0195)	(0.0476)	(0.0395)	(0.0186)	(0.0165)	(0.0177)	(0.0099)
2006-07	1.0228	1.0532	1.0246	0.9510	0.9950	0.9673	1.0755	1.0585	1.0592
	(0.0273)	(0.0236)	(0.0144)	(0.0298)	(0.0204)	(0.0122)	(0.0086)	(0.0110)	(0.0076)
2007-08	1.0058	1.0359	0.9852	0.9958	0.9924	0.9351	1.0100	1.0439	1.0535
	(0.0191)	(0.0481)	(0.0271)	(0.0362)	(0.0398)	(0.0293)	(0.0270)	(0.0173)	(0.0146)
2008-09	0.9637	0.9725	0.9942	1.2196	1.2012	1.2434	0.7902	0.8096	0.7995
	(0.0164)	(0.0299)	(0.0235)	(0.0472)	(0.0329)	(0.0263)	(0.0232)	(0.0203)	(0.0197)
2009-10	1.0819	1.0484	1.0579	1.0328	1.0374	1.0654	1.0475	1.0106	0.9930
	(0.0379)	(0.0316)	(0.0280)	(0.0280)	(0.0381)	(0.0270)	(0.0348)	(0.0414)	(0.0296)
2010-11	0.9833	1.0226	1.0292	0.7266	0.7461	0.7588	1.3533	1.3705	1.3564
	(0.0226)	(0.0310)	(0.0307)	(0.0244)	(0.0291)	(0.0319)	(0.0346)	(0.0266)	(0.0311)
Mean	**1.0057**	**1.0231**	**1.0053**	**0.9903**	**1.0082**	**1.0023**	**1.0155**	**1.0148**	**1.0030**

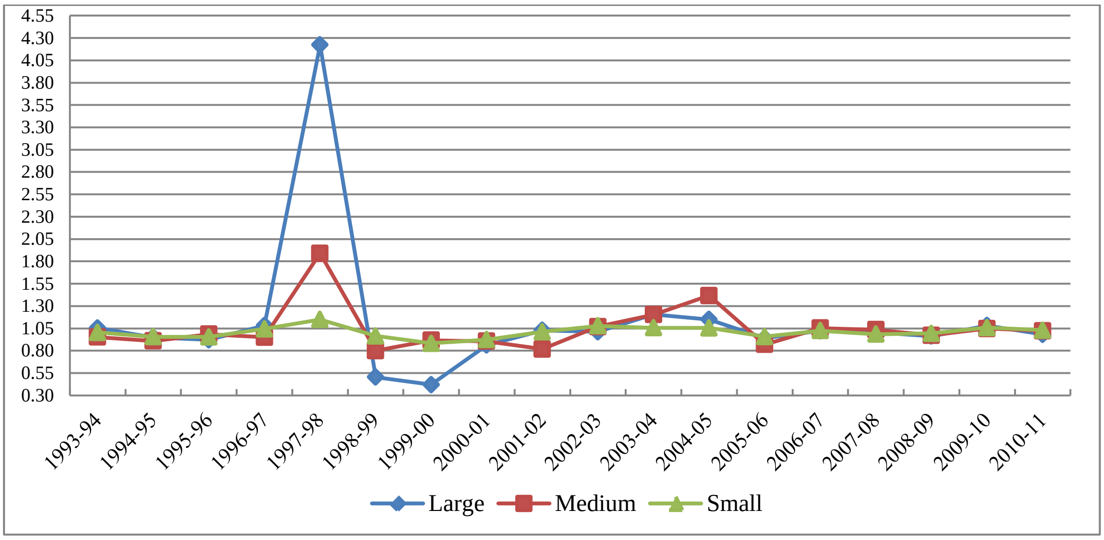
Sources: Author's calculations. Note: TFP denotes total factor productivity. The standard errors are in the parentheses.

Figure 6.7: MPI Estimates of Annual Mean TFP Index by Bank Size Category, 1993-2011 (Model A)



Source: Author's TFP results.

Figure 6.8: MPI Estimates of Annual Mean TFP Index by Bank Size Category, 1993-2011 (Model B)



Source: Author's TFP results.

In Model A, all three categories experience the lowest TFP in the period around the AFC of 1997, with medium banks suffering the most from a TFP decrease (-31.33%), followed by large banks (-26.21%) and small banks (-20.42%). However, the banks reach their highest productivity growth in different periods. Large banks reach their highest growth in 1999/2000 (42.28%), medium banks in 2002/2003 (12.68%) and small banks in 1994/1995 (13.64%).

On the decomposition side, TFP progress throughout the entire study period for all three categories results from the increase in technological change by large, medium and small banks (2.74%, 3.13% and 4.52%, respectively). These increases are offset by the decreases in efficiency change of -2.48%, -1.78% and -4.27% for large, medium and small banks, respectively. The decline in TFP in the three periods, which is during the Asian financial crisis of 1997, privatisation and the global financial crisis, is largely attributed to the decline in the efficiency index, which is larger than the increase in the technological index.

Table 6.8 presents the estimation results under Model B for the three size categories. The table reveals results that are similar to those in Model A with regard to the positive change of TFP (it is slightly higher than in Model A). The medium-sized banks are consistently the highest in terms of the overall mean TFP progress (2.31%), whereas large banks show progress of 0.57% and small banks show progress of 0.53%. However, the TFP index for medium banks shows progress during only eight out of 18 periods. This result is contrary to the annual mean of the large and small banks, which record positive growth in 10 periods and declines in eight periods.

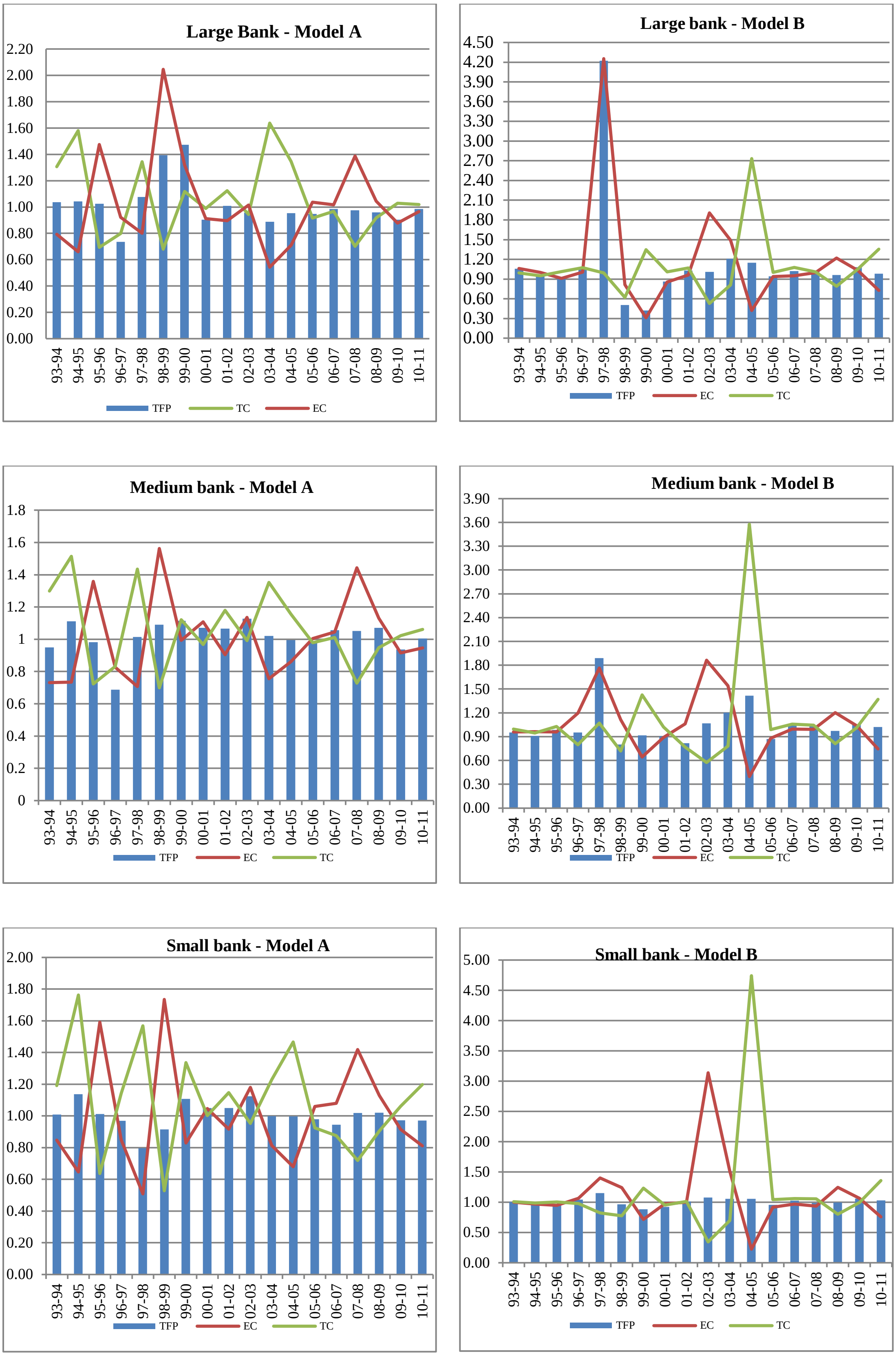
It is worth noting that the highest TFP index for all size categories in Model B occurs in the period of the AFC (1997/1998), which is the opposite of the worst result observed under Model A. This result is similar to that for the efficiency measure in the previous chapter. However, with regard to the results before that period, unlike the other banks, medium banks show no positive growth in any period before that highest score. The large and small banks have productivity gains in the initial period of 5.53% and 0.53%, before the decline that lasted until 1995/1996. Nevertheless, following the period 1997, the three size categories suffer TFP in the same direction towards the lowest productivity growth.

In particular, a sharp decline occurs even in medium banks during the following year (1998/1999) by 19.93%, immediately after reaching their highest productivity growth rate. Whereas, large banks suffer largest fall (58%) in 1999/2000, small banks declined by 11.8%. This result supports the finding in the previous chapter, indicating that the effect of the AFC of 1997 under Model B is felt in the following year, presumably because of the accrual accumulation of unpaid interest. This weakening of productivity change continuously occurs in three periods (large banks and small banks) and four periods (medium banks), after which productivity growth rebounds in 2001/2002 and 2002/2003.

Unlike in Model A, the source of productivity change in Model B is different across size categories. For the medium and small banks, both efficiency and technological index contribute positively to the gain in TFP by 0.82% and 1.48%, (medium banks), and by 0.23% and 0.30% (small banks), respectively. Meanwhile, the large banks' positive growth in TFP is created by technological gains of 1.55% which outweighs the deterioration in efficiency change of -0.97%. Among other periods, it is noted that in 1994/1995, all components show regress in three size categories, which results in the TFP regression in that period. Apart from that period, the role of each productivity component in each size category is varied. In the case of large banks, most of the productivity regression is associated with a fall in efficiency (five out of eight periods), whereas technological change dominates positively in most periods (11 periods).

To sum up, the overall average results show that all banks in Indonesia have a positive productivity change in all size categories. The consistency of technological change as the main component of productivity growth under both models is worth noting. This suggests that regardless the size, the industry has successfully gained the advantage of improved technology and capital equipment in business operations. Unlike efficiency measures, there is no strong evidence that higher bank productivity change is related to a larger bank. The results show that medium size banks gain higher productivity growth under both models.

Figure 6.9: Decomposition of TFP Index by Bank Size



Source : Author's calculation

6.5 Conclusions

This chapter empirically analyses the productivity performance of the Indonesian banking sector over the period from 1993 to 2011. This analysis highlights the importance of considering both efficiency and technological change in examining productivity growth in the banking sector.

Using panel data for Indonesian commercial banks, as previously analysed in the efficiency estimates of Chapter 5, the investigation is conducted under the two-model approach using the intermediation and revenue approaches. A bootstrap MPI based on the non-parametric DEA approach is employed to decompose TFP change into efficiency change and technological change. Furthermore, efficiency change is decomposed into pure efficiency change and scale efficiency change, and technological change is decomposed into pure technological change and the scale of technology change.

The overall mean TFP indices show that the productivity of the banking industry improves under both approaches and that Model B has slightly higher productivity growth (0.90%) than Model A (0.39%). The source of growth differs between the models. The TFP growth under the intermediation approach is primarily through technological progress, while efficiency change is negative. Under the revenue approach, productivity growth is driven by both components, although technological change is still marginally more important. The improvement of banking technology in the industry is evident. Overall, the productivity growth of the industry is progressing moderately and appears to be less volatile towards the end of the period.

The estimates of Malmquist indices for five groups of banks reveal that all groups greatly fluctuated from the beginning of the period until 2000/2001, with especially unstable economic performance surrounding the 1997 AFC. Subsequent productivity growth fluctuates less, but all of the groups tend to show slower growth, which is more evident for state owned banks than for foreign banks. During the period of analysis, positive growth is experienced by most of the groups, except for foreign banks in Model A and regional development banks in Model B.

The size category results show all size categories experience an improvement in productivity over the period of analysis under both models. Among other findings, medium banks consistently achieve the highest growth under both Model A (1.30%) and Model B (2.31%), followed by large banks at 0.19% in Model A and 0.57% in Model B. Finally, small banks record the lowest scores of 0.05% and 0.53%. The performance of medium banks indicates that these banks benefit from the rapid development of technology and superior best practices management compared with the two other size categories.

Generally, this research concludes that the productivity of Indonesian banks have improved under both models. The survey of the literature in Chapter 3 indicates that there are a series of environmental variables that can influence the efficiency and productivity growth. The following chapter investigates the factors affecting efficiency and productivity growth in the Indonesian banking sector.

Chapter 7
Determinants of Bank Efficiency and Productivity Growth in Indonesia

7.1 Introduction

The two previous chapters present the empirical measures of efficiency and productivity growth of Indonesian banks from 1993–2011. The estimation results are varied across the banks and also across time; also, different groups of ownership and size show dissimilar results. In addition, the results also show sensitivity to the differences in input-output combinations, which suggests that there are efficiency and productivity dynamics in the industry. The relative efficiency and productivity scores obtained from the non-parametric method are estimated using bank controlled variable inputs to produce outputs.

The variation in the scores among banks indicates that banks show varying responses to changes in regulations, policies and other external factors. These differences also imply that factors affected their performance other than policy and regulation. The ability of banks to cope with these factors determines their performance in the industry, which in turn affects the industry as a whole.

Most of the external factors could not be accommodated directly in the data envelopment analysis estimation method. Additionally, Hoff (2007) indicates that some exogenous factors could be included directly in DEA measurements, but other variables, especially categorical or classification variables, are mostly indirectly accommodated in the DEA measurement. In regard to the Indonesian banking sector, the tremendous change in policies and regulations, the differences in ownership types and the variance in the banks' business scales may lead to different performances in response to these variables. Coelli et al. (2005) suggest several approaches to incorporate such variables in a DEA analysis, but in most cases, they recommend the so-called two-stage approach (also known as the "second-stage approach"), in which the DEA score is regressed against a set of explanatory variables.

The focus of this chapter is to investigate what determines the variation in Indonesian banks' efficiency and productivity. The chapter explores potential correlates of bank efficiency and productivity growth, including environmental factors such as macroeconomic conditions, bank restructurings, regulatory changes, listed and non-listed banks, ownership structures and market concentration. In addition, differences in bank characteristics are also investigated. Following Coelli et al. and also previous empirical studies such as Sufian (2009), Tecles and Tabak (2010), Garza-García (2012), and Barth et al. (2013), this study adopts the two-stage method to analyse the relationship between bank efficiency and productivity measures and some explanatory variables.

The remainder of this chapter is structured as follows. Section 7.2 presents the variables and the data specification, including basic statistics of the data used. The empirical estimation model is provided in Section 7.3, followed by the empirical results in Section 7.4. The empirical results are presented in two subsections which comprises the aggregated banking industry and the various bank ownership groups. The final section concludes the chapter.

7.2 Variables and Data

A set of explanatory variables are selected to explain the sources of efficiency and productivity in the Indonesian banking industry. Theory provides little direction as to which determinants are important for explaining sources of efficiency and productivity, so previous studies use common yardsticks to determine the variables in the second stage (Mester 1996). Although there is no definite consensus, researchers tend to include variables that represent and classify macroeconomic environmental factors, banks basic characteristics and regulatory changes (see, e.g., Sufian (2009) and Zhao and Murinde (2011)).

Table 7.1 lists the explanatory variables included in this study. Following previous studies, this thesis includes variables that measure economic conditions, bank characteristics, market concentration, restructuring policies, bank status, regulatory changes, bank group and ownership status. These variables are regressed on the technical efficiency (TE) and total factor productivity (TFP) index measured in the previous chapters to analyse what determines the efficiency and productivity of Indonesian banks.[23]

Table 7.1: Variables and Definitions

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

[23] The regression on productivity only uses TFP as a dependent variable, although it is possible to utilise the TFP components, TC and EC, as alternative dependent variables.

The country and economics conditions are important determinants of the performance of a banking system because of the strong connection between a bank's business and economic development and policies. The country and economic condition variables are included in the model as external environment related effects that are faced equally by all banks. Three macroeconomic variables are used: the annual growth rate of *GDP*, the inflation rate (*Infl*), measured by the annual percentage increase of consumer prices, and broad money (*Bmoney*), which is the sum of currency outside the bank measured as a percentage of GDP.

Theoretically, *GDP* growth is positively associated with bank efficiency and productivity considering that higher economic growth relates to greater business activities, which in turn leads to higher deposits and loans to finance the economy. Similar consequences are also assumed for broad money in the economy. The variable of broad money is believed to be associated with greater financial activities, including banks. A positive relationship is expected between these two variables and the efficiency and productivity of Indonesian banks. On the contrary, inflation is commonly viewed as reducing the ability of a bank to allocate its resources effectively (Boyd, Levine, and Smith 2001). Given that the banking industry in Indonesia is still dominated by medium and small banks, increases in the inflation rate could simply reduce the banks' ability to operate at maximum capacity. Hence, a negative relationship is expected.

The bank characteristic factors include bank *size*, risk management (*NPL*), profitability (*ROA*) and capital strength (*CAR*) are incorporated to investigate the links from specific factors within banks to bank efficiency and productivity growth. A problem with these variables is the possibility of endogeneity as the variables are drawn from internal bank operations, which raises doubt about the interpretation of the findings. By utilising these factors as independent variables, it is assumed that they influence efficiency and productivity, although the relationship could possibly be reversed. For instance, because a bank is more efficient, it earns higher profits, has a larger size and a lower rate of non-performing loans.

However, Mester (1996) notes that a relationship need not have causality. It is possible to interpret the results as providing information on correlation only instead of causality. Furthermore, Mester argues that the results do imply guidance as to where banks might find ways to improve their efficiency by observing on-site the distinctions between banks identified as the most efficient and the least efficient. Many empirical studies include these four bank characteristic variables, but no consistent result has emerged regarding their relationship to bank efficiency and productivity. Hence, the relationship remains an empirical matter.

Bank size is considered to influence bank performance due to the possibility of an improper size, either because a bank may be too small or too large (Maredza and Ikhide 2013). A larger bank is assumed to be more efficient due to economies of scale, while other researchers argue that the more complex organisational structure of a large bank creates a lack coordination and hence a disincentive for its performance. In Indonesia, a large bank commonly has an extensive branch system, which makes it able to penetrate the market deeply, provide more diversified banking products and employ better managers, enabling it to perform better than smaller banks. Prior studies on Indonesian banks indicate higher efficiency levels for large banks compared with smaller banks; therefore, a positive coefficient is expected.

Risk management is represented by the non-performing loan ratio (*NPL*), which is the ratio of non-performing loans to total loans. Non-performing loans indicate poor outcomes in lending, thus indicating a bank's weak ability to manage risk. Inconsistent results have been found regarding the relationship between problem loans and bank performance. The common belief tends to suggest that a higher *NPL* indicates increased unproductive assets, which reduces efficiency and productivity. It is expected that the higher the *NPL*, the lower the bank efficiency and productivity.
The ratio of bank profits to total assets (*ROA*) is used to represent profitability. It is commonly believed that a profitable entity has a more efficient operation. As noted by Sufian (2009) a profitable bank is preferred by clients which in turn attract depositors and sound borrowers. Such circumstances thus create a favourable situation for a bank to be more efficient.

Capital strength is represented by the capital adequacy ratio (*CAR*), measured by the ratio of capital to risk-weighted assets.[24] Maintaining an adequate capital ratio is a primary requirement in any banking system to ensure a bank's smooth operation and reduce the risk related to banking failures. A bank's capital strength signifies its ability to face the risk of insolvency and a lower default risk incurs lower funding costs. Dietsch and Lozano-Vivas (2000) argue that a capital ratio that is measured by equity to total assets leads to lower efficiency because less equity indicates higher risk taken at greater leverage. On the contrary, holding a higher amount of capital generates expensive liabilities for a bank. Hence, there is no specific sign expected for this variable.

Market concentration is commonly measured by the number of banks, concentration ratio or the Herfindahl-Hirschman Index (*HHI*) (Gilbert 1984). *HHI* is considered to be more sophisticated and comprehensive because it provides the comprehensive condition of the banking industry. In this study, the market concentration ratio is represented by the *HHI*, which is calculated by the sum of the square of the ratio of bank loans for each individual bank to total loans as follows:

$$HHI = \sum_{i=1}^{n} (MS_i)^2$$

where MS_i represents the market share (loans) of bank *i*, and there are n banks in the industry. According to the US Department of Justice Guidelines from 1982, a market is considered highly concentrated if the *HHI* is above 0.18, it is moderately concentrated if the *HHI* is between 0.1 and 0.18 and the market is un-concentrated if the *HHI* is below 0.1. The relationship between market concentration and efficiency depends on the sources of market concentration and it therefore could be associated with higher or lower costs (Dietsch and Lozano-Vivas 2000). If market concentration is as a result of superior management, then it can represent lower bank costs and increased efficiency. However, if market concentration is as a result of market

[24] NPL, ROA and CAR are obtained directly from the individual bank financials in the Indonesian Bank Directory published by the Indonesian Central Bank.

power, which is associated with higher costs, then it is negatively related to efficiency.

Restructuring was the main policy implemented following the 1997 crisis. Unsound banks were forced to merge or find a new investor. A bank's restructuring is represented by a dummy variable for a merged or non-merged bank (*dmerger*) to examine the possible effect of a merged bank on efficiency and productivity. This variable is important because the industry has been implemented a very extensive restructure following the 1997 Asian financial crisis. Using a parametric approach Berger, Hunter, and Timme (1993) and Rezitis (2008) find a negative effect of a merger on bank performance, while mixed results have been found in second-stage studies. Given the facts that most of merged bank in Indonesian were "unhealthy" prior merger and long-term effect of the merger itself, a negative relationship is expected. However, the benefit of gaining economic of scale and stronger business structure from merger could also possibly improve bank performance. Thus, in this study there is no specific expectation on the relationship with efficiency and productivity.

Regulatory change (*dregch*) has been examined as one of the variables that determine bank efficiency and productivity in many international case studies, but as far as the author is aware, no previous studies have employed this in the case of Indonesian banks' efficiency and productivity growth. Hence, this study represents the first attempt to examine Indonesia's regulatory policy using a variable for changes in regulation. Indonesia's changes in regulations aimed to improve and guide the industry to the government's proposed destination. Following the 1997 crisis, a number of changes in the regulations of the Indonesian financial system aimed to rebuild, strengthen, and restructure the industry.

Given that changes were made to the regulation of the Indonesian banking industry in 2004, this study has adopted 2005 as a threshold for the analysis. The dummy (*dregch*) is included by lagging it by one year to capture the real impact of the change to the banking industry. The year 2004 signifies the end of the role of the Indonesian Bank Restructuring Agency (IBRA), including the end of the blanket guarantee (BG) system adopted to restore public confidence during the crisis.[25] Following the IBRA's dissolution, in September 2004 the government established a new deposit insurance agency, the Indonesian Deposit Insurance Corporation (IDIC), to assume the function of the blanket guarantee. Unlike the BG system, which insured the full amount of deposits – but did this for domestic banks only – the IDIC system insures all banks, including joint venture banks and the branches of foreign banks. However, this new insurance system is for limited amounts.[26] Under this new arrangement, banks may have to adjust their operations because they are forced to perform efficiently and soundly in order to gain or retain the confidence of their larger depositors. Another important reform in 2004 was the amendment of the 1999 Central Bank Law (BI Law No. 23/1999), which stipulated equal roles for and relationships between the central bank, the house of representative (the DPR) and the president (see Figure 2.9 Chapter 2). This reform may indirectly affect banks' performance due to the balanced monitoring of the authorities through to the central bank itself, which results in effective supervision of the banks.

Bank status is represented by dummies for a listing bank (*dlisting*) and for foreign exchange operation (*dforex*). In this study, only banks that are listed on the Indonesian Stock Exchange are considered as listing banks. More detailed and specific requirements are attached to banks with this status, which justifies that they are specifically investigated in determining Indonesian bank efficiency and productivity. The examination of listed and non-listed banks is important because of the common belief that publicly listed banks tend to perform better than their non-listed counterparts. Thus, the correlation of the listing bank variable with efficiency is expected to be positive.

Foreign exchange operation is a status or licence granted to an eligible bank that meets the requirements of the Indonesian central bank.[27] This licence permits a bank

[25] The IBRA was established in 1998 as part of the Letter of Intent with the IMF as an integrated agency to manage the restructure of the Indonesian banking sector after the 1997 AFC addressed the administration of the BGS. The IBRA was dissolved in February 2004.
[26] Initially, the IDIC only insured deposit up to IDR 100 million, but since October 2008 the coverage increases to IDR 2 billion up to present.
[27] A bank must have a minimum CAR of 8%, a minimum paid-in capital of IDR 150 billion, it must have been determined to be healthy during the last 24 months and it must have prepared organisational, human resources and foreign exchange operational guidance.

to directly conduct foreign exchange operations and transactions such as letters of credit, deposits and loans in a foreign currency, and purchases and sales of foreign currency. Given this authority, most banks aim to obtain the licence because it provides a bank the opportunity to enhance its revenue. Conversely, these international financial activities also expose banks directly to risks such as currency volatility and international business turbulence. Hence, there is no a priori relationship for this variable on bank efficiency and productivity.

The differences in ownership and organisational structure in the banking industry generate differences in bank roles, risk characteristics and the nature of their business. The bulk of the empirical studies examine whether ownership structure is correlated with differences in the efficiency frontier by relying on different theories and hypotheses. As noted by Isik and Hassan (2003a), most theories implicitly imply that an ownership structure or organisational form that creates stronger incentives to control costs and/or increase profits is expected to be more efficient.

Five dummies are simultaneously included to examine the impact of state banks (*d_state*), private banks (*d_private*), regional development banks (*d_rdb*), joint venture banks (*d_jvb*) and foreign banks (*d_purefb*) on bank efficiency and productivity growth.[28] Although previous Indonesian studies only include some of the ownership groups, these studies mostly conclude that state banks are the most efficient. However, many international studies find that foreign owned banks outperform their domestic counterparts, with a positive and significant influence on efficiency and productivity. Foreign banks are inherently viewed as having advanced technology and better managerial skills, which make them more efficient. However, in the Indonesian case, these findings might only hold for joint venture banks because foreign banks are limited to branches in only a certain number of cities. A large number of private banks seem to drive the performance of the industry as a whole, which often makes the group of private banks the target of restructuring. Given the ambiguous results of previous studies, there is no specific correlation sign expected in this study.

[28] These dummies also represent the groups of banks as specified in Chapter 5.

The dependent variables are obtained from the technical efficiency scores calculated in Chapter 5 and the TFP index calculated in Chapter 6. The data used in this second stage are obtained from various sources. Macroeconomic data, such as *GDP* growth, the inflation rate and broad money, are obtained from the World Bank databases. Bank characteristic variables (*CAR*, *NPL* and *ROA*), merger, listing, bank status and bank group are obtained from annual report of individual bank in various issues of the Indonesian bank directory published by Bank Indonesia.

It would be ideal if all of the variables could be regressed covering full period for which the efficiency and productivity measures are calculated in the two previous chapters (from 1993 to 2011). However, due to the unavailability of bank-specific variables from before 2000, the estimation is separated into two different periods. The period covering 1993-2011 is run without *CAR*, *NPL* and *ROA*, and the period from 2000-2011 includes all of the variables.

Table 7.2 presents the descriptive statistics of the variables. The number of observations of TFP is less than the TE because the TFP is estimated based on the adjacent year, so there is no value for the first year of the sample period. As noted previously, the data for the variables *ROA*, *CAR* and NPL are only available beginning in 2000. The mean values for TE are 59.4% and 69.3%, which indicates that the industry is not efficient, while both TFP values indicate that industry productivity has improved, with values above 1.

Table 7.3 provides the estimated Pearson correlation coefficients between the explanatory variables. Overall, the table shows that there is a relatively small correlation between the variables. The highest correlations, above 0.700, appear for *GDP* growth and the regulatory change variable (0.748) and the concentration ratio and broad money (0.721). The relatively small correlation between the variables implies that there is less risk of multicolinearity (Gujarati 2003).

Table 7.2: Summary Statistics of the Variables

Variable	Obs.	Mean	Median	SD
Dependent variables				
TE (A)	1919	0.594	0.546	0.261
TE (B)	1919	0.693	0.708	0.233
TFP (A)	1818	1.054	1.000	0.401
TFP (B)	1818	1.123	1.007	1.601
Independent variables				
GDP	1919	4.577	5.501	4.489
Infl	1919	11.352	8.518	11.709
BMoney	1919	46.851	45.306	6.736
Size	1919	9.577	9.352	1.781
HHI	1919	0.770	0.719	0.154
NPL	1212	0.054	0.027	0.092
ROA	1212	0.024	0.023	0.056
CAR	1212	0.349	0.196	1.111
Dmerger	1919	0.044	0.000	0.205
DRegCh	1919	0.368	0.000	0.483
Dlisting	1919	0.159	0.000	0.366
Dforex	1919	0.505	1.000	0.500
D_state	1919	0.040	0.000	0.195
D_PureFB	1919	0.089	0.000	0.285
D_JVB	1919	0.097	0.000	0.297
D_Private	1919	0.526	1.000	0.499
D_RDB	1919	0.248	0.000	0.432

Source: Author's calculation

Table 7.3: Correlation Coefficients of the Variables

Variable	TE (A)	TE (B)	TFPch (A)	TFPch (B)	Size	CAR	NPL	ROA	HHI	GDP	Infl	Bmoney	dforex	dlisting	dmerger	dregch	d_state	d_purefb	d_private	d_jvb
TE (B)	0.437																			
TFPch (A)	-0.107	-0.039																		
TFPch (B)	0.044	-0.064	0.097																	
Size	0.466	0.390	-0.054	0.036																
CAR	0.090	0.080	-0.043	-0.003	-0.193															
NPL	0.158	0.052	0.088	0.010	0.018	-0.005														
ROA	0.062	0.177	-0.088	-0.111	0.022	0.117	-0.041													
HHI	-0.034	-0.328	0.146	-0.010	-0.094	-0.018	0.225	0.022												
GDP	0.084	0.155	-0.123	0.027	0.097	-0.012	-0.269	-0.020	-0.699											
Infl	0.065	0.071	-0.040	0.019	-0.025	0.001	0.012	0.029	-0.042	-0.263										
Bmoney	-0.007	-0.131	0.170	-0.009	-0.118	-0.022	0.375	0.016	0.721	-0.692	0.102									
dforex	0.374	0.278	-0.027	0.041	0.631	-0.079	0.066	-0.030	-0.061	0.059	-0.026	-0.077								
dlisting	0.129	0.127	-0.018	0.007	0.467	-0.071	0.082	-0.139	-0.096	0.103	-0.030	-0.136	0.358							
dmerger	0.178	0.136	-0.046	-0.015	0.307	-0.034	-0.032	-0.046	-0.081	0.090	-0.046	-0.122	0.218	0.270						
dregch	0.033	0.282	-0.158	0.027	0.108	0.018	-0.295	-0.014	-0.916	0.748	-0.020	-0.876	0.072	0.116	0.106					
d_state	0.252	0.225	-0.063	-0.015	0.423	-0.032	0.028	-0.009	0.000	0.000	0.000	0.000	0.185	0.209	0.149	0.000				
d_purefb	0.358	0.213	-0.032	0.097	0.192	0.001	0.168	0.056	0.000	0.000	0.000	0.000	0.286	-0.160	-0.084	0.000	-0.064			
d_private	-0.298	-0.180	0.046	-0.016	-0.280	0.077	-0.104	-0.167	-0.004	0.003	0.003	-0.002	-0.035	0.322	-0.005	0.004	-0.214	-0.330		
d_jvb	0.217	0.079	0.026	-0.011	0.020	-0.004	0.203	0.050	0.007	-0.005	-0.006	0.003	0.141	-0.106	0.215	-0.007	-0.066	-0.102	-0.345	
d_rdb	-0.154	-0.089	-0.022	-0.031	-0.008	-0.072	-0.142	0.126	0.000	0.000	0.000	0.000	-0.329	-0.289	-0.154	0.000	-0.117	-0.179	-0.606	-0.188

Source: Author’s calculation.

7.3 Empirical Model

Multivariate regression has been widely used to estimate the factors determining the levels of efficiency and productivity. Moreover, Xue and Harker (1999) argue that regression analysis is among the most useful, reliable, simple and commonly used statistical methods. Although, Berger and Mester (1997) note that this analysis is suggestive but not necessarily conclusive because X-efficiency, the dependent variable, is obtained from an estimate, and its standard error is not taken into account in the subsequent regression. Thus, it is only possible to draw inferences about correlation, not causality.

Regression methods that commonly appear in the literature to estimate the second-stage DEA include the Tobit regression model, (Casu and Moluneux 2003; Havrylchyk 2006; Gardener, Molyneux, and Nguyen-Linh 2011; Castellanos and Garza-García 2013), conventional OLS regression (Salim, Hoquea, and Suyanto 2010; Ataullah and Hang 2006), logistic functional form (Mester 1996; Casu and Girardone 2004) and truncated regression, developed by Simar and Wilson (2007).
Hoff (2007) provides a comparison of the different approaches. He examines Tobit regression, conventional OLS regression, Quasi-maximum Likelihood Estimation (QMLE) using the Papke and Wooldridge (1996) approach and the unit-inflated beta model in modelling DEA efficiency in the second stage. The author concludes from his Danish fishery case study that the Tobit model and OLS are sufficient, while the two others are less reliable.

Because the estimated parameters are bounded between 0 and 1, the nature of the dependent variable (DEA score) makes the use of the common least square regression technique unsuitable (Saxonhouse 1976). The Tobit model is considered the most suitable model in this case because of the limited interval distribution of the dependent variable. However, McDonald (2009) claims that OLS regression provides a more consistent estimate compared with the Tobit model, but the author admits the problem of using OLS is that it is not an asymptotic efficient estimator. OLS estimation can possibly place the estimated value of the dependent variable outside the unit interval.

Another estimation method introduced by Simar and Wilson (2007) is the double bootstrap method, which is used to overcome the unobserved efficiency score in the first stage. They propose a complex seven-stage procedure to produce a valid result with the chosen data-generating process (DGP). However, their result has been argued to be non-robust to a plausible departure from it (McDonald 2009).

This study employs the Tobit regression method that allows for limited range dependent variables.[29] It is assumed that the estimated efficiency and productivity distribution is a normal distribution. The results from the estimation of the technical efficiency (TE) and the total factor productivity (TFP) change from the two previous chapters are employed as alternative dependent variables to estimate the effects of the determinants factors on efficiency and productivity. Recall the Equation 4.35 presented in Chapter 4:

$$Y_{it} = z_i \beta_i + \varepsilon_i \qquad 7.1$$

where Y is a measure of the efficiency or productivity growth of banks i in period t, z_i is the vector of observed variables explaining bank efficiency and productivity growth, β is the vector of parameters to be estimated and ε denotes an error term.

To estimate the effect of the explanatory variables on bank efficiency and productivity, the estimation procedure for Equation 7.1 can be extended as follows:

1. For the overall industry, the determinant variables are regressed on the TE and TFP change; hence, Equation 7.1 can be rewritten as:[30]

[29] Both, Tobit and OLS, are run, but there are no notable differences in the result.
[30] The equation is for the 2000-2011 period data estimation, while for the period from 1993 to 2011, CAR, NPL and ROA are excluded due to the unavailability of the data.

$$TE_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, Dforex_{it} + \beta_{10}\, Dlisting_{it} + \beta_{11}\, Dmerger_{it} + \beta_{12}\, DregCh_t + \beta_{13}\, D\_state_i + \beta_{14}\, D\_PureFB_i + \beta_{15}\, D\_private_i + \beta_{16}\, D\_JVB_i + \beta_{17}\, D\_RDB_i + \varepsilon_{it} \tag{7.2}$$

$$TFP_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, Dforex_{it} + \beta_{10}\, Dlisting_{it} + \beta_{11}\, Dmerger_{it} + \beta_{12}\, DregCh_t + \beta_{13}\, D\_state_i + \beta_{14}\, D\_PureFB_i + \beta_{15}\, D\_private_i + \beta_{16}\, D\_JVB_i + \beta_{17}\, D\_RDB_i + \varepsilon_{it} \tag{7.3}$$

Refer to Table 7.1 for descriptions of the variables included.

2. To analyse the variation across the bank groups, the related determinant variables are also regressed on TE within each bank group, while excluding the dummy variables of group ownership. Therefore, Equation 7.1 can be rewritten as follows:

$$TE_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, Dforex_{it} + \beta_{10}\, Dlisting_{it} + \beta_{11}\, Dmerger_{it} + \beta_{12}\, DregCh_t + \varepsilon_{it} \tag{7.4}$$

$$TFP_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, Dforex_{it} + \beta_{10}\, Dlisting_{it} + \beta_{11}\, Dmerger_{it} + \beta_{12}\, DregCh_t + \varepsilon_{it} \tag{7.5}$$

Equations 7.4 and 7.5 are regressed for each group of banks to determine the relation to each variable. Some of the variables do not apply to a particular group because they do not occur. For instance, no mergers occurred in the regional development banks and foreign banks, foreign banks are not listed on the Indonesian stock exchange, and all of the foreign banks conduct foreign exchange operations. Thus, the dummy merger variable should be excluded for RDBs and foreign banks, and the forex dummy and listing dummy should also be excluded for foreign banks. Then, Equation 7.1 for RDB can be rewritten as:

$$TE_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, Dforex_{it} + \beta_{10}\, Dlisting_{it} + \beta_{11}\, DregCh_t + \varepsilon_{it} \quad 7.6$$

$$TFP_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, Dforex_{it} + \beta_{10}\, Dlisting_{it} + \beta_{11}\, DregCh_t + \varepsilon_{it} \quad 7.7$$

While the estimation for a foreign bank is:

$$TE_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, DregCh_t + \varepsilon_{it} \quad 7.8$$

$$TFP_{it} = \alpha + \beta_1\, size_{it} + \beta_2\, CAR_{it} + \beta_3\, NPL_{it} + \beta_4\, ROA_{it} + \beta_5\, HHI_t + \beta_6\, GDP_t + \beta_7\, inlf_t + \beta_8\, BMoney_t + \beta_9\, DregCh_t + \varepsilon_{it} \quad 7.9$$

Given that efficiency and productivity are obtained using two different approaches, Model A (the intermediation approach) and Model B (the revenue approach), the estimations of Equations 7.2 to 7.9 are performed under each of these models. Similarly, the estimations are also run using two different periods, that is, the period from 1993-2011 without the bank-specific variables and the period from 2000-2011 with all variables.

All of the estimations, including the maximum-likelihood estimates of the parameters, are obtained using the commercial statistical software, STATA 12.

7.4 Empirical Results

7.4.1 The Aggregated Banking Industry

The empirical results are presented in two different subsections, for the full sample and for separate subsamples within each bank group. This section begins with the estimation of Equations 7.2 and 7.3 for the full sample of the banks. The estimation results are shown in Table 7.4 and Table 7.5. As indicated previously, there are two models presented: Model A (the intermediation approach) and Model B (the revenue approach), and for each model, there are two periods of estimation results, the period from 1993-2011, which is without the three internal bank characteristic variables, and the period from 2000 - 2011, which includes the three variables.

Table 7.4: Determinants of Efficiency (TE) – Tobit Regression Model

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

Sources: Author's calculation
Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively.

Table 7.5: Determinants of TFP Growth – Tobit Regression Model

Variable	Model A				Model B			
	1993–2011		2000–2011		1993–2011		2000–2011	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Size	-0.006	0.009	0.004	0.009	0.032	0.036	0.046	0.048
CAR	-		-0.010	0.009	-		0.031	0.046
NPL	-		0.093	0.119	-		-0.267	0.638
ROA	-		-0.489***	0.171	-		-3.888***	0.916
HHI	-0.169	0.128	0.582	0.562	-0.158	0.510	6.817**	3.013
GDP	0.008	0.007	-0.011	0.018	-0.004	0.028	0.100	0.098
Infl	0.000	0.003	-0.006*	0.003	0.013	0.011	0.020	0.018
BMoney	0.001	0.003	0.010**	0.004	0.008	0.013	0.044*	0.023
Dforex	0.000	0.027	-0.008	0.027	-0.080	0.109	-0.048	0.146
Dlisting	0.020	0.033	-0.008	0.032	0.152	0.131	0.011	0.173
Dmerger	-0.056	0.048	-0.048	0.041	-0.177	0.193	-0.172	0.221
DRegCh	-0.104***	0.038	0.059	0.074	0.158	0.153	0.926**	0.399
D_state	0.032	0.056	-0.091*	0.055	0.373*	0.224	-0.185	0.296
D_PureFB	0.026	0.040	-0.026	0.041	0.461***	0.161	0.623***	0.221
D_Private	0.006	0.026	0.028	0.028	0.064	0.104	0.023	0.148
D_JVB	0.076**	0.038	0.045	0.040	0.156	0.151	0.098	0.214
Intercept	1.156***	0.187	0.254	0.553	0.306	0.746	-6.993**	2.962
/sigma_u	0.000	0.014	0.000	0.013	0.000	0.077	0.000	0.140
/sigma_e	0.397***	0.007	0.321***	0.007	1.583***	0.026	1.723***	0.035
rho	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	-898.34		-343.95		-3414.19		-2378.42	
Wald chi^2	38.34***		64.16***		42.26***		38.73***	
Observation	1818		1212		1818		1212	

Sources: Author's calculation

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

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

In regard to the efficiency regression (Table 7.4), the coefficients show different results under different models and different estimation periods. Some explanatory variables demonstrate their significant roles, in explaining their effect on efficiency, although inconsistent signs of influence exist in some cases. For example, the variables for listing and merger are negative and statistically significant in the 1993–2011 Model B and the 2000–2011 Model A, while in the other period and model, these variables are not significant. This result demonstrates the various effects of the variables in the model. Apart from that, there are some variables exhibit consistent results across the models and periods: size, broad money, foreign bank, state bank and JVB are positive and significant, and *CAR* is positive but statistically insignificant. While other variables such as *NPL* and foreign exchange are insignificant but have a mixed sign, inflation, regulatory change and *ROA* are positive but show mixed significance. The remainder of the variables have mixed results.

The TFP regressions also demonstrate strong evidence of a good fit at l% for the Wald chi-square statistic, but the included variables exhibit fewer statistically significant coefficients compared with the efficiency results (only two to five significant coefficients across the models). Size, *CAR*, *NPL*, *GDP*, foreign exchange and listing are insignificant with mixed signs across the models.

Among the bank-specific variables, the size variable consistently shows a positive influence on the efficiency of the banking industry under both models and in different estimation periods. This supports the idea that larger banks are likely to be more efficient and have faster productivity growth than smaller banks, which confirms similar findings in other Indonesian studies such as Zhang and Matthews (2012), Hadad et al. (2008b), Hadad et al. (2010a), and Hadad et al. (2012), although those studies' results are not consistently significant. However, there is no strong evidence that higher rate of productivity growth is associated with larger bank as indicated by insignificant coefficient in all models. This result also confirms the results of efficiency and productivity growth based on bank size in two previous chapters (see Tables 5.9 and 5.10, Table 6.7 and 6.8). Furthermore, for a robustness check a separate regression based for each bank size (large, medium and small) is presented in Appendix Table 7.3 to 7.6.[31] The variables for size in efficiency regression are positive and more significant in large banks compared with small banks (see Appendix Table 7.3 and Appendix Table 7.4).

Some international studies, such as Ye, Xu, and Fang (2012) and Jha, Hui, and Sun (2013) obtain results with size negatively related to bank efficiency. A positive effect of bank size on efficiency can presumably be attributed to the ability to spread business risks through various loans. Conversely, a negative relationship might be attributed to the complexity of the business operation (Ataullah and Hang 2006). In Indonesia, as noted earlier, large banks possess extensive bank branches, diversified products and better technology, all of which seem to outweigh any negative effects of being “large”.

The results for the three others bank characteristic variables, *CAR*, *NPL* and *ROA*, provide varying results between the models at different estimation periods. This study finds that overall capital strength has a positive correlation with efficiency and productivity growth (except for Model A of productivity growth), although the coefficients are not statistically significant. This result is similar to the finding of Havrylchyk (2006) in Polish banks. The magnitude of this correlation is accords with that of Gardener, Molyneux, and Nguyen-Linh (2011) and Jha, Hui, and Sun (2013) but is contrary to that of Sufian (2009). The lack of significance is perhaps due to the increase in the average bank capital ratio following the rising of the capital ratio requirement in 2001.[32] In contrast to the minimum CAR of 8%, the average CAR of commercial banks from 2000 to 2011 was 18.4% (see Table 2.6 in Chapter 2). This result suggests that capital strength may help lessen the risk associated with bank operations but it does not significantly promote banks’ efficiency and productivity growth.

[31] The findings on the effect of size follow those of the two previous chapters.
[32] All commercial banks were required to meet the minimum CAR of 8% by the end of 2001 (Regulation No.21/PBI/2001), after it had previously been relaxed to 4% in 1998.

The coefficient of profitability (*ROA*) presents an opposite magnitude to the efficiency and productivity growth. It relates positively to the level of efficiency and even strongly significant at the 1% level under Model B, suggesting that banks with higher profits exhibit to be more efficient. This result is in line with the results of international studies such as those of Castellanos and Garza-García (2013), Jha, Hui, and Sun (2013). Moreover, this finding is also close to that of Sufian (2009), who finds that the coefficient of *ROA* is positive and insignificant under intermediation-based efficiency but highly significant under the operations approach to efficiency in Malaysian banks. The opposite result is found in other studies such as those of Ataullah and Hang (2006), Gardener, Molyneux, and Nguyen-Linh (2011) and Garza-García (2012). Conversely, with regard to the productivity, the results strongly suggest that higher ratio of profitability leads to a lower rate of productivity growth as indicated by the statistically negative coefficients. This result is coincide with other Indonesian study by Hadad et al. (2011) and Malaysian bank study by Sufian (2011). The negative effect of profitability on productivity is presumably because as bank gains productivity, it tends to engage in a higher volume of lending, meaning that it charges a lower interest rate but incurs higher personnel costs.

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

In the case of TFP change, both of the models present the same pattern of sign for the *HHI* coefficient. It is negatively related to the TFP change in the longer period (1993–2011) but positively related in shorter period (2000–2011). However, only for the shorter period in Model B the coefficient is statistically significant. Here, the positive coefficient suggests that banks tend to experience higher productivity growth in less competitive markets.[33]

Regarding the macroeconomic variables, the annual growth of GDP is statistically significant and positively correlated to bank efficiency (except for 2000–2011 of Model B). The positive and significant correlation result suggests that economic growth is important in maintaining bank efficiency, a claim that is supported by Drake, Hall, and Simper (2006) and Grigorian and Manole (2006). Yet, the effect of this variable upon productivity growth is mixed and statistically insignificant, which is similar to the findings of Sufian (2011) for Malaysian banks. The volatility of economic growth, especially toward the end of the 1990s, does not seem to have had a negative impact on productivity growth during the period of 1993–2011, except in Model B of TFP regression.

The inflation coefficients are the opposite of that expected. The results show it is positively related to bank efficiency and productivity growth, having a strongly statistically significant relationship to bank efficiency. This finding suggests a higher inflationary environment is favourable to bank efficiency and productivity growth. Although contradictory to the conventional findings of bank efficiency and productivity studies (Delis, Molyneux, and Pasiouras 2011; Barth et al. 2013; Castellanos and Garza-García 2013), this result seems to support the argument of Grigorian and Manole (2006). They argue that since inflation could take the form of price and non-price behaviour, high inflation is unnecessarily linked to large inefficiencies. In addition, the findings of Boyd, Levine, and Smith (2001) suggest the negative correlation between inflation and banking activities is more evident in countries with low rates of inflation. Also, Demirgüç-Kunt and Huizinga (1999) find a positive and significant association between inflation and realised interest margins and profitability. They argue that bank income increases more with inflation than bank costs – especially in developing countries.

[33] Market concentration (*HHI*) is assumed to be linearly related to efficiency and TFP. There is a possibility that the relationship is a non-linear.

Lastly, among the macroeconomic variables, a higher amount of currency outside of the banks, as measured by broad money, is strongly associated with more efficient banks. Similar correlations exist for the rate of productivity growth across models, although these are statistically significant for the longer period only.

Looking at bank status, this study does not seem to support the finding of Hadad et al. (2012) that listed banks are more efficient than the industry average. On the contrary, the results confirm the findings of Havrylchyk (2006) in Polish banking. Status as a listed bank tends to have an inverse relationship with efficiency and productivity growth, especially during the shorter period (2000-2011), and being a listed bank is only significant under Model B in period from 1993-2011.

Status as a foreign exchange bank shows a lack of significance and tends to be negative. This result suggests that the common prejudice of the public regarding the “exclusive” status of foreign exchange banks, in fact, does not benefit them in their performance. To some extent, this finding is surprising because most of the listed and foreign exchange banks in Indonesia are large banks, which are known to be the best performers.

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

There are several possible reasons for the restructuring results. First, most of the merged banks were inefficient and were forced by the authorities to merge because of their poor performance. Thus, they inherit this inefficiency in the new bank formed. Second, even if two merged banks were efficient before the merger, this does not ensure that the newly merged bank will operate more efficiently (see Halkos and Tzeremes 2013). Third, some of the prior literature notes that efficiency gains from mergers are mostly achieved in the long run, which is mainly due to a lack of managerial capability to cope with a newly merged entity in the short run (Rhoades 1998; Halkos and Tzeremes 2013).

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

The lack of significance in Model A is, to some extent, consistent with the findings of Barth, Caprio, and Levine (2004). The authors report that the generosity of the deposit insurance scheme has no strong correlation with bank efficiency; instead it has strong negative correlation with bank fragility. In relation to the rate of TFP growth in Model A, the results are mixed. For the longer period (1993–2011), the result suggests that changes in regulation significantly decrease the rate of productivity growth, whilst in the shorter period, the contrary relationship is apparent but not statistically significant. Using various proxies of regulatory change, Delis, Molyneux, and Pasiouras (2011) also find varying effects of changes in regulation upon productivity growth in transition countries. These findings highlight that the effect of changes in regulation depend on the various features of banks.

With regard to ownership type, all of the included types are positively related to bank efficiency and are also mostly positively related to productivity growth. The regressions contain five ownership dummies, and regional development bank (RDB) is the omitted category, so the implication is that other ownership groups are more efficient and have higher productivity growth than the RDB banks. Among the groups, the coefficients of state, foreign and joint venture banks are statistically significant in all of the efficiency regression models.

In general, foreign banks appear to be most efficient. The effect of foreign banks upon the rate of TFP changes, however, is inconsistent. In Model A of TFP change the coefficients are statistically insignificant and this group is not the best performer. However, under Model B of TFP change, it clearly indicates that foreign bank gain more productivity growth than that of any other group, having a positive and statistically significant coefficient. This result seems to support the typical findings in developing countries' studies, namely that foreign banks outperform their domestic counterparts. Nevertheless such comparisons have to be made with caution. In this study 'foreign bank' is defined as the branch of a bank that is 100% foreign-owned, while most other studies examine partially owned foreign banks, which are more comparable to the joint venture banks (JVBs) of this study.

Under Model A, the JVB itself is relatively more efficient and productive than other domestic banks (state, private and RDB). Therefore, as mentioned earlier, these results support the empirical findings in developing countries studies, such as those of Hasan and Marton (2003) Grigorian and Manole (2006), Gardener, Molyneux, and Nguyen-Linh (2011), Isik and Hassan (2003a). Moreover, this result is also consistent with the study by Zhang and Matthews (2012) in Indonesia – in particular, their crises and post-crises regressions. However, other researchers report dissimilar findings. Lensink, Meesters, and Naaborg (2008), for example, cite the negative impact of foreign ownership in 105 countries, while Williams and Nguyen (2005) report that such ownership reduces profit efficiency in Indonesian bank.

The results in Model B differ from those in Model A. For the longer period state banks in Model B tend to be more efficient and to increase their productivity more than JVBs. This is partially in line with the Indonesian study by Hadad et al. (2010a) who, also using revenue based efficiency for five years of monthly data for listed banks, report that foreign owned banks tend to underperform domestic banks. Unlike Hadad et al., this study finds JVBs are still more efficient than private and regional banks.

Compared to other domestic banks (private and RDBs), state banks are found to be relatively more efficient, having positive and statistically significant coefficients. The better performance of state banks over private national banks is consistent with Das and Ghosh (2009) and Bhattacharyya, Lovell, and Sahay (1997) in their Indian bank studies and with others studies (Denizer, Dinc, and Tarimcilar 2000; Altunbas, Evans, and Molyneux 2001; Kraft, Hofler, and Payne 2006). With regard to TFP change, state banks tend to have a negative impact in the shorter period (2000-2011), although this effect is only slightly statistically significant in Model A and not significant in Model B. This places state banks below private banks, which suggests that they contribute negatively to the productivity growth of Indonesian banks over the shorter period.

For private banks, the coefficients are consistently positive throughout the regression models, but most of them are statistically insignificant. These results place private banks only slightly above RDBs, the least efficient in the industry. As the largest group, their performance is inordinately reflected in the industry as a whole.

To check the robustness of the results, the technical efficiency and total factor productivity growth scores are also regressed using fixed and random effects panel data estimations. Applying a similar set of independent variables, model and period, the results are presented in Appendix Table 7.1 and Appendix Table 7.2. The estimation results are virtually similar to those reported for the Tobit regression model.

From these findings, it can be seen that the efficiency and productivity growth of Indonesian banks is determined by various factors. Variation in direction, statistical significance and magnitude for some of the variables is apparent in the model, indicating that the role of each variable depends on the period and the model used. The statistical significance of the variables is mostly strong for regressions explaining the level of efficiency, but has limited power in explaining productivity growth. The differences in the units of measurement of the dependent variables may affect the results. Efficiency is measured in the level of technical efficiency in a respective year, while productivity growth is measured as the change in efficiency, which is the rate of TFP growth from one base year to another year. The results at the industry level reflect the performance of all banks. Hence, these provide the general picture of the industry. To further investigate the determinants of each group, the next subsection presents the regression results for the separate groups of banks.

7.4.2 Bank Group Estimation

Differences in ownership forms may cause banks to react differently to the determinants of efficiency and productivity growth. Given the variations in the results of the variables, including the dummy group in the industry-level regression, this subsection further investigates whether the variables have similar effects in different groups. Also, it is important to see what groups' results are reflected in the industry-level. To date, as far as author aware few studies of the determinants of efficiency and productivity growth appear to have been conducted at the bank group level. As outlined previously, most of the previous empirical studies estimated the determinants at the level of the overall banking industry's efficiency and productivity growth. A study somewhat closer to this study is that of Gardener, Molyneux, and Nguyen-Linh (2011), which uses cross-country data (South East Asia). Beside the overall estimation, these researchers also separately estimated the effects of some factors on foreign, private and state owned banks efficiency.

This second part of this study's estimation is conducted separately for each of the five bank groups for efficiency and productivity growth in both models. The results of the efficiency estimation are presented in Table 7.6 and Table 7.7 for each period under both Model A and Model B. Further, the productivity growth estimations are presented in Table 7.8 and Table 7.9.

Table 7.6: Model A – Determinants of Efficiency (TE), Bank Group – Tobit Regression Model

Variable	State bank		Private bank		RDB		JVB		Pure foreign bank	
	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011
Size	0.1443***	0.1123***	0.0109	0.0329***	0.1174***	0.1114***	0.0229	0.1489***	0.0405**	0.0363
	(0.0204)	(0.0253)	(0.0089)	(0.0109)	(0.0257)	(0.0197)	(0.0233)	(0.0357)	(0.0193)	(0.0227)
CAR		0.7675**	-	0.0024	-	0.5343***	-	0.0361	-	0.0595
		(0.3281)		(0.0044)		(0.1167)		(0.1270)		(0.0964)
NPL	-	0.5001*	-	-0.0596	-	0.3233	-	-0.0737	-	0.0014
		(0.2942)		(0.1030)		(0.2178)		(0.1677)		(0.1213)
ROA	-	2.6359***	-	0.0455	-	0.5224	-	1.1837*	-	0.5772
		(0.8296)		(0.0835)		(0.7922)		(0.6167)		(0.6051)
HHI	-0.0090	-0.0652	-0.2012***	0.8274**	-0.3815***	0.3079	-0.0490	1.1256	-0.3939***	-0.0686
	(0.1201)	(0.6032)	(0.0575)	(0.3333)	(0.0970)	(0.4494)	(0.1321)	(0.8242)	(0.1319)	(0.7260)
GDP	0.0196**	0.0209	0.0082**	0.0603***	0.0211***	0.0789***	-0.0054	0.0718***	-0.0327***	0.0062
	(0.0082)	(0.0202)	(0.0041)	(0.0109)	(0.0061)	(0.0146)	(0.0095)	(0.0256)	(0.0094)	(0.0239)
Infl	0.0064**	0.0018	0.0071***	0.0084***	0.0118***	0.0172***	-0.0015	0.0066	-0.0070*	-0.0038
	(0.0031)	(0.0037)	(0.0016)	(0.0020)	(0.0023)	(0.0027)	(0.0036)	(0.0048)	0.0036	(0.0042)
BMoney	0.0005	-0.0052	0.0035**	0.0103***	0.0074***	0.0092**	0.0070*	0.0094	-0.0051	-0.0037
	(0.0033)	(0.0065)	(0.0017)	(0.0026)	(0.0026)	(0.0038)	(0.0039)	(0.0067)	(0.0038)	(0.0057)
Dforex	-0.2009***	-	0.0217	-0.0270	0.0455	-0.0048	0.0326	-0.2074*	-	-
	(0.0755)		(0.0258)	(0.0362)	(0.0394)	(0.0325)	(0.1013)	(0.1156)		
Dlisting	0.0099	-0.0064	0.0756***	0.0146	-0.1321	-0.2302*	-0.0882	-0.1917*	-	-
	(0.0335)	(0.0399)	(0.0229)	(0.0254)	(0.1778)	(0.1331)	(0.0957)	(0.1104)		
Dmerger	-0.0865**	-0.1206***	0.1066***	0.0196	-	-	-0.0776	-0.0807	-	-
	(0.0366)	(0.0366)	(0.0372)	(0.0388)			(0.0552)	(0.0731)		
DRegCh	0.0121	-0.0500	0.0109	0.0841*	-0.0248	-0.0343	0.0772	0.0573	0.0411	-0.0006
	(0.0458)	(0.0866)	(0.0224)	(0.0443)	(0.0344)	(0.0596)	(0.0541)	(0.1063)	0.0524	(0.0920)
Intercept	-0.9874***	-0.6095	0.2647**	-1.1901***	-0.8729**	-1.8137***	0.2794	-2.1504**	1.1406***	0.6735
	(0.2927)	(0.6760)	(0.1243)	(0.3407)	(0.3450)	(0.4933)	(0.2960)	(0.9155)	0.2995	(0.7626)
rho	0.0000	0.0000	0.4103	0.5482	0.3806	0.3095	0.4801	0.6855	0.1849	0.323
Log likelihood	74.96	60.95	297.84	284.15	128.59	167.59	52.85	46.48	62.54	69.15
Wald chi^2	101.33***	150.01***	138.35***	62.47***	123.99***	136.12***	16.09***	42.84***	93.44***	12.81
Observations	76	48	1010	639	475	300	187	117	171	108

Sources: Author's calculations. Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

Table 7.7: Model B – Determinants of Efficiency (TE), Bank Group – Tobit Regression Model

Variable	State bank		Private bank		RDB		JVB		Pure foreign bank	
	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011
Size	0.163 ***	0.084 ***	0.045 ***	0.040 ***	-0.037 **	0.039 **	0.039	0.074 **	0.051 ***	0.008
	(0.033)	(0.022)	(0.008)	(0.010)	(0.016)	(0.018)	(0.025)	(0.035)	(0.020)	(0.024)
CAR	-	0.163	-	0.004	-	-0.134	-	0.159	-	-0.146
		(0.283)		(0.004)		(0.154)		(0.133)		(0.112)
NPL	-	0.194	-	-0.044	-	0.771 ***	-	0.313 **	-	0.047
		(0.254)		(0.1075)		(0.2688)		(0.152)		(0.149)
ROA	-	2.633 ***	-	0.310 ***	-	4.377 ***	-	2.146 ***	-	3.576 ***
		(0.715)		(0.0872)		(0.9456)		(0.686)		(0.757)
HHI	-0.508 ***	-0.360	0.154 ***	-0.988 ***	0.221 **	-1.544 ***	0.184	-1.718 *	0.195	-2.921 ***
	(0.191)	(0.520)	(0.058)	(0.349)	(0.096)	(0.585)	(0.148)	(0.942)	(0.145)	(0.914)
GDP	0.020	-0.015	0.045 ***	-0.003	0.040 ***	-0.083 ***	0.044 ***	-0.047	0.025 **	-0.041
	(0.013)	(0.017)	(0.004)	(0.011)	(0.006)	(0.019)	(0.011)	(0.029)	(0.010)	(0.030)
Infl	0.009 *	0.001	0.014 ***	0.008 ***	0.011 ***	-0.010 ***	0.008 *	-0.006	0.009 **	-0.010 **
	(0.005)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.006)	(0.004)	(0.005)
BMoney	-0.010 *	0.004	0.011 ***	0.023 ***	0.010 ***	0.023 ***	0.004	0.019 **	0.004	0.015 **
	(0.005)	(0.006)	(0.002)	(0.003)	(0.003)	(0.005)	(0.004)	(0.008)	(0.004)	(0.007)
Dforex	-0.260 **	-	-0.058 **	-0.042	0.122 ***	0.077 **	0.102	0.031	-	-
	(0.120)		(0.024)	(0.035)	(0.037)	(0.037)	(0.076)	(0.079)		
Dlisting	-0.093 *	0.024	-0.035	-0.007	0.241	0.205	0.047	-0.036	-	-
	(0.053)	(0.034)	(0.023)	(0.026)	(0.188)	(0.172)	(0.088)	(0.095)		
Dmerger	-0.097 *	-0.023	0.048	0.130 ***	-	-	-0.086	-0.020	-	-
	(0.058)	(0.032)	(0.037)	(0.040)			(0.057)	(0.060)		
DRegCh	-0.106	0.021	0.112 ***	0.195 ***	0.288 ***	0.417 ***	0.126 **	0.263 **	0.180 ***	0.131
	(0.073)	(0.075)	(0.023)	(0.046)	(0.036)	(0.078)	(0.060)	(0.123)	(0.058)	(0.116)
Intercept	-0.271	-0.181	-0.748 ***	-0.251	-0.097	0.382	-0.358	0.262	-0.314	2.192 **
	(0.466)	(0.583)	(0.120)	(0.353)	(0.248)	(0.604)	(0.316)	(1.019)	(0.320)	(0.944)
rho	0.000	0.000	0.250	0.446	0.102	0.087	0.170	0.139	0.123	0.128
Log likelihood	39.56	68.07	296.35	264.07	115.31	103.39	39.05	41.09	47.72	48.15
Wald chi^2	51.78 ***	138.35 ***	240.60 ***	256.47 ***	153.81 ***	276.54 ***	78.65 ***	84.01 ***	34.04 ***	88.46 ***
Observation	76	48	1010	639	475	300	187	117	171	108

Sources: Author's calculations. Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

Table 7.8: Model A – Determinants of TFP Growth, Bank Group – Tobit Regression Model

Variable	State bank		Private bank		RDB		JVB		Pure foreign bank.	
	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011
Size	0.062	0.035	-0.005	0.004	-0.032	-0.010	-0.054	-0.012	-0.001	0.004
	(0.057)	(0.044)	(0.011)	(0.013)	(0.021)	(0.017)	(0.054)	(0.050)	(0.037)	(0.041)
CAR	-	-0.468	-	-0.010	-	0.044	-	0.162	-	-0.046
		(0.575)		(0.010)		(0.162)		(0.183)		(0.209)
NPL	-	0.2955	-	0.4729 *	-	-0.1396	-	-0.5569 **	-	-0.1497
		(0.516)		(0.248)		(0.301)		(0.221)		(0.296)
ROA	-	-0.482	-	-0.478 **	-	-1.836 *	-	-2.030 *	-	0.107
		(1.454)		(0.206)		(1.002)		(1.066)		(1.405)
HHI	1.647***	2.430**	-0.490 ***	0.329	0.506 **	0.812	-0.442	-1.756	-0.790	3.064
	(0.426)	(1.057)	(0.169)	(0.894)	(0.214)	(0.730)	(0.471)	(1.540)	(0.569)	(1.918)
GDP	-0.016	0.065*	0.010	-0.015	-0.020 *	0.016	0.054 **	-0.145 ***	0.037	0.059
	(0.023)	(0.035)	(0.009)	(0.029)	(0.011)	(0.024)	(0.026)	(0.049)	(0.031)	(0.063)
Infl	-0.005	0.002	-0.002	-0.007	-0.013 ***	-0.010 **	0.021 **	-0.007	0.027 **	0.015
	(0.009)	(0.006)	(0.004)	(0.005)	(0.004)	(0.004)	(0.010)	(0.009)	(0.012)	(0.011)
BMoney	0.015	0.011	0.006	0.014 **	-0.007	-0.003	-0.005	0.021 *	-0.002	0.015
	(0.010)	(0.011)	(0.004)	(0.007)	(0.005)	(0.006)	(0.012)	(0.012)	(0.014)	(0.015)
Dforex	0.084		-0.040	-0.019	0.062	0.042	0.125	0.066	-	-
	(0.275)		(0.033)	(0.041)	(0.051)	(0.038)	(0.110)	(0.098)		
Dlisting	-0.091	-0.052	0.046	-0.022	0.187	0.134	0.048	0.379 ***	-	-
	(0.093)	(0.070)	(0.040)	(0.045)	(0.329)	(0.210)	(0.143)	(0.137)		
Dmerger	-0.041	-0.031	-0.019	-0.017	-	-	-0.039	-0.108	-	-
	(0.101)	(0.064)	(0.063)	(0.064)			(0.114)	(0.075)		
DRegCh	0.376***	0.226	-0.130 ***	0.048	0.002	0.000	-0.265 *	0.000	-0.256	0.184
	(0.127)	(0.152)	(0.051)	(0.119)	(0.063)	(0.097)	(0.145)	(0.202)	(0.171)	(0.244)
Intercept	-1.781**	-1.985*	1.197 ***	0.319	1.505 ***	0.773	1.712 **	2.302	1.396 *	-2.229
	(0.831)	(1.185)	(0.235)	(0.875)	(0.373)	(0.732)	(0.726)	(1.629)	(0.839)	(1.943)
rho	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	-2.09	34.01	-429.58	-272.73	-134.41	46.79	-112.38	-12.46	-126.21	-27.64
Wald chi^2	52.36***	11.090	50.42 ***	44.57 ***	24.49 ***	18.86 *	12.34	33.65 ***	14.06 **	9.89
Observation	72	48	957	639	450	300	177	117	162	108

Sources: Author's calculations. Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

Table 7.9: Model B – Determinants of TFP Growth, Bank Group – Tobit Regression Model

Variable	State bank		Private bank		RDB		JVB		Pure foreign bank.	
	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011	1993–2011	2000–2011
Size	0.225	-0.114	0.001	0.023	0.026	-0.014	0.155 **	0.038	0.140	1.682 **
	(0.544)	(0.072)	(0.019)	(0.028)	(0.016)	(0.018)	(0.065)	(0.055)	(0.312)	(0.708)
CAR	-	0.842	-	0.017	-	0.101	-	-0.169	-	8.130 **
		(0.934)		(0.019)		(0.166)		(0.203)		(3.517)
NPL	-	-0.224	-	-0.361	-	-0.498	-	0.039	-	-3.299
		(0.837)		(0.468)		(0.308)		(0.246)		(5.142)
ROA	-	2.207	-	-3.253 ***	-	-0.796	-	-0.427	-	-63.160 **
		(2.361)		(0.390)		(1.026)		(1.188)		(25.492)
HHI	0.626	4.318 **	0.074	3.483 **	0.623 ***	2.079 ***	-1.014 *	-0.447	-3.107	56.936 *
	(4.103)	(1.717)	(0.309)	(1.640)	(0.161)	(0.747)	(0.559)	(1.716)	(4.838)	(31.341)
GDP	-0.100	0.065	-0.020	0.071	-0.015 *	0.047 *	-0.024	0.028	0.234	0.906
	(0.220)	(0.058)	(0.017)	(0.053)	(0.009)	(0.024)	(0.031)	(0.054)	(0.263)	(1.032)
Infl	0.132	0.024 **	0.001	0.002	-0.006 *	0.006	0.036 ***	0.025 **	0.079	0.196
	(0.082)	(0.010)	(0.006)	(0.010)	(0.003)	(0.004)	(0.012)	(0.010)	(0.101)	(0.179)
BMoney	-0.043	-0.033 *	-0.004	0.016	0.000	-0.008	-0.025 *	-0.029 **	0.157	0.455 *
	(0.101)	(0.018)	(0.008)	(0.013)	(0.004)	(0.006)	(0.014)	(0.014)	(0.121)	(0.243)
Dforex	-0.310		-0.012	0.001	-0.008	0.028	-0.355 ***	-0.066	-	-
	(2.648)		(0.061)	(0.085)	(0.038)	(0.039)	(0.130)	(0.109)		
Dlisting	1.225	0.140	0.149 **	0.070	-0.110	-0.077	0.033	-0.114	-	-
	(0.894)	(0.114)	(0.073)	(0.091)	(0.247)	(0.215)	(0.170)	(0.152)		
Dmerger	-0.418	0.072	-0.036	-0.295	-	-	-0.109	-0.044	-	-
	(0.974)	(0.104)	(0.115)	(0.209)			(0.135)	(0.083)		
DRegCh	-0.822	0.029	-0.035	0.312	0.120 **	0.096	-0.312 *	-0.281	1.980	7.603 *
	(1.224)	(0.246)	(0.093)	(0.218)	(0.048)	(0.099)	(0.172)	(0.225)	(1.455)	(3.980)
Intercept	-0.910	0.237	1.264 ***	-2.674 *	0.395	-0.248	1.605 *	2.179	-7.806	-85.587 ***
	(8.005)	(1.924)	(0.430)	(1.610)	(0.280)	(0.749)	(0.863)	(1.816)	(7.126)	(31.810)
rho	0.000	0.000	0.000	0.030	0.000	0.000	0.000	0.000	0.000	0.018
Log likelihood	-165.20	10.739	-1008.34	-669.16	-4.90	39.62	-142.93	-25.15	-472.85	-330.01
Wald chi^2	49.540 ***	46.570 ***	23.02 ***	78.15 ***	23.15 ***	26.67 ***	126.02 ***	16.18	4.02	1.36 *
Obsevartion	72	48	957	639	450	300	177	117	162	108

Sources: Author's calculations. Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

Similar to the aggregate banking industry result, the regression models also present convincing results for most of the bank groups with the significance of the Wald Chi2 test statistic at 1%. These outcomes suggest that the model is able to explain the banks' efficiency and productivity. However, exceptions are for foreign banks under TE regression Model A in the 2000–2011 period and Model B for TFP in the 1993–2011 period. Also, the TFP regression for joint venture banks appears to be insignificant under Model A in the 1993–2011 and Model B in the 2000–2011 period. Finally, for state banks under Model A for TFP in the 2000–2011 period, the results are not significant.

The roles of the variables in each model vary across the groups. Following the results at the industry level, compared to TFP growth, the statistically significance of the estimated coefficients is more evident in the efficiency regression (Table 7.6 and Table 7.7) However, the regression by bank group in TFP growth provides insight regarding the effect of the variables in each group. For certain groups, some variables can be seen to be important determinants of TFP growth, although for other groups and at the industry level they are not statistically significant. This implies the variables have a different effect in different groups, which is possibly due to the differences in business operations.

In regard to the bank-specific variables, all (size, *ROA*, *CAR* and *NPL*) are shown to have a positive and statistically significant correlation with intermediation based efficiency in state banks. While in other groups and models, the results are mixed. Among the bank-specific variables, the *size* coefficient consistently demonstrates statistical significance across the groups in both models of efficiency regression. Exceptions are for JVBs in the period of 1993-2011 and foreign banks in 2000-2011. Moreover, the positive coefficient of *size* is mostly significant at the 1% level across the estimations, except for the RDBs which show a negative coefficient in 1993-2011 in Model B. Hence, the strong positive correlation of this variable in the industry results, as shown previously, is mostly supported by all groups. This result is consistent with those of Gardener, Molyneux, and Nguyen-Linh (2011) with respect to foreign banks and state banks ownership (the latter only slightly), but not with regard private banks. This result, again, supports the argument that the larger the bank, the more efficient it will be. Correspondingly, the statistical insignificance of *size* in the rate of TFP growth is evident in all groups in Model A, which is reflected in the industry result. In Model B, however, *size* correlates significantly and positively to the TFP growth in JVBs and foreign banks. This suggests that among foreign owned banks, the larger banks make greater productivity gains in terms of revenue approach than do smaller banks.

Similarly, the profitability ratio (*ROA*) shows the expected sign over all of the groups. It is statistically significant for all of the groups under Model B with strong coefficients, which means this variable has the most consistently reliable influence. Specifically, the largest coefficient of *ROA* exists in RDBs, which mostly consist of small banks. The coefficient of this variable in the TFP growth regressions is generally negative, but for Model A is only statistically significant for private banks, RDBs and JVBs, whilst in Model B this occurs only for private and foreign banks.

Capital adequacy policies aim to strengthen banking operations. The positive effect of *CAR* on efficiency is apparent in all of the groups under Model A, although it is only significant (1%) in government banks (state banks and RDBs). This finding is in line with those of Gardener, Molyneux, and Nguyen-Linh (2011) concerning the positive significance of the capital variable in state banks and its insignificance in private banks. It suggests that the higher their capital ratio, the more efficient the banks in this group are. One possibility is the greater and continuous capital support from the government (state government for state banks and local government for RDBMs), while for other groups, especially private banks, capital is not always so readily available. However, under Model B and TFP regression this variable is not statistically significant, except for a positive coefficient in the TFP regression for Model B.

The asset quality or risk management, represented by the NPL ratio, shows a different result across the groups. Common theories regarding the negative effect of *NPL,* in this study only exist in JVBs in relation to TFP Model A. One possible explanation is that this group was still struggling with problem loans following the Asian financial crisis, but then recovering from these toward the end of the period of analysis. Government banks, in contrast, have greater ability to handle problem loans on their balance sheets, and foreign banks are known to be able to maintain the lowest NPL ratio as they used to finance selected market segments. Conversely, a higher bad loan ratio seems to be more favourable to revenue based efficiency (Model B) for RDBs and JVBs. The correlation of a similar magnitude is also found in private banks in relation to TFP under Model A. The accrual of unpaid interest and other costs of bad loans in these banks may be the reason for these results. In relation to the TFP growth, lower rates of bad loans tend to correlate with higher rates of productivity growth for most of the groups, except state and private banks in Model A.

Turning to the three macroeconomic variables, all show a significant relationship to the level of efficiency in most of the groups. By contrast the magnitude of their relationship to TFP growth is varied. In particular, macroeconomic variables are consistently shown to be a crucial factor in private banks' and RDBs' efficiency in both models and periods. Apart from that, the positive and significant effect of GDP in Model A is also seen in other groups, with the exception of foreign banks. This suggests that higher economic growth is more favourable for domestic banks' efficiency in their intermediation role. On the other hand, it tends to be a disincentive for revenue based efficiency in the shorter period (2000-2011) and for rate of productivity growth in the longer period (1993-2011). However, these results are statistically significant for RDBs alone.

The favourable effects of high inflation upon efficiency at the industry level are primarily for domestic banks, as indicated by the positive and significant coefficients. Conversely, inflation tends to be negatively associated with the efficiency of JVBs and foreign banks. On the contrary, JVBs show a positive and significant effect with regard to the rate of productivity. Similarly, foreign and state banks also exhibit the same correlation with TFP in the longer period of Model A and Model B, The inflationary environment, however, is unfavourable for RDBs as signified by the negative and significant coefficient for both models of TFP.

The different effect of market concentration (*HHI*) for different periods, as shown in the industry level result, also exists in most of the groups. In the efficiency regression Model A, the negative effect of market concentration in the longer period is more apparent in private banks, RDBs and foreign banks, while the positive effect in the shorter period is statistically significant for private banks only. In Model B the effect is reversed. The negative relationship is more evident in the shorter period, a feature which is noticeable in all groups. The positive effect in the longer period emerges in four groups, but is statistically significant only in private banks and RDBs. This result suggests that higher market concentration reduces bank intermediation based efficiency levels in the longer period, whilst in the shorter period it tends to be an incentive for efficiency improvement. Results under Model B in the shorter period seem to support the finding of Turk Ariss (2010) that higher degrees of market power do not favour banks' cost-efficiency in developing countries.

For instance, in private banks and RDBs it is negatively significant in the longer period of Model A, but is also negatively significant in the shorter period of Model B. Similar results are also found for foreign banks. *HHI* is consistently negatively correlated to state bank efficiency under both models. It is worth noting that state banks are known to have greater market power than other banks which, based on this result, would tend to reduce their rate of productivity growth.

Status as a foreign exchange bank or listed bank provides mixed results across the groups. Foreign exchange operation is shown to be unfavourable for state banks efficiency level as indicated by the negative and statistically significant coefficient under both model of efficiency. However, these results have to be interpreted with caution since the variations of the dummy exist only in the two initial years for state banks. A similar tendency also appears for JVBs and private banks under Model A and Model B, respectively. The role as a foreign exchange bank, in fact, is only significantly advantageous for RDBs under Model B. Presumably this is due to still limited numbers of RDBs engaging in foreign exchange operations compared to other groups. In addition, private and state banks are commonly involved in various foreign exchange activities and in more risky products than are RDBs. With regard to the TFP, the significant coefficient solely exists in JVBs under Model B with a negative magnitude. Other than that the results are not statistically significant.

Dlisting is inconsistent across groups and periods, which makes it is difficult to delineate a specific role for this variable, but the positive and significant magnitude of this variable for private banks is worth noting. It highlights the importance of public ownership to private banks' technical efficiency and productivity growth in the long-term.

Similarly, the restructuring variable (*dmerger*) is positively and significantly associated with higher level bank efficiency in private banks alone. In other groups (state banks and JVBs) the result is contrary. This emphasises that the policy of encouraging the mergers of private banks is correct, given that this group is dominated by small and medium banks. As noted previously, small banks are the least efficient group within the industry, and size is found to have a positive and significant effect on efficiency. However, a merger is associated with lower rates of productivity growth for private banks, although none of the coefficients is statistically significant.

Turning to the regulatory changes (*DRegCh*), results in Model A efficiency are insignificant for the majority of the groups, except private banks which show a slightly positive significance in the shorter period. Correspondingly, the strong positive significance of this variable in Model B is evident for most of the groups, except state banks. This result sheds the light on the new deposit insurance system that mostly benefits non-state banks. Prior to the adoption of guarantee system, non-state banks, especially private banks and JVBs, had to compete to attract depositors, which resulted in higher costs. State banks and RDBs, however, enjoyed the "privilege" of being the most trustworthy banks in Indonesia, because historically the government had never closed a state bank or RDB, making these safe for depositors. In addition, the public perception of state banks is that they are "too big to fail".

The effect of regulatory changes on the rate of productivity growth is ambiguous. Although the positive coefficient is apparent in most of the groups in both models, it is generally statistically insignificant. The result is positively significant in state banks in Model A and RDBs and foreign banks in Model B.

To summarise, the above findings on group bank ownership demonstrate the importance of examining the determinants of efficiency and productivity growth by ownership group. By focusing on banks with most homogenous ownership and business structures, the determinants of their efficiency and productivity growth can be more clearly identified. Some variables that are not statistically significant in the aggregate banking industry, exhibit statistically significance in a group. This might help authorities to formulate appropriate policies. Notably, the findings provide insight into bank behaviour with regard to environmental factors. Although the impact of regulatory reforms varies across the groups, models and periods, positive and significant evidence of revenue based efficiency measures emerges in most of the groups.

7.5 Conclusions

The objective of this chapter is to empirically examine the determinants of efficiency and productivity growth of banks in Indonesia. Using the censored Tobit regression model, for each model a set of explanatory variables is regressed on the calculated technical efficiency and total factor productivity change. The estimation is run on two versions of the dataset over two periods, from 1993 to 2011, which excludes three bank characteristic variables, and from 2000 to 2011, which includes all of the variables. By estimating the determinants of efficiency and productivity growth over these two periods, the differential effect of the variables in longer and shorter periods is identified. Furthermore, the same set of variables and models are also estimated across five groups of banks. This estimation enables us to analyse the sources of efficiency and productivity growth in each group of banks.

Using the entire model, the investigation is conducted in two phases. In the first phase, the aggregated industry data are estimated by using all of the explanatory variables, which include bank characteristics, macroeconomic factors, market concentration, bank status and restructuring policies. During this phase, the investigation provides the average picture of the industry's response to the determining factors. The efficiency results are convincing, namely, most of the included variables are significant, although the magnitude does not always support the initial hypothesis. However, the variables show limited explanatory power for productivity growth. External factors, such as bank size, macroeconomic cycle, regulatory changes, and ownership structures, are shown to be the most important factors in Indonesian banking performance.

In the second phase, the estimation is separately conducted for each type of banks. This is to further investigate the same factors based on the differences in ownership type. The results show that the different types of banks have estimated coefficients that are not similar. The effects of the factors on bank efficiency and productivity growth are mixed, both in terms of magnitude and significance. The variables that are strongly significant in influencing bank efficiency at the aggregate industry level are mostly significant for domestic banks (state banks, private banks and RDBs), especially under the intermediation efficiency-based measures. Two restructuring variables produce conflicting results. Participation in a merger seems to produce a disincentive for efficiency and productivity growth in general, but the positive effects of mergers upon private banks need to be properly noted, as these have important implications for future merger policies. Similarly, regulatory changes are found to provide a positive and significant effect on efficiency across the groups. An additional estimation based on bank size confirms that large banks are more efficient than small banks.

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

Chapter 8
Conclusion and Policy Implications

8.1 Introduction

The efficiency and productivity of the banking industry are essential to a sound and supportive financial system that can sustain economic growth. This is particularly true if a country's financial system is dominated by banks, as in Indonesia. Following the 1997 Asian financial crisis, a series of policy and regulatory changes were implemented to help rebuild and strengthen the Indonesian banking industry. The extensive restructuring of the industry, along with significant technological developments, has focused attention on the industry performance.

Many empirical studies around the world have investigated the effects of various government policies on bank efficiency and productivity growth. Although the theoretical literature supports the optimistic view that government regulation positively affects these variables, the empirical evidence is mixed. Some studies find that policies negatively affect bank efficiency and productivity growth, while others observe no effect at all. Hence, the effects of government policies and regulations on bank performance remain a subject of empirical issues.

This thesis investigates the impact of regulatory reform on the Indonesian banking industry, using data envelopment analysis approach to measure efficiency and productivity growth. The research is conducted using three analytical frameworks. A data envelopment analysis is applied to investigate the impact of regulatory reforms on the level of banks' technical efficiency. The Malmquist productivity index method is then used to examine productivity growth and decompose it into two subcomponents, efficiency changes and technological changes. This decomposition means to show that productivity growth can arise from both efficiency and technology. Both approaches are complemented with bootstrap methods proposed by Simar and Wilson (1998b, 1999a) to derive statistical inferences. Finally, a Tobit regression model is used to identify the determinants of efficiency and productivity growth.

The major contributions of this thesis are as follows. First, the study employs a non-parametric bootstrapping model (the bootstrapped DEA model) to measure bank efficiency and productivity growth in an inclusive way, with both measurements presented and analysed concurrently. Second, it analyses the determinants of bank efficiency and productivity growth both in terms of the aggregate banking industry and by ownership group. Third, this study is one of the first attempts to analyse efficiency and productivity growth in Indonesia, using a relatively long series of panel data (19 years, from 1993 to 2011). Fourth, it represents the first attempt, within the Indonesian context, to use the bootstrapped Malmquist productivity index (MPI) to measure and decompose productivity growth into its subcomponents. Finally, it is one of the first study to investigate the impact of financial reforms implemented following the 1997 AFC on Indonesian bank efficiency and productivity growth (as a single country study).

This final chapter, which summarises this study, is structured as follows. Section 8.2 summarises the major findings of the three empirical chapters, Chapters 5 through 7. Policy implications are then presented in Section 8.3. A final section discusses some limitations of the study and the focus of future research.

8.2 Major Findings

This thesis presents an empirical analysis of the impact of regulatory changes on bank efficiency and productivity growth in the Indonesian banking sector. The study is conducted by way of a two-stage analysis that employs DEA and the Malmquist productivity index in the first stage and a Tobit regression in the second stage. Efficiency and productivity growth are estimated using two different sets of input-output approaches: the intermediation approach and the revenue approach. The study period is 19 years, from 1993 to 2011, and the sample comprises of 101 commercial banks across 1,919 observations. An additional shorter period (12 years, from 2000 to 2011) is used in the second-stage analysis. The primary sources of our data are annual financial reports of individual banks compiled in the Indonesian Banking Directory, published by the Indonesian central bank (BI). The analysis is conducted on the aggregated banking sector, bank ownership groups and to bank size groups.

The study yields noteworthy findings, some of which are consistent with those of similar studies, both in Indonesia and in other countries. Nevertheless, some of the findings differ from those of other studies and may provide useful guidance for future research and have implications for policy makers in Indonesia and in other developing countries. The findings can be summarised as follows.

8.2.1 The Efficiency Measure of Indonesian Banks

Chapter 5 analyses bank efficiency. Using the bootstrap data envelopment analysis, efficiency estimates suggest that, overall, the banking industry is inefficient under both the intermediation and revenue approaches. Both models show upward and downward movements during the period of analysis, but in general a higher efficiency level is observed under revenue approach than intermediation approach. However, there is a slight upward trend in intermediation based model which suggests that the regulatory reforms are associated with improvements in bank efficiency.

Further analysis of efficiency at the bank group level shows various overall mean of technical efficiency of the group compared to the industry efficiency. State owned banks are the best performers, followed by foreign and joint venture banks. Private and regional development banks are the least efficient groups. Furthermore, the efficiency of banks in both models is strongly associated with bank size, with larger banks tending to be more efficient than smaller banks.

For small banks, revenue based efficiency is higher than intimidation based efficiency, but a contrary result is found in large and medium banks. Regulatory changes are found to mostly affect non-state banks. In particular, it improves the intermediation based efficiency of private banks, regional development banks (RDBs) and foreign bank, but there are no clear effects for JVBs and state banks. Decreasing revenue based efficiency is observed until 2004 for private banks, RDB, JVB and foreign banks, but all improve afterward especially private banks

Increased efficiency under the revenue based approach is observed in domestically owned banks (state, private and regional development banks), but the opposite is observed for foreign owned banks (joint-ventures and foreign banks). These findings demonstrate the sensitivity of the results to the method by which efficiency is measured. More importantly, economies of scale are suggested as improving bank technical efficiency, given the high efficiency scores for larger banks.

8.2.2 Decomposing Productivity Growth in the Indonesian Banking Sector

The measure of productivity growth (TFP) based on the bootstrap Malmquist productivity index described in Chapter 6 reveals that, in general, the industry exhibits productivity growth under both, intermediation based and revenue based models. The overall mean TFP indices reveal that productivity in the banking industry improves under both approaches. Moreover, the industry appears to achieve higher productivity growth under the revenue based approach than under the intermediation based approach. Although it is difficult to draw specific conclusions regarding the effects of regulatory changes, smaller fluctuations in TFP toward the end of the period may imply an improvement.

Productivity growth under the intermediation based approach is driven by improvements in technology, while efficiency, by contrast, declines. Under the revenue based approach, although both components contribute positively, technological change slightly dominates efficiency changes. This suggests that advances in banking technology outweigh improvements in managerial practices. Furthermore, the decomposition of technological change shows that, under the intermediation based approach, the scale of technology is the main contributor to technological progress. Under the revenue based approach, all additional components positively contribute either to efficiency changes or to technological change. An analysis of the five bank groups reveals that all groups exhibit significant fluctuations in performance from the beginning of the period through 2000/2001, especially around the period of the 1997 AFC.

Further analysis of the five bank groups reveals that all banks, except foreign banks, exhibit productivity growth under the intermediation based approach and that all banks, except regional development banks, exhibit productivity growth under the revenue based approach. Unstable economic conditions during the 1997 AFC are associated with large fluctuations in mean TFP indices in all bank groups through 2000/2001. Although joint-ventures and state banks are the groups that gain the most in productivity in both models, the main contributor to productivity growth for most groups is technological change.

Similarly, analysis in terms bank size reveals that all size categories experienced positive productivity change over the period considered. However, unlike the efficiency result, there is no evidence that bank productivity growth is associated with bank size. Medium sized banks are found to achieve the highest productivity gains under both models, and small banks consistently have the lowest product ivy growth.

8.2.3 Determinants of Bank Efficiency and Productivity

The third analysis in Chapter 7 seeks to identify the determinants of bank efficiency and productivity growth. A Tobit regression shows positive and significant effects of macroeconomic variables, bank size and ownership structure (except in the case of private banks) on technical efficiency. With regard to size and ownership structure, these findings are consistent with the estimated results for the technical efficiency of bank groups and size obtained in the first empirical analysis. Regulatory changes are positively correlated with technical efficiency, but the relationship is only significant under the revenue based approach. This result suggests that regulatory changes can improve bank efficiency in terms of revenue generation. Market concentration is statistically significant, but an ambiguous relationship across models is apparent. Under the intermediation based approach, market concentration has a negative effect on efficiency, both in the short and long term, but under the revenue-based approach, the effect is the opposite.

Bank status and bank restructuring are mostly not statistically significant at the aggregate industry level. However, further analysis shows a positive and significant effect of bank restructuring (merger) on private banks, suggesting that merged banks tend to be more efficient than non-merged banks. A negative effect of this variable emerges among state banks. Bank status (listing and foreign exchange operations) does not appear to have any meaningful correlation with technical efficiency.

Estimations in which productivity index (TFP) is the dependent variable produce dissimilar findings. Most variables are not statistically significant at the aggregate banking industry level and some variables even showing the opposite signs from those indicated in the technical efficiency results. Under the intermediation approach, some significant variables, including ROA and regulatory change over the long term, have negative signs, but under the revenue approach, positive effects are found for foreign banks, regulatory change and market concentration.

8.3 Policy Implications

Based on these findings, this study proposes several policy recommendations. First, we find that the main contributors to the poor technical efficiency of the Indonesian banking industry are small and medium-sized banks, which are most prevalent in the private and regional development banking sectors. Additionally, a Tobit regression indicates positive and significant effects of bank size on technical efficiency along with bank restructuring among private banks. As the industry has been dominated by private banks in term of numbers, the poor performance of such banks is strongly reflected in overall industry performance. This suggests that the government could be more strategic in its formulation of policies, which might include encouraging consolidation across private banks to achieve economies of scale.

With regard to the poor performance of regional development banks, the Indonesian central bank (BI) may need to work more closely with stakeholders and focus more attention on such banks. This would include close monitoring and supervision of the operations of local banks. Improvements in RDB performance are crucial to local economic growth, which in turn would boost the national economy.

Second, this study finds that regulatory changes contribute positively to bank efficiency and productivity growth, but the effects are statistically significant only under the revenue based efficiency. This finding suggests that the government should continue to introduce regulatory changes that promote bank efficiency and productivity growth.

8.4 Limitations and the Focus of Future Research

Despite the empirical findings and important insights this study provides to researchers and policy makers in Indonesia, the study has some limitations that should be considered in interpreting the results and in conducting further research. First, the data used in this study are gathered from secondary sources collected from banks' annual financial reports published by the BI (Indonesian central bank). As the data come from accounting reports, they are subject to measurement and allocation errors that may affect the results. In addition, changes in accounting standards and procedures mandated by BI during the period analysed may create distortions that in turn may bias the results.

Second, the empirical analysis covers only established and surviving banks during the 1993-2011 period. "Non-surviving" banks that existed at the beginning, but were liquidated or closed before the end of the period of study are excluded. Given the large number of bank closures following the 1997 crisis, estimation results for the period before the crisis must be interpreted with caution, owing to the relatively small sample of banks available. In addition, banks newly established within the period are omitted. Although the number of such banks is relatively small, newly established banks could potentially contribute updated technology and advanced managerial skills to the industry. Thus, this omission may exclude some important information.

Third, regulatory change is represented solely by a dummy variable, which limits the analysis of the result and possibly might not fully capture the full effect of the regulatory change. Therefore, it is noteworthy for future research to incorporate a more proper proxy or a continuous measure to capture regulatory change.

Fourth, as restructuring includes bank acquisitions, which occurred frequently following the crisis as part of the restructuring effort, it might be valuable to include acquisitions, along with merger variables in the second stage of the analysis. However, due to the unavailability of relevant data, this variable could not be included.

Finally, it might be valuable to estimate efficiency and productivity using the truncated regression model proposed by Simar and Wilson (2007), thus enabling a consistent bootstrapping methodology. Similarly, meta-frontier method is worth consideration to examine efficiency and productivity across bank groups, which may provide an insightful analysis.

Despite these limitations, the present study makes valuable contributions to the empirical literature, especially with respect to developing countries, where banking reforms are ongoing. The relatively long time period covered and the statistical inferences obtained with respect to efficiency and productivity growth distinguish this study from previous empirical studies. Additionally, this thesis makes a significant effort to analyse efficiency and productivity growth both at the aggregate industry level and that of individual bank groups. Finally, the analysis of the effect of bank regulatory reform and other determinants of bank efficiency and productivity at the bank group level provides insights that are relevant to Indonesian banking policy.

Appendices

Appendix to Chapter 2

Appendix Table 2.1: Selected Sequence of Regulation and Financial Reforms

Year		Event(s)
1967		Reopening of market to a limited number of foreign banks after bank nationalizations era.
	December	The first Banking Act (No. 14 of 1967) launched
1968	December	The first Central Bank Act (No 13 of 1968) launched
1974		Limit the maximum annual loan and offshore borrowing by each bank and required state-owned firm to keep their fund in state owned banks.
	April	Payment of interest on banks' excess reserves
1977	December	- Cut in the required reserve ratio from 30% to 15% - Cut in excess reserve interest rate from 10% p.a. to 6%
1982	August	Withdrawal of BI refinance for lower priority state bank loans
1983	March	Devalued rupiah (IDR) by 28%
	May	Interest rate on state banks' 6 month time deposit rate freed
	June	*PAKJUN* launched: - Removed control of remaining deposit interest rate and lending rate on state banks - Removed control on credit ceilings for all banks - Discontinued most loan programs relying on subsidized funds from BI
1984	February	Introduced *Sertifikat Bank Indonesia-SBI* (Certificate of Bank Indonesia)
	September	Limit imposed on interbank borrowing 7.5% of total funds
1985	February	Introduced money market securities (Surat Berharga Pasar Uang-SBPU)
1986	September	Devalued rupiah by 31% and removal of banks' foreign swap limit
1987	June	Instructed four large state enterprises to transfer their funds in state banks to SBIs and banks have to buy back their SBPU from BI
	July	Initiated managed auction system for issuing SBIs and SBPUs
1996	August	Interbank borrowing limit increased to 15%
1988	October	*PAKTO* launched - Opening of market to new domestic banks and new joint venture banks - Eased to allow domestic banks branch to open and allow foreign bank branches to open sub-branch office in seven major cities - Eased to open rural banks - Eased the requirement for domestic banks to become foreign exchange banks and allowed all foreign exchange banks branch to deal in foreign exchange - Permitted state and local government enterprises to put their deposit fund maximum 50 % outside state banks - Lowered banks' required reserved ratio from 15% to 2% - Imposition of 15% income tax on deposit interest with the possibility of tax restitution - Removed limitation on interbank borrowing - Allowed non-bank financial institution to issue certificate of deposit - Introduced the stipulation of the maximum percentage of legal lending limit - Banks permitted to increase capital through issuance of new shares in the capital market. - Allowed banks to introduce saving products of their own design
	December	*PAKDES*, Regulation on establishment of multi-finance companies empowered to engage in leasing, factoring, venture capital, credit card

Year		Event(s)
		corporation and consumer credits.
1989	March	- Removal of controls on banks' borrowing Overseas - Extended prudential standards to cover limits on foreign exchange exposure ('net open position')
	April	State saving bank permitted to accept checking deposit
	May	- Introduced net open position (NOP) of foreign exchange for all foreign exchange banks at 26% of their capital - Foreign exchange domestic banks permitted to borrow offshore - Limited swap transactions of foreign bank branches with BI
	September	Foreign investor allowed to purchase stock in the primary market (up to 49%) except stock issued by private banks
	December	- Introduced tax exemption for the maximum balance (RP 5 million) of a savings deposit within 1 month - Allowed banks to develop their saving scheme
1990	January	- Most remaining subsidized loan programs discontinued except for four categories; for small farmers, cooperatives, food and sugar procurement and investment. - Required all domestic banks to allocate minimum 20% of their total credit to small scale enterprises. - Allowed joint venture and foreign banks to operate in Batam island
1991	February	- Required 12 large state enterprises to transfer their deposit in state banks to 1 year SBIs, BI bought various maturities SBPUs from affected banks by75% of their deposit loses Prudential Banking regulation improved by: - Required CAR to be gradually increased: 5%, 7% and 8% by the end of March 1992, March 1993 and December 1993 respectively. - Required minimum standard for banks' owner, board of commissioners and board of directors - Lowered NOP from 25% to 20% of the bank's capital - Required for banks to hold reserves allowance to cover for all classified assets - Improved the requirement to open sub-branch offices by imposing subject to bank soundness - Domestic banks allowed to open offshore branches and invest in equity participation in foreign financial institutions - Lowered maximum bank swap to BI from 25% to 20% of the capital. BI lending to banks begins to rebound after falling significantly
	November	Re-imposition of controls on banks' borrowing overseas
1992	February	Distinctions between 'development', 'savings' and 'general' banks removed
	March	Announced of the new Banking Act No 7 of 1992 (This new banking act gives the government the option of treating all banks as 'agent of development')
	October	Increased minimum paid-up capital for opening new banks from IDR 10 billion to IDR 50 billion and for joint venture increased from Rp 50 billion to 100 billion
1993	February	- Foreigners allowed to buy commercial banks' share listed on the stock exchange - State banks permitted to list on the stock exchanges at the maximum listed share 46 % of total share issues
	May	- Lowered the requirement of reserve allowance from 1% to 0.5% of total earning assets - Allowed profit from the previous year to be calculated as capital component. - Imposed gradual reduction of existing credit from 50 % to 35% of capital by December 1996 and 20% by December 1997, new credit

Year		Event(s)
		was a maximum 20% of capital - Commenced a serious examination of the bad loans at state banks
	December	Expanded the spread of bank notes transaction from IDR 2 to IDR 3 of BI's rate
1994	January	BI stopped issuing indicative foreign exchange rates
	September	- Widened the spread of spot exchange transaction with BI from IDR 20 (1%) to IDR 30 (1.5%) - Expanded the spread of transaction of bank notes from Rp 3 to Rp 5 of BI rates - Increased overall NOP from 20% to 25% of capital and removed the NOP for per currency
1995	January	Re-imposition of *de facto* controls on bank lending by the enactment of regulation on legal lending limit
	August	Extension of central bank controls to bank involvement with commercial paper issues
	December	Extension of central bank supervisory authority to non-bank finance companies
1996	February	Increased the required reserve ratio from 2% to 3%, and exclusion of cash from the definition of 'reserves'
	June	- Tightened of licensing of new bank branches - Expanded the intervention bands from 3% to 5%
	July	Issued Yankee Bond on the New York market
	September	- Increased reserve requirement from 3% to 5%, which will be effective on April 1997 - Expanded the intervention band from 5% to 8%
1997	March	- Reduced legal lending limit for group debtor and connected debtor to 20% and 10% respectively - Required bank's offshore borrowing minimum 80% has to be used to finance export credit.
1998	January	As part of Letter of Intent with the IMF : - Blanket guarantee scheme introduced to guarantee deposits in domestic banks - IBRA (Indonesian Bank Restructuring Agency) established.
	November	- New Banking Act No. 10/1998 introduced as a revised and replaced of Law No. 7/1992 - Reduced 'temporarily' minimum CAR from 8% to 4%
	December	Legal Lending Limit for commercial bank
1999	May	New Bank Indonesia Act no 23 of 1999 announced
2001	December	Amended the regulation by requiring all commercial banks to meet minimum CAR of 8% by the end 0f 2001
2004	January	- Introduced *Arsitektur Perbankan Indonesia*-API (Indonesian Banking Architecture) - The amendment of the 1999 Bank Indonesia Act
	September	IDIC establishment (Law No 24 of 2004) as a new scheme for deposit insurance
2008	July	Sharia Banking Law No. 21 of 2008 launched
2011	November	Launched Law No. 21 of 2011 regarding the establishment of Financial Service Authority (FSA)

Source: Authors' compilation from McLeod (1999), Astiyah (2001) and Annual report of Bank Indonesia various editions.

Appendix to Chapter 6

Appendix Table 6.1: Decomposition of Efficiency Index by Bank Group, 1993-2011 (Model A)

Year	Efficiency Index (EC)									
	Pure Efficiency (PE)					Scale Efficiency (SE)				
	SOB	**PNB**	**RDB**	**JVB**	**FB**	**SOB**	**PNB**	**RDB**	**JVB**	**FB**
1993-94	1.0260	0.8148	0.8948	1.1517	1.1924	0.8461	0.9003	1.0438	0.9368	0.8411
	(0.0270)	(0.0380)	(0.1295)	(0.1138)	(0.1126)	(0.1202)	(0.0383)	(0.0426)	(0.0455)	(0.0553)
1994-95	0.9630	0.8760	0.7043	0.8863	0.8339	0.7689	0.8228	0.6722	0.9450	0.7610
	(0.0350)	(0.0366)	(0.0559)	(0.0595)	(0.1561)	(0.0394)	(0.0259)	(0.0463)	(0.0435)	(0.0543)
1995-96	1.0000	1.2649	1.1237	0.9582	0.9365	1.4570	1.4081	1.4516	1.0714	1.1656
	(0.0000)	(0.0668)	(0.1036)	(0.1077)	(0.1178)	(0.1855)	(0.0822)	(0.2370)	(0.1119)	(0.1111)
1996-97	1.0593	1.0304	1.1491	0.8854	1.1589	0.9033	0.7689	0.7871	0.9522	0.8919
	(0.0545)	(0.0670)	(0.2138)	(0.1062)	(0.2034)	(0.1182)	(0.0328)	(0.0705)	(0.0698)	(0.1170)
1997-98	1.2485	0.5760	0.6074	0.8989	0.6410	0.9207	0.7687	0.7892	0.9679	1.0929
	(0.2810)	(0.0322)	(0.0546)	(0.0787)	(0.0910)	(0.1664)	(0.0384)	(0.0411)	(0.0412)	(0.0800)
1998-99	0.8525	1.1761	1.2399	1.0563	0.9973	3.3092	1.5806	1.5032	1.2052	1.0314
	(0.0918)	(0.0830)	(0.0903)	(0.1460)	(0.0560)	(0.9996)	(0.1066)	(0.1880)	(0.1386)	(0.0936)
1999-00	1.1216	1.1418	1.0796	0.9999	1.0021	0.7478	0.7640	0.7582	0.9366	1.0543
	(0.1456)	(0.0723)	(0.0657)	(0.0505)	(0.0763)	(0.2250)	(0.0490)	(0.0676)	(0.0343)	(0.0929)
2000-01	0.9284	1.1057	0.9045	1.2962	1.0454	0.8974	1.0323	0.8731	1.1742	0.9651
	(0.0642)	(0.0623)	(0.0452)	(0.1567)	(0.0598)	(0.2421)	(0.0396)	(0.0357)	(0.1524)	(0.0879)
2001-02	0.9276	0.8788	0.9349	0.8341	0.9720	1.0187	1.0091	1.0243	0.9668	1.0892
	(0.0649)	(0.0458)	(0.0428)	(0.0616)	(0.0703)	(0.1032)	(0.0695)	(0.0418)	(0.1348)	(0.1003)
2002-03	1.0183	1.0194	0.9383	1.0399	0.9408	0.9799	1.1534	1.2630	1.1441	1.0795
	(0.0189)	(0.0301)	(0.0398)	(0.1794)	(0.0514)	(0.0595)	(0.1013)	(0.0441)	(0.1571)	(0.0627)
2003-04	0.9685	0.8853	0.8936	0.7922	1.0191	0.5618	0.8420	1.0682	0.7412	0.7950
	(0.0346)	(0.0416)	(0.0369)	(0.0857)	(0.0495)	(0.1394)	(0.0552)	(0.0575)	(0.0792)	(0.0923)
2004-05	1.0374	0.9277	0.9546	1.0496	1.0142	0.6205	0.7360	0.7447	0.9248	0.9033
	(0.0451)	(0.0350)	(0.0299)	(0.0420)	(0.0571)	(0.0517)	(0.0252)	(0.0232)	(0.0599)	(0.0496)
2005-06	0.9455	1.0358	0.9024	1.0321	0.9517	1.1946	1.0564	1.0395	1.0579	0.9657
	(0.0502)	(0.0274)	(0.0243)	(0.0910)	(0.0622)	(0.1150)	(0.0185)	(0.0295)	(0.0461)	(0.0382)
2006-07	0.9889	0.9762	1.0651	0.9045	0.9688	1.0426	1.0758	1.0916	1.0604	0.9785
	(0.0461)	(0.0183)	(0.0350)	(0.0438)	(0.0333)	(0.0185)	(0.0287)	(0.0303)	(0.0318)	(0.0396)
2007-08	1.0474	1.3497	1.3027	1.2706	1.0050	1.3435	1.0835	1.0975	1.0956	1.2024
	(0.0457)	(0.0411)	(0.0588)	(0.1501)	(0.0295)	(0.0537)	(0.0356)	(0.0447)	(0.0594)	(0.0709)
2008-09	1.0229	1.0815	1.3183	1.1144	0.9833	1.0361	0.9988	0.9434	1.0290	0.9797
	(0.0820)	(0.0439)	(0.0970)	(0.0752)	(0.0492)	(0.0477)	(0.0283)	(0.0292)	(0.0316)	(0.0563)
2009-10	0.8981	0.8767	0.8015	0.8834	1.0416	0.8422	1.0503	1.1127	0.9951	0.9433
	(0.0439)	(0.0214)	(0.0295)	(0.0512)	(0.0661)	(0.0664)	(0.0330)	(0.0339)	(0.0972)	(0.0473)
2010-11	1.0551	0.9298	1.0363	1.0418	0.9285	0.8785	0.9436	0.8796	0.9666	0.8801
	(0.0598)	(0.0386)	(0.0402)	(0.0551)	(0.0336)	(0.0649)	(0.0285)	(0.0259)	(0.0395)	(0.0412)
Mean	**1.0025**	**0.9807**	**0.9733**	**0.9963**	**0.9722**	**0.9864**	**0.9785**	**0.9838**	**1.0037**	**0.9716**

Sources: Author's calculations. Note: SOB, PNB, RDB, JVB and FB are state owned banks, private national banks, regional development banks, joint venture banks and foreign banks, respectively. The standard errors are in the parentheses.

Appendix Table 6.2: Decomposition of Efficiency Index by Bank Group, 1993-2011 (Model A)

Year	Technological Index (TC)									
	Pure Technology (PT)					Scale of Technology (ST)				
	SOB	PNB	RDB	JVB	FB	SOB	PNB	RDB	JVB	FB
1993-94	1.1265	1.3097	1.2243	0.9274	0.8099	1.2722	0.9962	0.9622	1.0638	1.2057
	NA	(0.0349)	(0.0521)	(0.0700)	(0.0237)	NA	(0.0372)	(0.0544)	(0.0922)	(0.0812)
1994-95	1.1238	1.4571	1.6496	1.7422	1.1477	1.2739	1.1040	1.2664	1.0961	1.3859
	(0.1042)	(0.0319)	(0.0775)	(0.3495)	(0.0823)	(0.1359)	(0.0337)	(0.1472)	(0.0698)	(0.1998)
1995-96	1.0982	0.8529	0.9161	0.9868	1.2037	0.6199	0.6660	0.6618	0.9096	0.8770
	(0.0005)	(0.0370)	(0.0986)	(0.09998)	(0.1757)	(0.2924)	(0.0247)	(0.0474)	(0.0607)	(0.0939)
1996-97	0.5562	0.9142	0.9228	0.7933	0.4307	1.8069	1.3464	1.2986	1.1332	1.2346
	(0.2650)	(0.0432)	(0.0669)	(0.1064)	(0.0903)	(0.4272)	(0.0860)	(0.1766)	(0.1547)	(0.1027)
1997-98	1.3308	1.2058	1.2419	1.1229	1.8810	0.7983	1.3468	1.3355	1.0385	0.8605
	(0.3402)	(0.0547)	(0.0559)	(0.0445)	(0.5572)	(0.1586)	(0.0488)	(0.0699)	(0.0251)	(0.0486)
1998-99	3.9586	0.7780	0.7174	1.0646	0.9691	0.1263	0.6422	0.6860	0.7447	0.8976
	NA	(0.0472)	(0.0720)	(0.1291)	(0.0945)	NA	(0.0246)	(0.0334)	(0.0944)	(0.0950)
1999-00	1.0173	1.0114	0.9843	1.1673	0.9555	1.6912	1.3583	1.2531	1.0748	1.0537
	(0.3775)	(0.0536)	(0.0218)	(0.2171)	(0.0715)	(1.1331)	(0.0683)	(0.0547)	(0.0841)	(0.0926)
2000-01	0.9782	0.9610	0.9905	0.8609	1.0265	0.9291	1.0366	1.1065	0.9719	0.9159
	(0.1849)	(0.0244)	(0.0180)	(0.0685)	(0.0559)	(0.2409)	(0.0263)	(0.0214)	(0.0670)	(0.0671)
2001-02	0.9657	1.0653	1.1579	1.1958	1.4130	1.1887	1.0764	0.9729	1.0079	0.8514
	(0.0894)	(0.0295)	(0.0249)	(0.0663)	(0.1909)	(0.0981)	(0.0278)	(0.0205)	(0.0483)	(0.0371)
2002-03	0.8281	1.0313	1.1310	1.1260	1.0801	1.1420	0.9242	0.8339	0.8953	0.9198
	(0.0156)	(0.0167)	(0.0305)	(0.0437)	(0.0652)	(0.0340)	(0.0127)	(0.0208)	(0.0347)	(0.0613)
2003-04	0.8777	1.1357	1.1210	1.2381	0.8796	1.9553	1.1874	0.9697	1.3096	1.2910
	(0.0602)	(0.0469)	(0.0421)	(0.1870)	(0.0709)	(0.5540)	(0.0949)	(0.0598)	(0.1513)	(0.1829)
2004-05	0.8561	1.0853	0.9873	0.9137	0.9648	1.7164	1.3818	1.3468	1.1399	1.0789
	(0.0791)	(0.0563)	(0.0188)	(0.0456)	(0.1308)	(0.1632)	(0.0606)	(0.0446)	(0.1058)	(0.0760)
2005-06	0.9502	0.9141	0.9843	1.0404	1.0044	0.9031	0.9770	1.0348	0.9387	1.0173
	(0.1014)	(0.0150)	(0.0222)	(0.0245)	(0.0487)	(0.1370)	(0.0173)	(0.0346)	(0.0227)	(0.0317)
2006-07	0.9854	0.9557	1.0999	1.0459	0.9974	0.9296	0.9188	0.8909	0.9551	1.0738
	(0.0216)	(0.0210)	(0.0374)	(0.0300)	(0.0524)	(0.1239)	(0.0197)	(0.0252)	(0.0278)	(0.0711)
2007-08	0.8279	0.7643	0.8928	0.7774	0.9077	0.7996	0.9058	0.8426	0.9360	0.8560
	(0.1540)	(0.0173)	(0.0415)	(0.0291)	(0.0747)	(0.1260)	(0.0179)	(0.0289)	(0.0193)	(0.0625)
2008-09	0.9729	0.9087	0.8404	0.9064	0.8717	0.9699	1.0280	1.0448	1.0903	1.0572
	(0.0587)	(0.0197)	(0.0319)	(0.0559)	(0.0672)	(0.0018)	(0.0200)	(0.0310)	(0.0484)	(0.0822)
2009-10	0.9268	1.0684	1.1361	1.0474	0.9283	1.1386	0.9846	0.9292	0.9407	1.0656
	(0.0993)	(0.0238)	(0.0270)	(0.0321)	(0.0896)	(0.1544)	(0.0166)	(0.0205)	(0.0196)	(0.1233)
2010-11	0.8966	1.0619	0.9653	0.9150	0.9266	1.1131	1.0650	1.1605	1.0505	1.1746
	(0.1126)	(0.0507)	(0.0262)	(0.0774)	(0.0958)	(0.2114)	(0.0264)	(0.0256)	(0.0263)	(0.0484)
Mean	**1.0238**	**1.0131**	**1.0367**	**1.0299**	**0.9849**	**1.0044**	**1.0305**	**1.0117**	**1.0094**	**1.0338**

Sources: Author's calculations. Note: SOB, PNB, RDB, JVB and FB are state owned banks, private national banks, regional development banks, joint venture banks and foreign banks, respectively. The standard errors are in the parentheses. NA: Not available because only one bank feasible to compute.

Appendix Table 6.3: Decomposition of Efficiency Index by Bank Group, 1993-2011 (Model B)

Year	Efficiency Index (EC)									
	Pure Efficiency (PE)					Scale Efficiency (SE)				
	SOB	**PNB**	**RDB**	**JVB**	**FB**	**SOB**	**PNB**	**RDB**	**JVB**	**FB**
1993-94	0.9985	0.9819	0.9628	1.0511	1.0161	1.0056	1.0328	1.0134	0.9510	0.9459
	(0.0015)	(0.0194)	(0.0230)	(0.0141)	(0.0319)	(0.0530)	(0.0265)	(0.0272)	(0.0256)	(0.0285)
1994-95	1.0000	1.0801	0.9646	1.0379	1.0092	1.0344	0.9235	0.9041	1.0029	0.9771
	(0.0000)	(0.0480)	(0.0311)	(0.0449)	(0.0338)	(0.0541)	(0.0260)	(0.0185)	(0.0233)	(0.0314)
1995-96	1.0040	0.9288	0.9895	0.9980	0.9940	0.9219	0.9909	1.0075	0.9747	0.9760
	(0.0041)	(0.0203)	(0.0167)	(0.0389)	(0.0294)	(0.0541)	(0.0139)	(0.0075)	(0.0121)	(0.0131)
1996-97	0.9960	0.9981	1.1230	1.1750	1.1636	1.1879	0.9856	1.0362	1.0306	1.0626
	(0.0040)	(0.0278)	(0.0258)	(0.1007)	(0.0509)	(0.2064)	(0.0082)	(0.0292)	(0.0200)	(0.0367)
1997-98	1.5692	1.2118	1.1712	1.7859	0.8877	2.7260	1.1851	1.0730	0.9752	1.1380
	(1.2657)	(0.1622)	(0.0645)	(0.6233)	(0.0943)	(4.4203)	(0.1192)	(0.0321)	(0.0189)	(0.1225)
1998/-99	1.9718	1.3252	1.3973	0.7616	1.3129	0.6640	0.9276	0.9021	1.0266	1.0130
	(2.9144)	(0.1100)	(0.1744)	(0.1089)	(0.4422)	(1.3026)	(0.0405)	(0.0213)	(0.0172)	(0.0414)
1999-00	0.3774	0.7608	0.6449	0.5475	0.7871	0.5932	0.9616	1.0752	1.0036	0.9181
	(0.1963)	(0.0413)	(0.0593)	(0.0951)	(0.1688)	(0.1534)	(0.0281)	(0.0355)	(0.0204)	(0.0485)
2000-01	0.9247	0.9543	1.0496	1.0099	0.9904	0.7598	0.9642	0.9669	1.0066	0.9637
	(0.0672)	(0.0283)	(0.0539)	(0.0593)	(0.0644)	(0.0563)	(0.0125)	(0.0182)	(0.0192)	(0.0311)
2001-02	1.0013	0.9827	1.0033	1.3329	1.4146	0.9315	0.9696	0.9307	0.9772	0.9663
	(0.0087)	(0.0327)	(0.0353)	(0.1828)	(0.1696)	(0.0269)	(0.0099)	(0.0203)	(0.0212)	(0.1111)
2002-03	1.0420	1.8549	3.0883	1.3753	0.9041	2.1779	1.6193	1.2541	1.1245	1.1446
	(0.0414)	(0.1218)	(0.2075)	(0.3114)	(0.1062)	(0.5032)	(0.1281)	(0.0872)	(0.0606)	(0.0439)
2003-04	1.0041	1.2596	1.3392	1.4062	1.1293	1.5468	1.2726	1.1222	1.0415	1.0287
	(0.0171)	(0.1961)	(0.0591)	(0.1353)	(0.0860)	(0.2180)	(0.0599)	(0.0593)	(0.0378)	(0.1422)
2004-05	0.9755	0.4797	0.2505	0.4113	0.7283	0.4163	0.5685	0.7428	0.9116	0.9447
	(0.0800)	(0.0443)	(0.0444)	(0.0705)	(0.2602)	(0.0953)	(0.0403)	(0.0418)	(0.0611)	(0.1377)
2005-06	0.9516	0.9190	0.9168	1.1027	0.8328	0.9494	0.9487	1.0370	0.9832	1.0345
	(0.0336)	(0.0147)	(0.0308)	(0.0856)	(0.0855)	(0.0657)	(0.0112)	(0.0143)	(0.0319)	(0.0794)
2006-07	1.0059	0.9960	0.9915	0.9793	0.9790	0.9777	0.9948	0.9706	0.9716	0.9422
	(0.0059)	(0.0121)	(0.0128)	(0.0577)	(0.0170)	(0.0428)	(0.0058)	(0.0072)	(0.0225)	(0.0724)
2007-08	1.0143	1.0673	0.8864	0.9421	1.0794	0.8709	0.8964	1.0310	1.0573	1.0884
	(0.0356)	(0.0271)	(0.0157)	(0.0972)	(0.0860)	(0.0559)	(0.0168)	(0.0128)	(0.0314)	(0.0399)
2008-09	0.9915	1.1054	0.9452	1.0950	1.0375	1.3062	1.1684	1.2163	1.1626	0.9642
	(0.0151)	(0.0248)	(0.0256)	(0.0573)	(0.0240)	(0.0651)	(0.0248)	(0.0264)	(0.0501)	(0.0424)
2009-10	1.0048	1.0018	0.9842	0.9511	0.9677	1.0258	1.0488	1.1295	0.9825	1.0391
	(0.0319)	(0.0282)	(0.0246)	(0.0509)	(0.0410)	(0.0122)	(0.0179)	(0.0230)	(0.0311)	(0.0442)
2010-11	0.9725	0.7638	0.9873	0.9088	0.9626	0.7353	0.8967	0.8429	0.9237	0.8590
	(0.0279)	(0.0257)	(0.0307)	(0.0496)	(0.0326)	(0.0520)	(0.0247)	(0.0210)	(0.0562)	(0.0479)
Mean	**1.0020**	**1.0024**	**0.9929**	**0.9990**	**0.9980**	**0.9981**	**1.0001**	**1.0066**	**1.0041**	**0.9977**

Sources: Author's calculations. Note: SOB, PNB, RDB, JVB and FB are state owned banks, private national banks, regional development banks, joint venture banks and foreign banks, respectively. The standard errors are in the parentheses.

Appendix Table 6.4: Decomposition of Technological Index, by Bank Group, 1993-2011 (Model B)

Year	Technological Index (TC)									
	Pure Technology (PT)					Scale of Technology (ST)				
	SOB	**PNB**	**RDB**	**JVB**	**FB**	**SOB**	**PNB**	**RDB**	**JVB**	**FB**
1993-94	0.9540	1.0665	1.0185	0.9845	0.8691	1.0490	0.9372	0.9882	1.0259	1.1856
	(0.0613)	(0.0499)	(0.0280)	(0.0108)	(0.0614)	(0.0683)	(0.0190)	(0.0181)	(0.0110)	(0.1808)
1994-95	0.9423	0.9422	0.9564	0.8359	0.9104	0.9990	1.0557	1.0819	1.0327	0.9890
	NA	(0.0113)	(0.0104)	(0.0235)	(0.0256)	NA	(0.0110)	(0.0176)	(0.0190)	(0.0216)
1995-96	0.9914	1.0058	1.0152	1.0309	0.9650	1.0108	0.9827	0.9928	1.0299	1.0895
	NA	(0.0075)	(0.0132)	(0.0502)	(0.0287)	NA	(0.0070)	(0.0096)	(0.0126)	(0.0549)
1996-97	INF	1.0591	0.9423	0.8901	0.6688	INF	1.0178	0.9701	1.0046	0.9277
	NA	(0.0096)	(0.0181)	(0.0857)	(0.0728)	NA	(0.0058)	(0.0172)	(0.0317)	(0.0244)
1997-98	1.9660	0.8628	0.8769	1.1134	1.2797	0.5206	0.8630	0.9305	1.0475	1.0761
	(0.1367)	(0.0414)	(0.0257)	(0.1251)	(0.1697)	(0.1296)	(0.0234)	(0.0264)	(0.0262)	(0.0560)
1998/-99	0.9736	0.6632	0.7717	0.7710	0.8736	0.7432	1.1247	1.1373	0.9789	0.7462
	(0.0299)	(0.0247)	(0.0269)	(0.0972)	(0.1177)	(0.0950)	(0.0450)	(0.0324)	(0.0135)	(0.0618)
1999-00	1.1929	1.2709	1.1922	1.3316	1.6479	1.1877	1.0313	0.9358	0.9535	0.8880
	(0.4390)	(0.0482)	(0.0530)	(0.0613)	(0.4515)	(0.4100)	(0.0212)	(0.0226)	(0.0248)	(0.0685)
2000-01	0.8771	0.9686	0.8324	1.0657	0.9009	1.1390	1.0303	1.0252	0.9944	1.1387
	(0.0489)	(0.0147)	(0.0260)	(0.0714)	(0.0564)	(0.0203)	(0.0161)	(0.0328)	(0.0266)	(0.0871)
2001-02	0.9628	1.0335	0.9566	0.7488	0.4937	1.1180	1.0342	1.0827	1.0133	1.0160
	(0.0243)	(0.0143)	(0.0372)	(0.0929)	(0.1033)	(0.0350)	(0.0131)	(0.0478)	(0.0105)	(0.0884)
2002-03	0.8741	0.5550	0.3578	0.6608	1.2370	0.5240	0.6441	0.7953	0.9068	0.8575
	(0.0156)	(0.0291)	(0.0451)	(0.1587)	(0.2342)	(0.0898)	(0.0273)	(0.0345)	(0.0429)	(0.0395)
2003-04	0.8983	0.8761	0.7910	0.7979	0.6582	0.8506	0.8146	0.8713	0.9675	1.2854
	(0.1592)	(0.0314)	(0.0492)	(0.0325)	(0.0704)	(0.1549)	(0.0240)	(0.0304)	(0.0333)	(0.3953)
2004-05	1.2408	2.2606	4.3936	2.5306	2.7800	3.5228	1.7950	1.3124	1.0850	1.0663
	(0.0181)	(0.1786)	(0.2886)	(0.4622)	(3.3407)	(0.6115)	(0.1842)	(0.1097)	(0.1019)	(0.2658)
2005-06	0.9902	0.9705	1.0401	1.0101	0.8777	1.0507	1.0754	0.9830	1.0003	1.0148
	(0.0384)	(0.0118)	(0.0148)	(0.0251)	(0.0714)	(0.0469)	(0.0103)	(0.0076)	(0.0194)	(0.0719)
2006-07	1.0862	1.0446	1.0445	1.0507	1.1429	0.9497	0.9998	1.0316	1.0199	0.9677
	NA	(0.0073)	(0.0094)	(0.0157)	(0.1793)	NA	(0.0059)	(0.0109)	(0.0166)	(0.0870)
2007-08	0.9344	0.9979	1.1162	1.0231	0.8836	1.1575	1.0867	0.9612	0.9750	0.8957
	(0.0737)	(0.0212)	(0.0097)	(0.0491)	(0.0640)	(0.0521)	(0.0198)	(0.0094)	(0.0229)	(0.0326)
2008-09	0.9682	0.8975	1.0585	0.8831	0.8043	0.7617	0.8631	0.8286	0.8528	1.0264
	(0.0208)	(0.0302)	(0.0217)	(0.0500)	(0.0566)	(0.0577)	(0.0158)	(0.0161)	(0.0384)	(0.0659)
2009-10	1.1428	1.1062	0.9812	1.0869	1.0013	0.9247	0.9266	0.9063	1.0384	1.2175
	(0.1070)	(0.0282)	(0.0164)	(0.0671)	(0.1490)	(0.0505)	(0.0123)	(0.0189)	(0.0886)	(0.3221)
2010-11	0.9834	1.2730	1.0892	1.1693	1.4194	1.4353	1.1141	1.1724	1.1394	0.9091
	(0.0536)	(0.0302)	(0.0127)	(0.0605)	(0.8276)	(0.0729)	(0.0292)	(0.0317)	(0.0669)	(0.1554)
Mean	**1.0362**	**1.0051**	**1.0012**	**1.0063**	**0.9977**	**1.0075**	**1.0019**	**0.9931**	**1.0017**	**1.0077**

Sources: Author's calculations. Note: SOB, PNB, RDB, JVB and FB are state owned banks, private national banks, regional development banks, joint venture banks and foreign banks, respectively. The standard errors are in the parentheses. INF: Infeasible. (It could not be computed due to constraints imposed in the linear programming to estimate cross-period distance functions), NA: Not available.

Appendix Table 6.5: Decomposition of Efficiency Index and Technological Index by Size, 1993-2011 (Model A)

Year	Efficiency Index (EC)						Technological Index (TC)					
	Pure Efficiency (PE)			Scale Efficiency (SE)			Pure Technology (PT)			Scale of Technology (ST)		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
1993-94	1.0527	0.9817	0.8921	0.7531	0.7447	0.9497	Inf.	0.9867	1.2017	Inf	1.4461	0.9909
	(0.0540)	(0.0136)	(0.0465)	(0.1215)	(0.0739)	(0.0257)	NA	(0.0306)	(0.0310)	NA	(0.0415)	(0.0274)
1994-95	0.8681	0.9247	0.8224	0.7602	0.7943	0.7854	1.2503	1.1259	1.5179	1.2030	1.3407	1.1615
	(0.0694)	(0.0849)	(0.0314)	(0.0350)	(0.0827)	(0.0219)	(0.0176)	(0.1421)	(0.0505)	(0.0593)	(0.1678)	(0.0504)
1995-96	0.9102	0.8425	1.1947	1.6202	1.6131	1.3314	Inf.	1.1906	0.8935	Inf.	0.6073	0.7121
	(0.0820)	(0.0465)	(0.0512)	(0.1729)	(0.1852)	(0.0830)	NA	(0.0491)	(0.0407)	NA	(0.0786)	(0.0236)
1996-97	0.9956	1.3871	1.0217	0.9249	0.5955	0.8309	0.3796	0.4642	0.9178	1.9721	1.8701	1.2432
	(0.0121)	(0.1573)	(0.0763)	(0.0911)	(0.1240)	(0.0283)	(0.0297)	(0.0567)	(0.0338)	(0.2906)	(0.3752)	(0.0573)
1997-98	0.9589	0.6976	0.6196	0.8356	1.0125	0.8192	1.6489	1.5633	1.2266	0.7858	0.8822	1.2782
	(0.0745)	(0.1243)	(0.0290)	(0.1490)	(0.0640)	(0.0280)	(0.2120)	(0.1536)	(0.0657)	(0.1466)	(0.0348)	(0.0374)
1998/-99	0.9687	1.0365	1.1801	2.1126	1.5068	1.4695	1.1803	1.1737	0.7642	0.5245	0.5950	0.6902
	(0.0222)	(0.0996)	(0.0615)	(0.2966)	(0.4340)	(0.0894)	(0.3637)	(0.2635)	(0.0327)	(0.0634)	(0.1067)	(0.0206)
1999-00	1.2313	1.0383	1.1014	1.0705	0.9569	0.7524	1.8382	0.9235	1.0115	0.6825	1.2142	1.3200
	(0.4141)	(0.0889)	(0.0426)	(0.1404)	(0.1082)	(0.0320)	(0.2078)	(0.0507)	(0.0415)	(0.1193)	(0.1411)	(0.0480)
2000-01	1.0754	1.0395	1.0586	0.8486	1.0653	0.9890	0.9612	1.0331	0.9460	1.0322	0.9363	1.0597
	(0.1858)	(0.0472)	(0.0504)	(0.1269)	(0.1034)	(0.0279)	(0.0917)	(0.0423)	(0.0177)	(0.1266)	(0.0555)	(0.0169)
2001-02	0.7839	0.8415	0.9300	1.1443	1.0750	0.9849	1.0246	1.2900	1.0888	1.1038	0.9135	1.0529
	(0.1464)	(0.0429)	(0.0330)	(0.2664)	(0.0807)	(0.0435)	(0.0614)	(0.0835)	(0.0241)	(0.0689)	(0.0307)	(0.0218)
2002-03	0.9257	0.9831	1.0047	1.0968	1.1555	1.1747	0.9142	1.0868	1.0684	1.0256	0.9127	0.8904
	(0.0538)	(0.0201)	(0.0359)	(0.1114)	(0.0414)	(0.0787)	(0.0411)	(0.0365)	(0.0165)	(0.0519)	(0.0323)	(0.0120)
2003-04	0.9283	0.9571	0.8654	0.5845	0.7893	0.9385	0.8627	0.9986	1.1778	2.0416	1.3534	1.0437
	(0.0432)	(0.0297)	(0.0361)	(0.0931)	(0.0650)	(0.0443)	(0.0503)	(0.0318)	(0.0456)	(0.4140)	(0.1272)	(0.0487)
2004-05	1.0605	1.0903	0.8824	0.6683	0.7887	0.7697	0.8635	0.9044	1.1161	1.5703	1.2792	1.3141
	(0.0498)	(0.0363)	(0.0253)	(0.0501)	(0.0377)	(0.0208)	(0.0256)	(0.0522)	(0.0456)	(0.1095)	(0.0661)	(0.0504)
2005-06	0.9074	0.9513	1.0352	1.1417	1.0563	1.0226	0.9561	0.9841	0.9314	0.9595	0.9942	0.9928
	(0.0399)	(0.0324)	(0.0273)	(0.0483)	(0.0338)	(0.0105)	(0.0353)	(0.0178)	(0.0169)	(0.0500)	(0.0342)	(0.0110)
2006-07	0.9985	1.0017	0.9812	1.0190	1.0431	1.0998	0.9834	1.0646	0.9712	0.9882	0.9502	0.9004
	(0.0450)	(0.0327)	(0.0143)	(0.0291)	(0.0225)	(0.0296)	(0.0304)	(0.0310)	(0.0225)	(0.0597)	(0.0216)	(0.0194)
2007-08	1.0447	1.2312	1.4185	1.3279	1.1720	0.9998	0.8947	0.8888	0.7405	0.7750	0.8196	0.9696
	(0.0281)	(0.0523)	(0.0443)	(0.0431)	(0.0394)	(0.0278)	(0.0302)	(0.0376)	(0.0140)	(0.0333)	(0.0245)	(0.0112)
2008-09	0.9664	1.1188	1.2023	1.0809	1.0103	0.9388	0.9408	0.9182	0.8526	0.9952	1.0319	1.0604
	(0.0306)	(0.0788)	(0.0489)	(0.0491)	(0.0327)	(0.0192)	(0.0171)	(0.0331)	(0.0204)	(0.0209)	(0.0311)	(0.0226)
2009-10	0.9702	0.8057	0.8865	0.9054	1.1361	1.0325	0.9297	1.1071	1.0929	1.1047	0.9233	0.9711
	(0.0309)	(0.0306)	(0.0208)	(0.0355)	(0.0425)	(0.0279)	(0.0199)	(0.0296)	(0.0251)	(0.0315)	(0.0324)	(0.0141)
2010-11	1.1035	1.0828	0.8127	0.8757	0.8741	0.9968	0.8496	0.9131	1.2028	1.1893	1.1628	0.9960
	(0.0297)	(0.0323)	(0.0371)	(0.0412)	(0.0228)	(0.0270)	(0.0246)	(0.0209)	(0.0589)	(0.0356)	(0.0224)	(0.0235)
Mean	**0.9814**	**0.9889**	**0.9788**	**0.9937**	**0.9933**	**0.9781**	**0.9790**	**1.0091**	**1.0243**	**1.0563**	**1.0274**	**1.0204**

Sources: Author's calculations. The standard errors are in the parentheses. INF: Infeasible. (It could not be computed due to constraints imposed in the linear programming to estimate cross-period distance functions), NA: Not available.

Appendix Table 6.6: Decomposition of Efficiency Index and Technological Index by Size, 1993-2011 (Model B)

Year	Efficiency Index (EC)						Technological Index (TC)					
	Pure Efficiency (PE)			Scale Efficiency (SE)			Pure Technology (PT)			Scale of Technology (ST)		
	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small	Large	Medium	Small
1993-94	1.0000	0.9844	0.9871	1.0629	0.9730	1.0124	1.0783	0.9522	1.0280	0.9183	1.0450	0.9785
	(0.0000)	(0.0253)	(0.0133)	(0.0682)	(0.0246)	(0.0177)	NA	(0.0163)	(0.0309)	NA	(0.0207)	(0.0233)
1994-95	1.0000	0.9785	1.0426	0.9999	0.9834	0.9294	0.7033	0.9210	0.9352	1.1730	1.0401	1.0534
	(0.0000)	(0.1104)	(0.0302)	(0.0496)	(0.0977)	(0.0165)	NA	(0.1149)	(0.0084)	NA	(0.1337)	(0.0088)
1995-96	1.0000	0.9985	0.9542	0.9097	0.9587	0.9947	Inf.	0.9480	1.0115	Inf.	1.0826	0.9937
	(0.0000)	(0.0072)	(0.0140)	(0.0571)	(0.0310)	(0.0083)	NA	(0.0283)	(0.0080)	NA	(0.0718)	(0.0056)
1996-97	1.0070	1.0613	1.0615	1.0004	1.1256	1.0042	1.0509	0.8189	0.9844	1.0607	0.9901	0.9950
	(0.0071)	(0.0295)	(0.0239)	(0.0431)	(0.0738)	(0.0106)	NA	(0.0794)	(0.0159)	NA	(0.0236)	(0.0077)
1997-98	0.9865	1.2703	1.2908	4.3116	1.3903	1.0838	2.0048	1.1885	0.8828	0.4854	0.8842	0.9310
	(0.0132)	(0.3721)	(0.1328)	(3.2294)	(0.2591)	(0.0197)	(0.0876)	(0.1543)	(0.0244)	(0.0840)	(0.0733)	(0.0152)
1998/-99	1.7292	1.1576	1.2846	0.4714	0.9615	0.9665	0.9120	0.9854	0.6837	0.8210	0.7301	1.1362
	(1.9288)	(0.1761)	(0.0995)	(0.8928)	(0.0447)	(0.0236)	(0.0804)	(0.0575)	(0.0216)	(0.0961)	(0.0306)	(0.0290)
1999-00	0.5276	0.7290	0.6955	0.5904	0.8824	1.0287	0.9770	1.4124	1.2754	1.4148	1.0090	0.9669
	(0.1472)	(0.0802)	(0.0380)	(0.1039)	(0.0501)	(0.0185)	(0.3477)	(0.1233)	(0.0590)	(0.2842)	(0.0304)	(0.0136)
2000-01	1.0328	0.9465	0.9901	0.8279	0.9386	0.9815	0.8231	0.8955	0.9544	1.2258	1.1395	0.9955
	(0.0799)	(0.0500)	(0.0258)	(0.0407)	(0.0297)	(0.0082)	(0.0530)	(0.0352)	(0.0169)	(0.0893)	(0.0279)	(0.0131)
2001-02	1.0302	1.2157	1.0088	0.9322	0.8739	0.9898	0.9488	0.6628	1.0098	1.1281	1.1612	1.0035
	(0.0379)	(0.0912)	(0.0375)	(0.0228)	(0.0508)	(0.0049)	(0.0295)	(0.0577)	(0.0177)	(0.0338)	(0.0608)	(0.0048)
2002-03	0.9258	1.3872	2.2254	2.0584	1.3439	1.4107	0.8739	0.7612	0.4768	0.5849	0.7529	0.7198
	(0.0571)	(0.2658)	(0.1213)	(0.2604)	(0.1004)	(0.1014)	(0.0351)	(0.1258)	(0.0365)	(0.0796)	(0.0367)	(0.0245)
2003-04	1.0217	1.2808	1.3015	1.4594	1.2043	1.1619	0.9464	0.8489	0.8039	0.8520	0.9192	0.8688
	(0.0176)	(0.4326)	(0.0338)	(0.1179)	(0.1394)	(0.0260)	(0.0571)	(0.0793)	(0.0160)	(0.0572)	(0.1662)	(0.0146)
2004-05	0.9101	0.4306	0.3709	0.4624	0.9199	0.5997	1.2259	3.3287	2.8240	2.3585	1.0749	1.6791
	(0.0390)	(0.1177)	(0.0260)	(0.0654)	(0.0626)	(0.0294)	(0.0330)	(1.0741)	(0.1914)	(0.3072)	(0.1210)	(0.1625)
2005-06	0.9673	0.8493	0.9643	0.9684	1.0368	0.9521	0.9711	0.9746	0.9902	1.0367	1.0134	1.0539
	(0.0146)	(0.0315)	(0.0214)	(0.0429)	(0.0219)	(0.0096)	(0.0278)	(0.0263)	(0.0099)	(0.0289)	(0.0218)	(0.0100)
2006-07	0.9925	1.0314	0.9681	0.9582	0.9647	0.9991	1.0538	1.0471	1.0589	1.0173	1.0110	1.0003
	(0.0104)	(0.0156)	(0.0126)	(0.0261)	(0.0175)	(0.0050)	(0.0291)	(0.0485)	(0.0074)	(0.0383)	(0.0216)	(0.0029)
2007-08	1.0406	0.9571	1.0267	0.9570	1.0369	0.9108	0.9732	1.1067	0.9744	1.0311	0.9432	1.0812
	(0.0168)	(0.0439)	(0.0289)	(0.0338)	(0.0141)	(0.0186)	(0.0208)	(0.0272)	(0.0194)	(0.0363)	(0.0112)	(0.0198)
2008-09	0.9936	0.9513	1.1507	1.2275	1.2627	1.0806	0.9349	1.0385	0.8550	0.8431	0.7796	0.9351
	(0.0166)	(0.0236)	(0.0240)	(0.0416)	(0.0337)	(0.0130)	(0.0195)	(0.0400)	(0.0237)	(0.0473)	(0.0196)	(0.0084)
2009-10	0.9919	0.9513	1.0220	1.0412	1.0904	1.0425	1.1349	1.0570	1.0393	0.9415	0.9561	0.9555
	(0.0207)	(0.0311)	(0.0281)	(0.0243)	(0.0236)	(0.0178)	(0.0298)	(0.0398)	(0.0326)	(0.0245)	(0.0774)	(0.0160)
2010-11	0.9538	0.9003	0.7650	0.7617	0.8287	0.9919	1.0139	1.1755	1.3753	1.3424	1.1660	0.9862
	(0.0185)	(0.0282)	(0.0349)	(0.0192)	(0.0181)	(0.0255)	(0.0108)	(0.1740)	(0.0305)	(0.0348)	(0.0359)	(0.0226)
Mean	**0.9863**	**0.9770**	**1.0059**	**1.0041**	**1.0319**	**0.9963**	**1.0112**	**1.0419**	**0.9977**	**1.0114**	**0.9744**	**1.0052**

Sources: Author's calculations. The standard errors are in the parentheses. INF: Infeasible. (It could not be computed due to constraints imposed in the linear programming to estimate cross-period distance functions), NA: Not available.

Appendix to Chapter 7

Appendix Table 7.1: Determinants of Efficiency (TE) - Panel Data Fixed Effect and Random Effect Model

Variable	Model A								Model B							
	1993–2011				2000–2011				1993–2011				2000–2011			
	FE		RE		FE		RE		FE		RE		FE		RE	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Size	0.044 ***	0.008	0.039 ***	0.007	0.042 ***	0.011	0.050 ***	0.008	0.034 ***	0.009	0.039 ***	0.006	0.038 ***	0.013	0.041 ***	0.008
CAR	-		-		-0.001	0.004	0.005	0.004	-		-		-0.002	0.005	0.006	0.005
NPL	-		-		-0.041	0.061	0.008	0.060	-		-		0.017	0.071	0.041	0.068
ROA	-		-		0.152 *	0.081	0.123	0.082	-		-		0.491 ***	0.095	0.524 ***	0.094
HHI	-0.269 ***	0.043	-0.273 ***	0.043	0.551 **	0.244	0.571 **	0.249	0.190 ***	0.045	0.196 ***	0.045	-1.319 ***	0.284	-1.311 ***	0.289
GDP	0.005 *	0.003	0.005 *	0.003	0.061 ***	0.008	0.062 ***	0.008	0.041 ***	0.003	0.041 ***	0.003	-0.030 ***	0.009	-0.029 ***	0.009
Infl	0.006 ***	0.001	0.006 ***	0.001	0.009 ***	0.001	0.009 ***	0.001	0.012 ***	0.001	0.012 ***	0.001	0.000	0.002	0.000	0.002
BMoney	0.003 **	0.001	0.003 **	0.001	0.007 ***	0.002	0.007 ***	0.002	0.009 ***	0.001	0.009 ***	0.001	0.019 ***	0.002	0.019 ***	0.002
Dforex	0.021	0.023	0.004	0.020	-0.050 *	0.029	-0.034	0.023	-0.023	0.024	-0.022	0.019	0.041	0.033	0.009	0.023
Dlisting	0.007	0.020	0.016	0.019	-0.026	0.023	-0.007	0.021	-0.069 ***	0.021	-0.052 ***	0.019	-0.054 **	0.026	-0.031	0.023
Dmerger	-0.038	0.028	-0.030	0.027	-0.094 ***	0.031	-0.059 **	0.029	0.007	0.029	0.009	0.027	-0.014	0.037	0.004	0.031
DRegCh	0.015	0.017	0.017	0.017	0.042	0.032	0.040	0.033	0.156 ***	0.018	0.153 ***	0.018	0.230 ***	0.038	0.230 ***	0.038
D_state	-		0.255 ***	0.077	-		0.229 ***	0.072	-		0.150 **	0.060	-		0.167 ***	0.060
D_PureFB	-		0.249 ***	0.054	-		0.318 ***	0.051	-		0.148 ***	0.043	-		0.146 ***	0.043
D_Private	-0.358 ***	0.065	0.021	0.033	-0.326 ***	0.064	0.031	0.032	-0.074	0.068	0.046 *	0.026	-0.139 *	0.075	0.030	0.028
D_JVB	-		0.292 ***	0.046	-		0.286 ***	0.044	-		0.088 **	0.037	-		0.097 **	0.039
Intercept	0.336 ***	0.113	0.124	0.101	-0.659 **	0.268	-1.050 ***	0.256	-0.509 ***	0.119	-0.660 ***	0.100	0.389	0.313	0.238	0.292
sigma_u	0.208		0.128		0.218		0.115		0.118		0.095		0.142		0.090	
sigma_e	0.174		0.174		0.139		0.139		0.183		0.183		0.162		0.162	
rho	0.587		0.352		0.711		0.405		0.294		0.212		0.435		0.234	
F-test/ Wald Chi^2	24.54 ***		344.9 ***		11.2 ***		276.1 ***		33.57 ***		397.15 ***		34.42 ***		536.3 ***	
R^2	0.158		0.327		0.1406		0.387		0.165		0.231		0.272		0.359	
Observations	1919		1919		1212		1212		1919		1919		1212		1212	

Sources: Author's calculation. Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The FE and RE denote fixed effect and random effect, respectively.

Appendix Table 7.2: Determinants of Productivity (TFP) - Panel Data Fixed Effect and Random Effect Model

Variable	Model A								Model B							
	1993–2011				2000–2011				1993–2011				2000–2011			
	FE		RE		FE		RE		FE		RE		FE		RE	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Size	-0.010	0.020	-0.006	0.009	0.032	0.027	0.004	0.009	0.100	0.079	0.032	0.036	0.224	0.141	0.046	0.048
CAR	-		-		-0.023 **	0.010	-0.010	0.009	-		-		0.036	0.055	0.031	0.046
NPL	-		-		-0.010	0.144	0.093	0.120	-		-		-1.249	0.761	-0.267	0.643
ROA	-		-		-0.508 ***	0.193	-0.489 ***	0.172	-		-		-4.400 ***	1.017	-3.888 ***	0.922
HHI	-0.159	0.130	-0.169	0.128	0.577	0.577	0.582	0.566	-0.125	0.515	-0.158	0.512	6.950 **	3.043	6.817 **	3.034
GDP	0.008	0.007	0.008	0.007	-0.015	0.019	-0.011	0.018	-0.008	0.028	-0.004	0.028	0.079	0.099	0.100	0.098
Infl	0.000	0.003	0.000	0.003	-0.007 *	0.003	-0.006 *	0.003	0.012	0.011	0.013	0.011	0.018	0.018	0.020	0.018
BMoney	0.001	0.003	0.001	0.003	0.011 **	0.005	0.010 **	0.004	0.006	0.013	0.008	0.013	0.057 **	0.024	0.044 *	0.023
Dforex	0.080	0.057	0.000	0.028	-0.044	0.068	-0.008	0.027	-0.051	0.226	-0.080	0.110	0.073	0.359	-0.048	0.147
Dlisting	-0.004	0.048	0.020	0.033	-0.023	0.053	-0.008	0.032	0.012	0.190	0.152	0.132	0.044	0.281	0.011	0.174
Dmerger	-0.163 **	0.066	-0.056	0.048	-0.093	0.074	-0.048	0.041	-0.421	0.260	-0.177	0.193	-0.670 *	0.391	-0.172	0.222
DRegCh	-0.107 ***	0.039	-0.104 ***	0.038	0.063	0.076	0.059	0.075	0.141	0.157	0.158	0.154	0.968 **	0.403	0.926 **	0.402
D_state	-		0.032	0.056	-		-0.091	0.056	-		0.373 *	0.225	-		-0.185	0.299
D_PureFB	-		0.026	0.041	-		-0.026	0.041	-		0.461 ***	0.162	-		0.623 ***	0.222
D_Private	0.194	0.152	0.006	0.026	0.090	0.152	0.028	0.028	1.026 *	0.602	0.064	0.104	0.403	0.803	0.023	0.149
D_JVB	-		0.076 **	0.038	-		0.045	0.040	-		0.156	0.152	-		0.098	0.215
Intercept	1.106 ***	0.271	1.156 ***	0.188	-0.041	0.635	0.254	0.557	-0.667	1.075	0.306	0.748	-9.393 ***	3.351	-6.993 **	2.982
sigma_u	0.134		0.000		0.092		0.000		0.628		0.000		0.642		0.000	
sigma_e	0.402		0.402		0.329		0.329		1.595		1.595		1.737		1.737	
rho	0.100		0.000		0.072		0.000		0.134		0.000		0.120		0.000	
F-test/ Wald Chi^2	4.15 ***		38.04 ***		4.58 ***		63.26 ***		3.08 ***		41.94 ***		2.73 ***		38.18 ***	
R^2	0.0034		0.0207		0.099		0.0503		0.0012		0.0227		0.0101		0.031	
Observations	1818		1818		1212		1212		1818		1818		1212		1212	

Sources: Author's calculation. Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The FE, RE and SE denote fixed effect, random effect and standard errors, respectively.

Appendix Table 7.3: Model A - Determinants of Efficiency (TE) Bank Size Based - Tobit Regression Model

eff_a	Large Bank		Medium bank		Small bank	
	1993-2011	2000-2011	1993-2011	2000-2011	1993-2011	2000-2011
Size	0.123***	0.117***	0.115***	0.125***	-0.021**	0.011
	(0.024)	(0.026)	(0.019)	(0.021)	(0.009)	(0.012)
CAR	-	-0.323**	-	0.387***	-	0.001
		(0.156)		(0.081)		(0.004)
NPL	-	0.472**	-	-0.052	-	-0.020
		(0.233)		(0.111)		(0.075)
ROA	-	4.740***	-	-0.051	-	0.323*
		(0.957)		(0.082)		(0.182)
HHI	0.265**	0.649	-0.150	1.414***	-0.233***	0.097
	(0.133)	(0.599)	(0.113)	(0.438)	(0.046)	(0.291)
GDP	-0.010	-0.002	0.029***	0.075***	0.011***	0.075***
	(0.007)	(0.017)	(0.006)	(0.013)	(0.003)	(0.010)
Infl	-0.002	0.000	0.012***	0.010***	0.008***	0.011***
	(0.003)	(0.003)	(0.002)	(0.003)	(0.001)	(0.002)
BMoney	-0.001	-0.003	-0.001	0.006*	0.005***	0.010***
	(0.003)	(0.005)	(0.003)	(0.004)	(0.001)	(0.002)
Dforex	-	-	0.000	0.015	0.075***	0.003
			(0.037)	(0.036)	(0.024)	(0.033)
Dlisting	-0.074***	-0.120***	-0.082**	-0.071*	0.022	0.001
	(0.029)	(0.034)	(0.037)	(0.038)	(0.026)	(0.030)
Dmerger	-0.040	-0.060	0.011	0.008	-0.205**	-0.155**
	(0.038)	(0.042)	(0.042)	(0.041)	(0.081)	(0.069)
DRegCh	0.129***	0.124	-0.117***	0.007	0.013	0.010
	(0.041)	(0.076)	(0.032)	(0.056)	(0.019)	(0.040)
Intercept	-0.796**	-0.993	-0.611***	-2.463***	0.487***	-0.577*
	(0.323)	(0.649)	(0.231)	(0.477)	(0.112)	(0.308)
rho	0.289	0.329	0.534	0.551	0.494	0.608
Log likelihood	121.22	112.71	167.38	176.75	384.60	333.27
Wald chi^2	41.78***	70.51***	97.16***	125.61***	174.12***	101.14***
Observations	184	158	404	339	1331	715

Sources: Author's calculation

Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

Appendix Table 7.4: Model B - Determinants of Efficiency (TE) Bank Size Based - Tobit Regression Model

Variable	Large Bank		Medium Bank		Small Bank	
	1993-2011	2000-2011	1993-2011	2000-2011	1993-2011	2000-2011
Size	0.079 ***	0.060 ***	0.101 ***	0.058 **	0.005	-0.009
	(0.023)	(0.019)	(0.020)	(0.023)	(0.008)	(0.012)
CAR	-	0.077	-	-0.087	-	0.000
		(0.084)		(0.099)		(0.005)
NPL	-	0.128	-	0.191	-	0.032
		(0.139)		(0.141)		(0.084)
ROA	-	2.189 ***	-	0.449 ***	-	0.987 ***
		(0.600)		(0.107)		(0.214)
HHI	-0.365 ***	-0.440	0.277 **	-1.858 ***	0.160 ***	-1.063 ***
	(0.115)	(0.326)	(0.141)	(0.577)	(0.050)	(0.347)
GDP	0.000	-0.005	0.012	-0.056 ***	0.055 ***	-0.015
	(0.006)	(0.009)	(0.008)	(0.017)	(0.004)	(0.012)
Infl	0.003	-0.002	0.001	-0.006 *	0.017 ***	0.008 ***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.001)	(0.002)
BMoney	-0.003	0.008 ***	0.006	0.004	0.012 ***	0.029 ***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.001)	(0.003)
Dforex	-	-	-0.009	0.023	0.019	0.049 *
			(0.037)	(0.038)	(0.021)	(0.029)
Dlisting	-0.089 ***	-0.015	-0.033	-0.015	-0.081 ***	-0.068 **
	(0.025)	(0.021)	(0.033)	(0.037)	(0.027)	(0.032)
Dmerger	0.008	0.035	-0.083 *	-0.073	-0.036	-0.005
	(0.035)	(0.030)	(0.046)	(0.046)	(0.087)	(0.080)
DRegCh	0.006	0.077 *	0.241 ***	0.143 *	0.126 ***	0.295 ***
	(0.035)	(0.041)	(0.042)	(0.074)	(0.021)	(0.047)
Intercept	0.278	0.003	-0.998 ***	1.409 **	-0.583 ***	-0.084
	(0.292)	(0.391)	(0.251)	(0.601)	(0.112)	(0.354)
rho	0.301	0.597	0.195	0.296	0.218	0.343
Log likelihood	148.02	200.2	86.14	104.57	320.73	243.5
Wald chi^2	31.99 ***	75.57 ***	80.24 ***	122.50 ***	364.14 ***	351.55 ***
Observations	184	158	404	339	1331	715

Sources: Author's calculation

Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

Appendix Table 7.5: Model A - Determinants of Productivity (TFP) Bank Size Based - Tobit Regression Model

Variable	Large Bank		Medium Bank		Small Bank	
	1993-2011	**2000-2011**	**1993-2011**	**2000-2011**	**1993-2011**	**2000-2011**
Size	-0.010	-0.038	0.004	0.014	-0.021 *	-0.025 *
	(0.029)	(0.025)	(0.035)	(0.036)	(0.013)	(0.014)
CAR	-	0.171	-	-0.063	-	-0.012
		(0.232)		(0.133)		(0.009)
NPL	-	0.995 ***	-	-0.071	-	0.055
		(0.364)		(0.256)		(0.137)
ROA	-	-1.333	-	-0.408 **	-	-0.563
		(1.354)		(0.204)		(0.396)
HHI	0.324	0.186	-0.373	-0.068	-0.197	0.829
	(0.356)	(1.118)	(0.317)	(1.167)	(0.155)	(0.734)
GDP	-0.008	0.035	-0.018	-0.047	0.014 *	-0.006
	(0.017)	(0.031)	(0.016)	(0.035)	(0.009)	(0.026)
Infl	-0.007	-0.019 ***	-0.004	-0.008	0.002	-0.005
	(0.006)	(0.006)	(0.006)	(0.007)	(0.003)	(0.004)
BMoney	0.024 ***	0.030 ***	0.004	0.014	0.000	0.006
	(0.008)	(0.009)	(0.007)	(0.010)	(0.004)	(0.006)
Dforex	-	-	-0.044	-0.051	0.027	0.014
			(0.056)	(0.051)	(0.029)	(0.030)
Dlisting	0.029	0.073 *	0.048	0.028	-0.006	-0.001
	(0.046)	(0.041)	(0.046)	(0.046)	(0.049)	(0.046)
Dmerger	-0.025	-0.008	-0.078	-0.077	0.138	0.117
	(0.051)	(0.040)	(0.066)	(0.059)	(0.188)	(0.152)
DRegCh	0.175 *	0.174	-0.052	0.084	-0.145 ***	0.024
	(0.094)	(0.141)	(0.084)	(0.149)	(0.048)	(0.100)
Intercept	-0.137	-0.197	1.285 ***	0.677	1.360 ***	0.504
	(0.501)	(1.108)	(0.456)	(1.161)	(0.229)	(0.717)
rho	0.000	0.000	0.000	0.000	0.000	0.000 ***
Log likelihood	-19.42	27.06	-174.66	-104.30	-667.48	-229.77
Wald chi^2	21.44 ***	55.53 ***	10.05	20.40 *	35.62 ***	32.01 ***
Observations	182	158	399	339	1237	715

Sources: Author's calculation

Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

Appendix Table 7.6: Model B - Determinants of Productivity (TFP) Bank Size Based - Tobit Regression Model

Variable	Large Bank		Medium Bank		Small Bank	
	1993-2011	2000-2011	1993-2011	2000-2011	1993-2011	2000-2011
Size	0.119	-0.016	0.413	0.436	-0.001	-0.005
	(0.175)	(0.023)	(0.282)	(0.344)	(0.012)	(0.010)
CAR	-	-0.331	-	2.410 *	-	-0.001
		(0.217)		(1.289)		(0.007)
NPL	-	0.076	-	-0.489	-	0.158
		(0.340)		(2.469)		(0.103)
ROA	-	0.067	-	-5.801 ***	-	-0.879 ***
		(1.266)		(1.972)		(0.299)
HHI	0.057	2.565 **	-2.562	22.221 **	0.275 *	1.487 ***
	(2.167)	(1.045)	(2.556)	(11.277)	(0.150)	(0.553)
GDP	-0.200 *	0.079 ***	-0.019	0.270	-0.023 ***	0.048 **
	(0.102)	(0.029)	(0.133)	(0.338)	(0.009)	(0.020)
Infl	0.062 *	0.016 ***	0.021	0.039	-0.002	0.001
	(0.038)	(0.006)	(0.048)	(0.065)	(0.003)	(0.003)
BMoney	-0.057	-0.023 ***	0.055	0.174 *	-0.005	-0.007 *
	(0.051)	(0.009)	(0.060)	(0.092)	(0.004)	(0.004)
Dforex	-	-	0.170	0.202	-0.008	0.020
			(0.455)	(0.496)	(0.028)	(0.023)
Dlisting	0.249	0.037	0.076	-0.165	0.039	-0.039
	(0.280)	(0.038)	(0.370)	(0.444)	(0.047)	(0.034)
Dmerger	-0.207	-0.021	-0.195	-0.466	-0.036	-0.011
	(0.312)	(0.038)	(0.532)	(0.570)	(0.182)	(0.114)
DRegCh	-0.241	-0.047	0.945	3.748 ***	-0.002	-0.002
	(0.572)	(0.132)	(0.677)	(1.444)	(0.047)	(0.075)
Intercept	2.568	0.021	-4.729	-30.284 ***	1.202 ***	0.149
	(3.050)	(1.036)	(3.680)	(11.222)	(0.221)	(0.540)
rho	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	-348	37.65	-1008	-873.3	-626.4	-27.62
Wald chi^2	76.91 ***	35.15 ***	8.68	20.4 *	60.89 ***	37.25 ***
Observations	182	158	399	339	1237	715

Sources: Author's calculation

Note: ***, **, and * denote significance at the 1% level, the 5% level and the 10% level, respectively. The standard errors are in the parentheses.

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