An Empirical Analysis of Cost Efficiency and Share Performance in Indonesian Banking Industry

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MSc Finance and Investment

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Abstract

Indonesia is a member of G-20 major economies which has rapid development and is likely to offer new market. It is therefore important to learn and understand Indonesian banking sector. Competitive market has driven banks to deliver higher returns to their shareholders, make the measurements of bank performance and their relationship with the market performance become more crucial. To the authors' knowledge, this study is the first that estimates the cost efficiency of the listed Indonesian commercial banks using parametric approach (SFA) and links it to their stock price using the very recent dataset (2006-2013) that takes into account the global financial crisis. The empirical results from this study indicate that cost efficiency scores in Indonesian banks deteriorated gradually during 2006 to 2013. With respect to the asset size, large banks are the most cost efficient compared to medium and small banks. While examining the relationship between efficiency and stock returns as the market performance, the regression result suggests that change in cost efficiency is statistically significant and negatively reflected in the stock returns.

Key words: Cost Efficiency ● Stochastic Frontier Analysis ● Commercial Banks ● Indonesian Listed Banks

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1 Introduction

1.1 Introduction

The nature of a company in running the business is to create value in order to increase the wealth of its shareholders. Competitive pressure in banking industry has forced banks to focus in maximising returns to shareholders. To achieve their goals, it is necessary for companies to measure their performance. This measurement is helpful for managers to evaluate, control, budget, learn, improve and develop management strategy (Behn, 2003). Stock return is usually used to measure value creation to shareholders (Brealey and Myers, 1991). Efficiency is one performance measurement that is commonly used in many literatures. Focusing at banking industry, financial ratios are usually used to measure bank performance while in the past few years, research in bank performance has shifted from accounting-based studies to economics-based studies (Becalli, et al., 2006). Economic-based examination such as operating efficiency has been proved to be a better indicator in measuring bank performance rather than financial ratios (Berger & Humphrey, 1992). Stock performance has been the subject of many empirical studies in the accounting and finance area since 1970s. Relating efficiency to the share price, efficiency is calculated using published accounting information and according to efficient market hypotheses (EMH), securities prices are always reflect all relevant information about the firm that issues them. As Fama (1970) defined, *"A market in which prices always fully reflect available information is called efficient".* As efficiency should be incorporated in the share prices, it is important to know the relationship between bank performance and stock market performance.

Aforementioned above, accounting-based studies usually use traditional financial ratios such as Return on Assets (ROA) and Return on Equity (ROE) to identify the key determinants of bank profitability as an indicator of banks' performance. One of the most typical accounting-based studies is Kosmidou (2008) which investigated the Greece bank profitability by testing the relationship of the bank characteristics (internal accounting ratios), macroeconomic and financial structure (external factors) with ROAA (selected variable of bank profitability).

Economics-based studies focus on the efficiency of the bank. The more efficient the transformation process from resources to be finished goods or services, the higher value added of goods and services produced (Heizer & Render, 2011). Bank efficiency is calculated by looking at the distance away the actual efficiency score of a bank from the ideal efficiency frontier, in which the deviation determines inefficiency. Operating efficiency can be viewed by whether the bank is profit efficient or cost efficient. According to Coelli et al. (2005), a bank can be cost efficient by consuming less input in order to produce the same level of outputs; while profit efficient can be achieved by maximising profit through producing more outputs without adding more inputs. The objective of profit maximisation is not only producing goods and services at minimum cost but also maximising revenue (Coelli, et al., 2005). It is expected that efficient bank will be more profitable compare to the less efficient banks and therefore contribute more value to the shareholders. Furthermore, the lower cost of capital which associated with high profitability and better efficiency should have a better stock market performance (Beccalli et al., 2006). Therefore, it is expected that bank with higher efficiency score has a better stock performance.

Despite of many literatures on capital market research and bank efficiency, there are only few papers have examined the link between cost efficiency and market performance (Becalli, et al., 2006). To get the information required in examining the relationship between bank efficiency and share performance, researchers estimated the efficiency scores using parametric and/or non-parametric methods. Then, they calculated the annual returns of banks. Finally, they used regression analysis to test the predictions of their model. These steps are known as the three-stage procedures (Becalli, et al., 2006).

A large number of papers on bank efficiency have been focusing on European and US banking sector. For instance, Bikker (2001) used cost frontier approach for Luxembourg, Belgium and Switzerland. Becalli, et al. (2006) examined the relationship between bank efficiency and stock performance in France, Germany, Italy, Spain and UK. Liadaki and Gaganis (2010) also conducted a similar study by providing a larger sample of banks from 15 EU countries. From US banking industry, Berger, et al. (1993) investigated US banking efficiency by using profit function while Grabowski et al. (1993) used cost frontier to measure bank efficiency. Several studies have also taken into account some Asian countries such as India (Ataullah & Le, 2006; Bhattacharya, et al., 1997), Korea (Gilbert & Wilson, 1998), Japan (McKillop, et al., 1996; Fukuyama, et al., 1999) and Hongkong (Kwan, 2006). Although there were some studies in Singapore (Chu & Lim, 1998), Malaysia (Dogan & Fausten, 2003) and Philippines (Unite & Sullivan, 2003), there were still limited studies examining bank efficiency in South-East Asia countries that have rapid development in the banking systems (Hadad, et al., 2011). Therefore, the importance of further studies regarding South-East Asian banking system such as Indonesia should be considered.

1.2 Contribution to Indonesian Literature on Bank Efficiency

The aims of this paper are to explain efficiency through cost frontier and understand the influence of cost efficiency on the stock market performance in Indonesian banking industry, focusing on listed commercial banks. By knowing the link between them, banks could have better management and maximising return to shareholders. Moreover, replenish the limited numbers of academic paper on bank efficiency and its market performance in Indonesia.

The present study will contribute to Indonesian banking literature in the following ways: 1) Majority of preceding Indonesian banking studies have considered limited dataset in the years prior to global financial crisis (GFC), however this study employs a more recent data that involves the impact of GFC on the efficiency scores in the Indonesian banking industry. 2) Most of previous studies on banking efficiency in Indonesia used non-parametric methods namely data envelopment analysis (DEA) methods to estimate efficiency, while this study employs parametric techniques i.e Stochastic Frontier Analysis (SFA). 3) To the author's knowledge, this paper is the first in the study of Indonesian banking industry to apply three-stage methods that use parametric technique on the estimation of efficiency; which investigates the relation between changes in efficiencies and their stock prices.

1.3 Dissertation Structure

The arrangement of this paper is organised as follows: Chapter 2 presents a basic explanation of the nature of banking, regulatory authority and basel implementation in Indonesian banking system as well as an overview of the banks performance during financial crisis. Chapter 3 reviews several literatures regarding bank efficiency including the basic concept of efficiency. Chapter 4 discusses the three-stage methodology based on Becalli et al. (2006) to derive the information to help the analysis on bank efficiency and its relation to market performance. It discusses the SFA, cost efficiency, intermediation approach to the utilized data set and translog functional form to estimate efficiency frontier. This section also outlines the equation to calculate annual return and presents the regression model. Chapter 5 shows and discusses empirical findings and analysis from efficiency estimation and regression result. The final section presents conclusions of the study and recommendation to future studies.

2 Introduction to Indonesia's Economy and Banking Industry

This study scrutinizes the efficiency of listed Indonesian commercial banks during 2006 to 2013. A brief introduction to the basic information of Indonesian banking system is provided to understand some background and the role of banking in Indonesia.

Bank of Indonesia (BI) as Indonesia's central bank has the authority to regulate and issue all policies in the banking sector. In 2011, BI established a new agency namely *Otoritas Jasa Keuangan* (FSA) through the Law of the Republic of Indonesia (RI) No. 21 year 2011. FSA is an independent institution, which has the authority on regulation, supervision, inspection and investigation in financial sector which include securities companies, insurance companies, pension funds, financing companies and banks (Susandarini, 2012). Since the end of year 2013, banking supervision and regulation has been transferred from the Central Bank to FSA.

When the FSA takes over BI's duties over the regulation and supervision in the financial sector, coordination between FSA and BI is still required when it comes to formulate banking policies. These policies include the capital adequacy ratio for banks, an integrated banking information system, receiving foreign exchange, commercial loans, banking products, derivative transactions, and other banking activities. Special investigations on banks may also be taken by BI after informing the FSA and will communicate the result to the FSA (Susandarini, 2012).

According to the FSA on the published Indonesian Banking Booklet (IBB), 2014, banking is everything related to banks, including institutions, business activities, nature and process in doing their business operations.

Its operations based on economic democracy and employ prudential principal. The main function of Indonesian banking is as a collector and distributor of public funds, moreover, it also supports national development in order to improve economic growth and maintain economy stability.

2.1 Banking: definition and operation

In general, the clauses of deposit and loan products in banks are different from other types of financial firms. Bank has the aptitude of transforming liabilities into assets (Webb & Brahma, 2013). The term of deposits means liabilities for banks, which need to be managed to create maximum profit. On the contrary, they managed assets by providing loans or lending. Banks facilitate the need between depositors and borrowers; hence act as intermediaries between depositors and borrowers (Heffernan, 2005).

The definition of banks in Indonesia according to the FSA (2014) is "*business entities that collect funds from the society in the form of savings/deposits and distribute them to the society in the form of credits and/or other form in order to improve the living standard of the people*". Previously described above, banks carry out their duties as financial intermediation, where they act as creditors and debtors.

The FSA classifies banks into two categories: Conventional banks and Sharia banks. Conventional banks run their business operations conventionally, while Sharia banks conduct their business by implementing Islamic laws on banking. Both Conventional and Sharia has two types of bank. The two types of conventional banks are known as Conventional Commercial Banks and Rural Banks, whereas Sharia banks consist of Sharia Commercial Banks and Sharia People Financing Bank.

Due to time constraints, this study focuses on the relationship of efficiency and share performance in conventional commercial banks.

2.2 Bank regulation and supervision

Bank regulations are a form of government regulations that require banks to follow and obey some rules, objectives and guidelines. The regulatory principles and objectives are executed by the central Bank of Indonesia which has the main function of ensuring that banking system operates in the proper manner. However, since the end of year 2013, this function was transferred to the FSA. It has the rights to grant and revoke licenses and certain business activities of banks, set the rules, carry out supervision of banks and impose sanctions when banks fail to obey the rules. The purpose of regulation and supervision is maximising the function of banking to uphold the interest of community and to contribute to the national economy.

As a regulator, the FSA verify the requirements of bank establishment such as paid-up capital as well as the opening of a foreign bank branch office or foreign bank representative office. It also sets the procedure and oversees the ownership of the bank, sets the basic policy of sole proprietorship in Indonesian banking and constructs the guideline of banks management. For instance, members of Board of Commissioners and Board of Directors need to pass the requirements of integrity and competency. Such requirements and systems of assessment are governed in the Good Corporate Governance (GCG) regulations. By examining the GCG appliance in banks, regulator can assess bank's management in the implementation of GCG principles.

In delivering its responsibilities to supervise the banks, the FSA establishes two procedures to the system which are compliance based supervision and risk-based supervision. Compliance based supervision is taken to assure that bank has followed the regulation related to business operations and management in accordance to prudential principle. In addition to the first method, risk based supervision strives to identify the risk in favour of early detection for any failure that might occur.

Banks perform special function in the financial system. They have the ability to transform deposits into assets. The process of asset transformation might expose banks to several risks, hence they need to measure the risk to ensure their sustainability and prevent the possibility of failure in banks (Webb & Brahma, 2013). Assessing the risk profile includes an assessment of inherent risk and quality of managing risks in bank activities. These risks include credit risk, market risk, liquidity risk, operational risk, strategic risk, reputation risk, compliance risk and legal risk. In line with previous statement, according to FSA (2014), below are the risks that need to be reviewed regularly:

a) Credit risk

Credit risk has a large portion of risks in banks. The risk that counterparty or borrower might not be able to meet their obligations. This condition also known as counterparty default.

b) Market risk

The risk may arise due to market condition, where the change in interest rate and/or exchange rate might affect traded assets or liabilities. Consequences arise from this risk could reduce the earnings or capital due to volatility of trading book position or unable to hedge the balance sheet.

c) Liquidity risk

The risk that the assets of the bank are not easily traded, hence cannot meet short time obligation.

d) Operational risk

Risk arising due to human errors, failures in internal process as well as external support system or technology that affected the operation of bank.

e) Legal risk

The juridical aspect weaknesses are among others due to lawsuits, inexistence of supporting laws and regulations or weaknesses in the agreement such as validity of contract terms are not met and imperfect binding of collateral agreement.

f) Reputation risk

Risk due to bad information related to business activities of the bank that damage bank reputation.

g) Strategic risk

The failure arises due to bad management decision and/or responses to external changes.

h) Compliance risk

The risk that the bank may not operates the business in accordance with the law regulations.

2.3 Asian Financial Crisis

Indonesia had been affected by the Asian financial crisis in 1997-1998 more than any other Asian countries involved in the crisis. Indonesia encountered a severe economic downturn, where the currency fell drastically and people believed that banks became insolvent which led to bank runs. Banks did not have enough capital to absorb losses and as a result, a large amount of capital had been injected into banks. Bank restructuring is usually undertaken as a solution of the crisis. Some possible approaches in bank restructuring are government capital injection, asset management, domestic bank merger and foreign bank takeover (Casu, et al., 2006).

In 1999, capital injections have been conducted to restructure banks. Banks were classified into three categories based on their capital adequacy ratio (CAR) to identify which banks needed capital injections. Category A (CAR of 4% or higher) was for healthy banks, group B was for banks that required capital injections with CAR ranged from -25% to 4% and banks in category C (CAR of -25% or below) were subjected to be shut down. In pre-crisis 1996, the number of banks in Indonesia was 239 banks, decreased to 151 in 2000 and kept falling to 138 at the end of 2003 (Harada & Ito, 2005).

The International Monetary Fund (IMF) helped Indonesia to break the crisis. Together with the government, the IMF agreed a plan of program for Indonesian banking sector. The IMF program was to close 16 fragile private banks and insurance for the first time in Indonesian banking introduced deposit insurance to small depositors at the closed banks with the maximum amount of 20 million rupiah-IDR (£1,050-GBP), per depositor per bank (Heffernan, 2005).

The other program was to establish Indonesian Banking Restructuring Agency (IBRA), part of the Ministry of Finance, to help the process of reconstruct the banks. Healthy banks in category A could manage and recover their performance by themselves. Bank in category B have been divided into four: 1) closed banks; 2) banks merged after being put under state control; 3) banks successful in boosting capital to receive support from the government but not giving up management control; and 4) banks that failed to raise capital and came under the control of the IBRA. Interestingly, there were four banks from banks in category C that were not closed. These banks were large state banks that were considered as "Too Big To Fail" and government chose to inject more capital for them to restructure (Harada & Ito, 2005). In addition, Indonesian government decided to inject capital into all state owned banks no matter how much it cost (Heffernan, 2005).

Since then, in the last ten years Indonesia has undergone merger and acquisitions due to changes in regulations as the impact of Asian Financial Crisis. Theoretically, bank mergers and acquisition could add, mix or diversify banks' product and reduce costs. Banks that have large size of capital and asset tend to be more efficient, competitive and powerful (Soetanto & Ricky, 2011). In spite of this condition, the extended work and effort by the Indonesian government and realignment of the banking structure and supervision enabled Indonesia to exit the IMF program and the IBRA was suspended after accomplishing its duty. In 2004, Indonesia appeared to have defeated the impact from the Asian currency crisis and turn to an economic growth. Indonesian banking sector and the general macro economy got its confidence rapidly. Macro economy data on bank performance, the financial data of individual banks, and individual banks' stock prices, suggest recovery of the management of banks (Harada & Ito, 2005).

2.4 Mergers and Acquisitions in Indonesia from 2006 to 2013

One way to restructure the bank is through merger and acquisition. Furthermore, a series of bank mergers and acquisitions has been done to meet the minimum capital requirement and single presence policy (Mulyaningsih & Daly, 2011).

The purpose of single presence policy is to rearrange the structure of bank ownership. This policy refers to a condition in which one party is a majority shareholder in one bank. This regulation is applicable to shareholders that hold more than 25% of the total bank shares in several banks or hold less than 25% but have the power to control the bank. As a consequence, there must be an alteration in the structure of ownership by transferring some or all of the ownership only to one bank. Thus, they became the largest shareholder to one bank only. Furthermore, banks with the same owner are encouraged to merge the banks (Mulyaningsih & Daly, 2011). Table 2.1 presents merger and acquisition in Indonesian banking sector from 1997 to 2010.

Table 2.1 List of bank merger and acquisition in Indonesia 1997-2010

No.	Year of Merger	Mergered Banks	Bank Name after Merger
1	2000	Bank Dai-Ichi Kanggo	PT Bank Mizuho Indonesia
		Bank IBJ Indonesia	
2	2001	Bank Bali	PT Bank Permata Tbk
		Bank Artha Media	
		Bank Universal	
		Bank Prima Express	
		Bank Patriot	
3	2001	PT Bank Sumitomo Mitsuo Indonesia	PT Bank Sumitomo Mitsuo Indonesia
		Sakura Swadarma Bank	
4	2001	UFJ Indonesia Bank	UFJ Indonesia Bank
		Tokai Lippo Bank	
5	2001	Bank Pikko	PT Bank Mutiara Tbk
		Bank CIC	
	2004	Bank Danpac	
6	2005	Bank Artha Graha	PT Bank Artha Graha International Tbk
		Bank Inter-pacific Tbk.	
7	2006	UFJ Indonesia	PT Bank of Tokyo Mitsubishi UFJ Ltd.
		PT Bank of Tokyo	
		Mitsubishi	
8	2007	Commonwealth Indonesia	PT Bank Commonwealth
		Artha Niaga Kencana	
9	2007	Bank Multicor	PT Bank Windu Kentjana International Tbk.
		Bank Windu Kentjana	
10	2008	PT Bank Niaga	PT Bank CIMB Niaga Tbk
		PT Bank Lippo	
11	2008	Bank Hagakita	PT Bank Rabobank International Indonesia Bank
		Bank Haga	
		Bank Rabobank Duta	
12	2008	Bank Harmoni International	
		Bank Index Selindo	PT Bank Index Selindo
13	2008	Bank Haga	Rabobank Duta Bank
		Bank Hagakita	
14	2009	Bank OCBC	PT Bank OCBC-NISP Tbk
		Bank NISP	
15	2010	Bank Buana	PT Bank UOB Buana Tbk
		Bank UOB Indonesia	

Source: Mulyaningsih & Daly (2011 p.152)

2.5 Indonesian Banking Architecture

In order to maintain and further enhance the recovery of banks, in 2004, BI launched the Indonesian Banking Architecture (IBA) in order to strengthen the fundamental of banking industry to achieve financial stability. The background of this policy was the economic crisis in 1997 which exposed financial institutional weaknesses in banking industry and lack of adequate supporting infrastructure. According to Bank of Indonesia (2013), the Indonesian Banking Architecture is *"a comprehensive basic framework for the Indonesian banking system, outlining the direction, outline, and structure of the banking industry for the next five to ten years"*. This is a long-term fundamental framework of Indonesian banking system with a purpose to strengthen and improve the financial system stability to achieve a sound, strong, efficient banking industry and support national economic growth. The following figure shows the fundamental of Indonesian Banking Architecture:

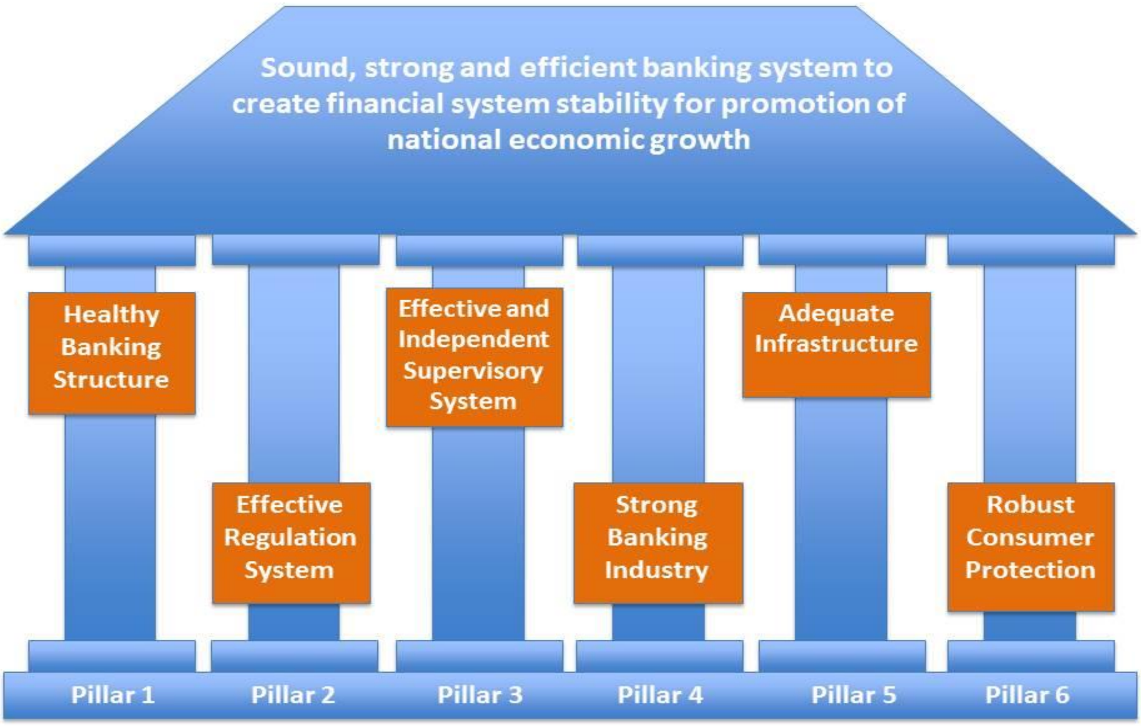


Figure 2.1 Six pillars of Indonesian Banking Architecture
Source: Bank of Indonesia

The IBA program has been implemented for approximately ten years and up to November 2013 evaluation on this program has been conducted. The result indicated that bank's capitalisation structures are strengthened. Enhancement in supervisory function have also been applied by reorganizing banking sector, perfecting banking supervision infrastructure and perfecting risk-based supervision implementation. Several policies and regulations have been implemented with respect to GCG; concerning bank soundness rating related to the quality of GCG implementation. The expansion of sharia financial market is part of improving the banking infrastructure and the development of information transparency on products with regards to consumer protection (FSA, 2014).

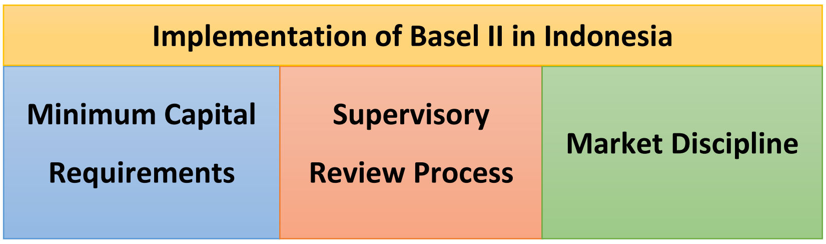
It has been almost ten years since the first implementation of IBA program, the FSA considers to set a new program for Indonesian banking system for the period of 2014-2023. The new master plan will consider the dynamics in national and global scope such as uncertainties of global economic conditions that might affect Indonesian banking system, development of new standard and regulation and free trade between countries regionally.

2.6 Basel implementation

Indonesia is a member of several international organisations such as G-20 major economies, Financial Stability Board (FSB) and Basel Committee on Banking Supervision (BCBS). The government attempts to have a healthy and prudent banking sector. To achieve this goal, the government limit the magnitude and scope of bank operational failure and ensure confidence by imposing minimum capital requirements for banks (Webb & Brahma, 2013). Capital is important because it holds several crucial functions. These functions among others are to absorb any shocks that will resulted in loss, to fund new business expansion and provides easier access to financial markets allowing access to liquidity.

The Central Bank of Indonesia adopted international banking regulatory standards introduced by BCBS namely Basel regulation. One of the regulations that have been implemented in Indonesian banking is the capital adequacy framework. Figure 2.2 represents Basel II framework that was adapted by Bank of Indonesia.

Figure 2.2 Basel II – Risk Sensitive Capital Management Framework



Source: *Otoritas Jasa Keuangan* (FSA), 2014

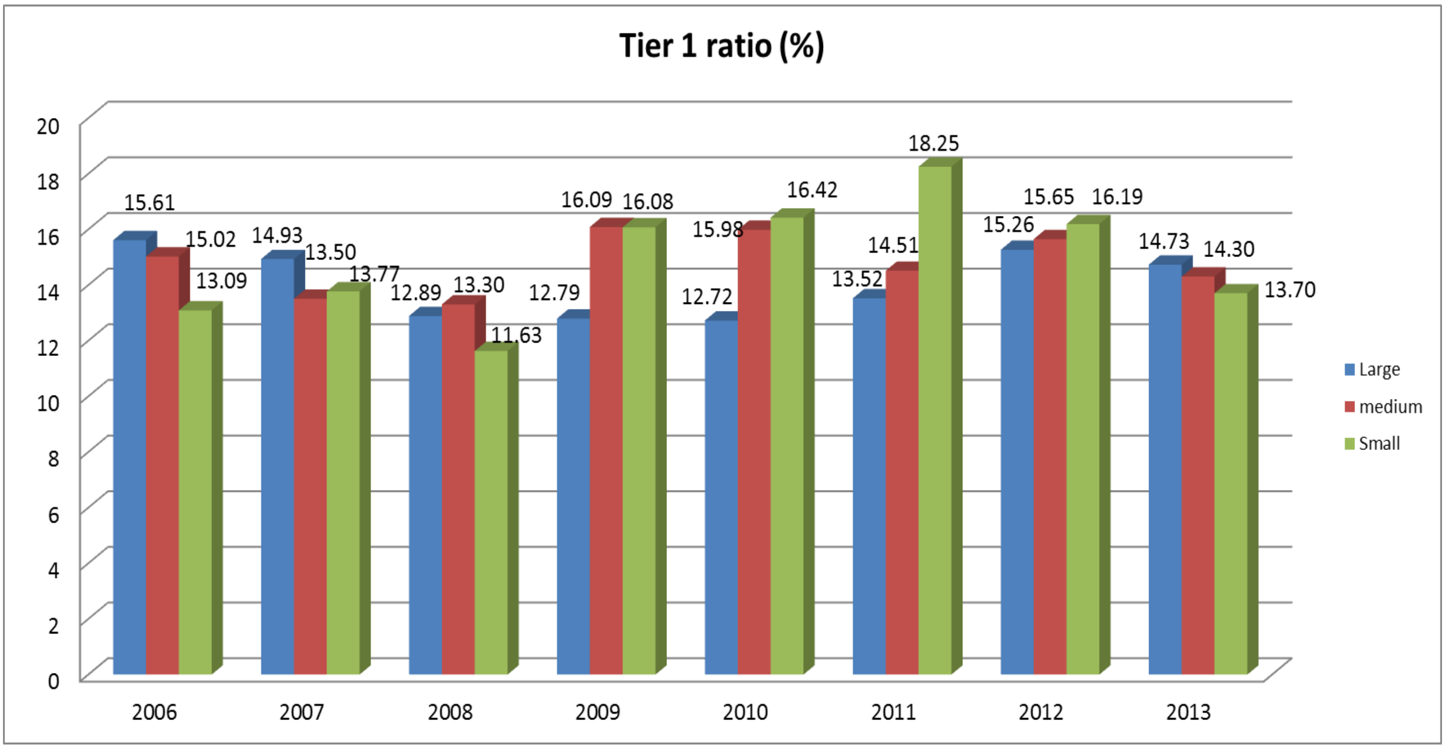
Basel is a set of regulations and recommendation in banking industry. Since December 2012, Indonesian banking sector has completely applied Basel II regulations. As seen in Figure 2.2, Basel II comprises three main pillars. Pillar 1 standardise the minimum capital requirements that consider related risks such as credit risk, market risk and operational risk. It provides a guideline on calculating risk-weighted asset for credit risk and operational risk using standard approach and basic indicator approach, respectively.

Pillar 2 administers supervisory review process to assure that the banks have sufficient capital through an adequate calculation process relative to their risk profile. It concerns about supervisory on capital adequacy where banks are obligated to have minimum capital according to the category of risk profile as following (IBB, 2014):

1. Bank with level 1 risk profile, with minimum capital requirements of 8%.
2. Bank with level 2 risk profile, with minimum capital requirements of 9% up to < 10%.
3. Bank with level 3 risk profile, with minimum capital requirements of 10% up to < 11%.
4. Bank with level 4 or 5 risk profiles, with minimum capital requirements of 11% up to 14%.

To be prudent and more confident about the banking industry, regulator has set the minimum capital requirement above the minimum of capital required by Basel. As in Figure 2.3, banks in Indonesia have accomplished the minimum capital required. These capital ratios accommodate in ascertaining the risk and liquidity of banks.

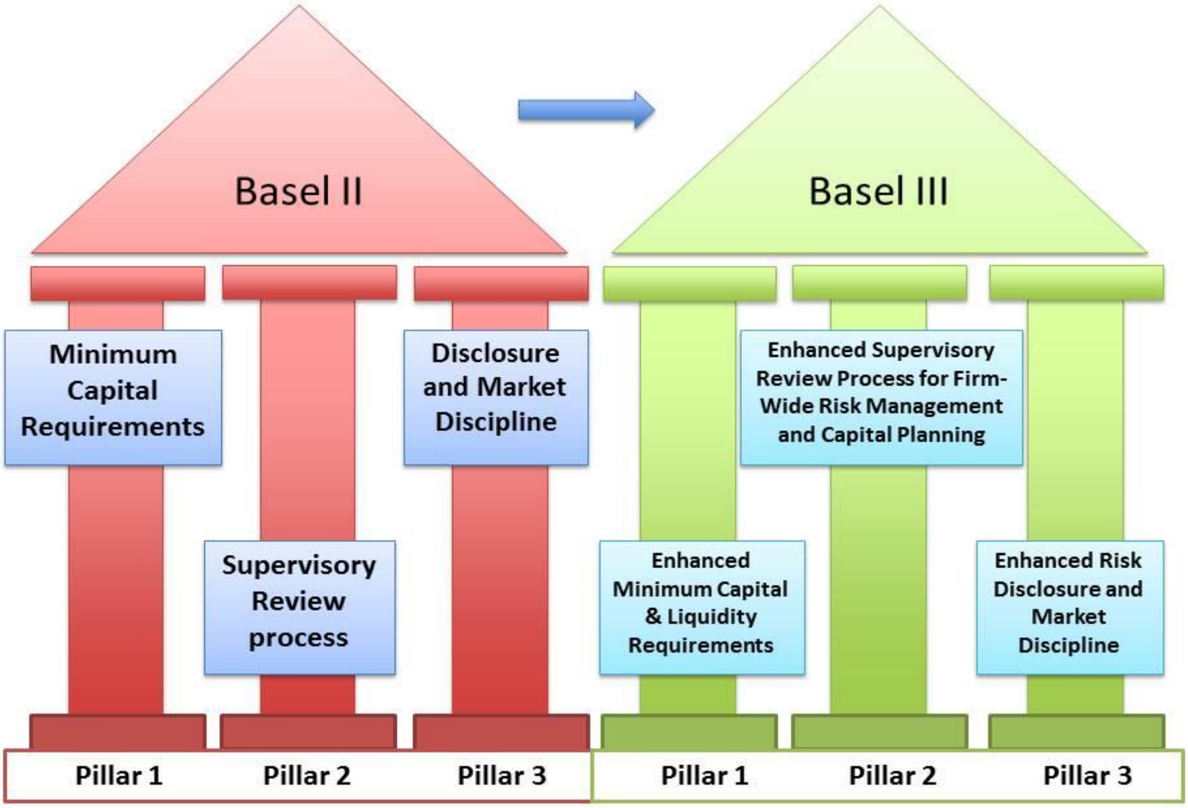
Figure 2.3 Tier 1 capital ratio based on the asset size of listed commercial banks in Indonesia



Source: Sorted by authors using data from Bankscope database.

Pillar 3 affiliates with market disciplines, where transparency and public disclosure allows market participants to make an independent assessment of the risk profile and banks' capital adequacy. In Pillar 3, transparency and publication of bank report, as well as delivery of an annual report to the central Bank of Indonesia are regulated in PBI regulation No. 14/14/PBI/2012.

Figure 2.3 Changes in Basel regulation



Source: Moody's 2013

In response to global financial crisis, BCBS published the global standard for banking regulation known as Basel III. Basel III was proposed to enhance the regulatory framework from Basel II. Under Basel III, capital consists of Tier 1 equity capital, Additional Tier 1 capital and Tier 2 capital. Tier 1 capital ratio (Tier 1 equity capital and additional Tier 1 capital) increases from 4% in Basel II to 6% in Basel III. This implies that banks tend to hold more capital in the future (Hull, 2012). According to Bank for International Settlements (BIS, 2010), Basel III requires higher quality of capital to ensure banks can absorbs loses and better coverage of risk, such as capital market risk. It also allows banks to have capital buffers during good economy condition to cover any losses in the period of stress. Figure 2.4 shows changes from Basel II to Basel III.

3 Literature review on Bank Efficiency

3.1 The Concept of Efficiency

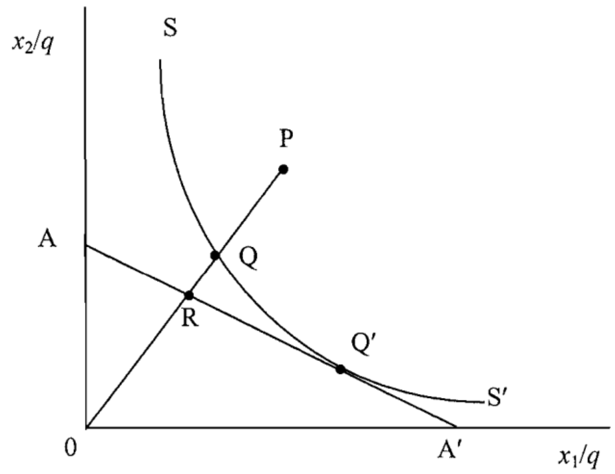
Efficiency is a measure of performance on how firm manage their resources to produce maximum output. It can be achieved by using less input to produce the same amount of output, by using the same input to produce more output and by using less input to produce more output (Coelli, et al., 2005).

According to Farrell (1957), firm efficiency is a combination of technical efficiency and allocative efficiency. Technical efficient signifies the ability to avoid waste in the process of transforming inputs into outputs. This could be done by minimising the use of input to produce a given level of output or the ability to produce as much output from a given set of input. The failure to attempt the best feasible combination of the usage of input and the amount of output produced is known as technical inefficiency. On the other hand, the allocative component refers to the ability to combine inputs and/or outputs in optimal proportions considering prevailing prices (Coelli, et al., 2005). Kumar & Arora (2010) on their paper argue that efficiency can be evaluated by generating a frontier in order to eliminate the drawbacks of ratio analysis and provide a more appropriate level or score of efficiency.

There are some approaches to estimate the efficiency of banks. These approaches are mainly focused on estimating an efficient frontier and measuring differences between the point at which the bank is operating and the best-practice frontier. This measurement of efficiency is called X-efficiency. It measures the use of inputs in order to create outputs, which reflect the productivity of a bank. Several functions can be used to derive efficient frontier namely production, cost, revenue and profit function (Coelli, et al., 2005). From these functions, cost function and profit function are commonly used in many literatures to measure the X-efficiency of a bank. With respect to cost frontier, it shows how management of the bank makes use of the inputs to produce outputs in a manner of reducing or minimising costs (Yildirim & Philippatos, 2007). Chu and Lim (1998) defined cost efficiency as the relative efficiency of banks at minimising costs in the production of earning assets. Profit efficiency, in contrast, measures how close a bank's profit is to the maximum possible profit (profit frontier) with a given level of input prices and output prices (Yildirim & Philippatos, 2007).

Cost efficiency measures bank's performance by looking at the operation of best practice banks, which operate on the efficient frontier that produces the same level of output. Production frontier can be used to get a more comprehensive concept of efficiency. The correlation between technical and allocative efficiency is illustrated in Figure 3.1 as follows:

Figure 3.1 Technical and allocative Efficiencies



Source: Coelli, et al., (2005)

Under the assumption of constant returns to scale, we assume that a firm utilised two factors of production or resources that are represented by X_1 and X_2 in order to produce a single output denoted by *q*. Returns to scale means that the behaviour of the rate of increase/decrease in production level (output) relative to the associated increase/decrease in the resources (input) in the long run. Line SS' is an isoquant line of production that is drawn by connecting set points at while changing the combination of quantities of two inputs, will produce the same quantity of output (Varian, 1992). This frontier is a measure of technical efficiency that portrays the operation of perfectly efficient firms and need to be determined using either parametric methods or non-parametric methods from a sample of firms in specified industry. Line OP defines the amount of resources used by a firm to produce a single output. Point P and Q produce the same amount of output. However, point Q lies on the efficient frontier which is technically efficient; while point P is on the above of the efficient frontier, thus the technical inefficiency of the firm can be measured by QP. To be technically efficient, a firm operating in point P needs to reduce the amount of input that can be expressed in a ratio resulted by dividing QP to OP. Technical efficiency also can be expressed by the ratio of OQ/OP, in which the highest value of this ratio is 1 (perfectly efficient). It indicates that the closer the ratio to 1 signifies higher technical efficiency.

Although a firm is technically efficient (point Q), it may not completely efficient relative to cost efficiency because point Q does not lie on the isocost line AA'. To be costly efficient, a firm operates in point Q should shift their operation to point Q', where SS' is tangent to AA'. This means that the firm is not only technically efficient, but also allocative efficient where it is able to combine an optimal proportion of inputs. The overall cost efficiency (CE) then can be expressed with the equation below:

$$CE = TE \times AE = \left(\frac{OQ}{OP}\right) \times \left(\frac{OR}{OQ}\right) = \left(\frac{OR}{OP}\right) \qquad (3.1)$$

Based on how they recognise inefficiency, Coelli, et al. (2005) introduce four methods to estimate frontier functions and efficiency measures. These four methods are least-squares econometric production models, total factor productivity (TFP) indices, data envelopment analysis (DEA) and stochastic frontier analysis (SFA). Further, these methods can be categorised into two techniques i.e. parametric techniques and non-parametric techniques (Berger & Humphfrey, 1997). Least-squares econometric production models and stochastic frontiers methods involve the econometric estimation of parametric functions, thus they are called parametric technique while TFP indices and DEA are included in non-parametric technique. The essential differences between these models are the shape imposed on the frontier and the assumption of distributional random error and inefficiency (Tahir & Haron, 2008).

3.2 Previous studies on Bank Efficiency

In the literatures, researchers used different approaches to estimate the efficient frontier. Yildirim & Philippatos (2007) examined bank efficiency and the effect of market structure, ownership and capitalisation. The SFA and the distribution–free approach (DFA) were employed to estimate cost and profit efficiency in twelve transition economies countries of Central and Eastern Europe (CEE) during 1993 to 2000. Then, the efficiency scores on bank-specific and industry-specific variables were regressed to see the influence of bank characteristics and industry factors on efficiency scores. Based on cost efficiency, banks in twelve CEE countries were operating efficiently with average cost efficient scores of 77% and 72% measured by SFA and DFA, respectively. This result suggests that inefficient banks would have to decrease their actual cost for about 23% to 28% to perform as best-practice banks. Profit efficiency, however, showed a lower average of efficiency levels at 5% truncation of 65.6% for SFA and 50.8% for DFA. Furthermore, higher efficiency banks usually have a large and well capitalisation compared to banks with lower efficiency. Looking at funding behaviour, banks that heavily rely on internal funding (i.e core deposits) to fund their assets tend to be more efficient.

Taking China banking sector as their samples, Fu and Heffernan (2007) applied the Stochastic Frontier Approach (SFA) to analyse cost X-efficiency over the period 1985 to 2002. A two-stage regression model is estimated to identify the significant variables affecting X-efficiency. Refer to the result, banks in China were found to be inefficient. The result implies that banks were operating in ranged between 40–60% below the best-practice frontier. This might happen as a result of agency problems. To improve the operation, banks need to be more efficient by reducing approximately 59% of their cost. Based on banks' ownership, the joint-stock commercial banks were found to be more X-efficient than the state-owned commercial banks.

Pasiouras et al. (2007) derived technical, allocative and cost efficiency using DEA for 16 Greek banks over 5 years. Tobit regression is used to see the link between internal factors as well as external factors on bank efficiency. The outcome of DEA efficient frontier presents a higher score of technical efficiency compare to allocative efficiency. It indicates that managers were able to manage the use of minimum level of input at a given level of outputs, however, they poorly selected the combination of optimal input at a particular price. Overall, Greek banks average efficiency score was 82%. From tobit regression, it appears that SIZE, EQAS, ATMs and BRANCHES as proxies of banks' internal factors and GDP per capita, unemployment rate, disposal income of household as variables of external factors have an effect on technical, allocative and cost efficiency. The result revealed that well-capitalised banks were technically efficient even if it did not affect allocative and cost efficiency. With respect to the size, larger banks tend to have higher efficiency scores in all three efficiencies. On the contrary, GDP per capita and unemployment rate were negatively correlated to efficiency. Pasiouras et al. (2007) also argue that the number of ATMs and bank branches affect bank efficiency differently correspond to the measurement of efficiency.

Olson & Zoubi (2011) on the paper of *"Efficiency and bank profitability in MENA countries",* traditional accounting-based and economic-based of banks' performance measurement were compared in ten Middle East and North Africa (MENA) countries. Using DFA to estimate cost and profit efficiency, it was reported that profit efficiency could explain financial performance of MENA banks better than cost efficiency. Spearman correlation coefficient was employed to assess the relationship between accounting-based variables (ROE and ROA) and economic-based variables (cost and profit efficiency). The result suggested there were a negative correlation between cost efficiency and profit measurement i.e. ROE and ROA. In contrast, profit efficiency was positively correlated to ROE and ROA. Although accounting numbers are able to explain financial ratio and economic efficiency, accounting-based and economic-based measure different feature of financial performance.

Numerous efficiency studies that are applied to banking industry take into account various topics in the literature. Some researchers investigated bank efficiency to bank governance (Burki & Ahmad, 2010; Girardone et al, 2009; Kauko, 2009; Pathan et al, 2007; Sanyal & Shankar, 2011), others examine efficiency and loan quality (Berger & De Young, 1997; Karim et al, 2010; Louzis et al, 2012), others focus on market structure (Berger, 1995; Frame & Kamerschen, 1997; Maudos, 1998; Zhang et al, 2013), some of them look into mergers and acquisitions (Akhavein et al, 1997; Al-Sharkas et al, 2008; Lin, 2005; Rezitis, 2008) and others consider the impact of efficiency on risk (Fiordelisi et al, 2011; Rao, 2005).

Despite of many researches pertaining to bank efficiency, only a few studies have examined the relationship between bank efficiency and share price performance in the marketplace (Beccalli et al, 2006). These include a study conducted by Kwan & Eisenbeis (1996) employing stochastic cost frontier based on a multiproduct translog function. Semi-annual data with a sample of 254 bank holding companies in US banking sector was used to analyse the link between X-inefficiency with risk-taking behaviour and stock returns from 1989 to 1991. To test the effect of efficiency on bank stock performance, OLS pooled was separately utilised for time-series and cross-section observations based on the bank size. The result showed a strong relationship between X-inefficiency and various indicators of bank risk-taking behaviour. Inefficient companies have a high deviation of common stock return, low capitalisation and high loan charge-offs. Relating to market performance, X-inefficiencies are able to explain firm's stock returns, after controlling for the stock market return and change in the risk-free interest rate.

Chu and Lim (1998) applied DEA to evaluate the relative cost and profit efficiencies of six Singapore listed banks over 5 years. Annual stock returns were used as the dependent variable and regressed it on annual percentage change in efficiencies. In an oligopolistic market, Singapore banks have a higher cost efficiency compared to profit efficiency. It means that banks in Singapore tend to minimise their cost rather than maximise their profit. Furthermore, larger banks have better average of efficiencies scores, for both cost and profit efficiencies, rather than small banks. Chu and Lim (1990) also found that changes in the price of bank shares signify percentage changes in the profit efficiency rather than cost efficiency.

Using DEA and SFA with three inputs and two outputs to estimate cost frontier, Becalli et al. (2006) investigated efficiency and stock performance in European banking such as France, Germany, Italy, Spain, and the UK between 1999 and 2000. Further, Becalli et al. (2006) examined whether changes in efficiency scores could have better explanation of changes in share price rather than financial ratios. The study employed a three-step procedure to help the analysis. To analyse the impact of X-efficiency to stock returns, three OLS regression models were tested. The first model was to regress stock performance on bank efficiency. Bank characteristics such as size, risk and profit were added to the second model. Finally, country dummies were entered to the second regression model. The key findings of the study indicated that changes in cost efficiency were reflected in changes in stock prices. On the contrary, the relationship between changes in stock prices and the cost to income ratio was not significant. It indicates that cost efficiency tend to outperform the cost to income ratio which is a proxy of traditional accounting ratios.

In another empirical study, Sufian and Majid (2006) studied the cost and profit efficiencies of Malaysian banks that are listed on the Kuala Lumpur Stock Exchange (KLSE) for the period of 2002-2003 by applying the non-parametric DEA model. Evidence showed that profit efficiency was more significant to the stock prices of Malaysian banks rather than cost efficiency. However, it was found that on the average, the score of cost efficiency of Malaysian banks was higher than profit efficiency. The results also suggested that on the average, the large banks were more cost efficient, but the smaller banks were found to be more profit efficient.

Kirkwood and Nahm (2006) used Data Envelopment Analysis (DEA) to evaluate cost efficiency of Australian banks in producing banking services and profit for the period of 1995 to 2002. The empirical result indicate that profit efficiency were statistically significant in determining stock returns of banks, particularly the regional banks. Moreover, evidence showed that major banks have improved their efficiency in producing banking services and profit, while the regional banks only had a slight change in the efficiency of producing banking services and a decline in their efficiency of producing profit.

Research in Greece banking industry has been done by Pasiouras, et al. (2008). The population was ten commercial banks that were listed in the

Athens stock exchange during 2000 to 2005. The study examined the association between the efficiency of Greek banks and their share price performance. Following Becalli, et al. (2006), three steps procedure were utilised in the analysis. Firstly, the annual share price returns were calculated. Then, the efficiency of the individual banks for each year obtained from DEA was estimated. Finally, the annual share price returns were regressed to the annual change of bank efficiency adding together with other bank financial characteristics as control variables. Two-way fixed effects panel regression was used for a panel data set which has observation over 5 years. Adopting studies from Drake et al. (2006), profit-oriented approach was chosen to select inputs and outputs for efficiency estimation, which denotes cost components as inputs and revenue components as outputs. As a result, it was found that the average technical efficiency under the constant returns to scale is 93.1% and increases to 97.7% under variable returns to scale. Moreover, scale efficiency was not significant to stock returns while technical efficiency was positively significant to bank's stock returns.

Liadaki & Gaganis (2010) have conducted an analysis into the cost frontier and profit frontier model using translog function. Their sample comprised of 171 banks in the EU markets during 2002-2006. Intermediation approach that was first introduced by Sealey & Lindley (1977) was applied using three outputs and three inputs. Stock performance was calculated as cumulative annual stock returns (CASR), based on monthly stock price data. Using fixed effects to regress annual return against percentage changes in profit and cost efficiency, the result implies that profit efficiency was positively related to stock returns, while cost efficiency was not related to market performance. Liadaki & Gaganis (2010) argue that profit is naturally reflected in the stock performance; hence, more profitable banks were expected to perform better in the market. Nonetheless, there was no correlation between cost efficiency and stock returns. It means that cost management was not accessible by the public and not incorporated directly in the stock price. Shareholders and investors are more profit oriented and therefore, they should consider profit efficiency scores which provide more relevant information.

Vardar (2013) empirically investigated the profit and cost efficiencies of Central and Eastern European (CEE) Countries that are listed on the stock exchanges of CEE countries over the period 1995-2006 by applying the parametric SFA model. Moreover, the study considered the influence of changes in efficiency to stock returns. Stock return was regressed against annual changes in efficiency, while controlling for bank size and risk using panel data analysis. To determine whether random effects or fixed effects that is more appropriate, several tests such as likelihood ratio, Breusch-Pagan Lagrange Multiplier (LM) test and Hausman's test were utilised. From these tests, the results implied that the fixed effects model was more appropriate than the random effects. The empirical findings indicate that changes in profit efficiency have a positive and statistically significant to stock returns. In contrast, the change in cost efficiency has a negative and statistically significant on bank stock returns. These results were not consistent to the results form preceding studies by Sufian and Majid (2006) and Liadaki and Gaganis (2010). In addition, among the two control variables included in the model, only bank size showed statistically significant result for both efficiencies scores.

Aforementioned above, the majority of studies regarding bank efficiency have covered banking industry in the U.S. and other developed countries (Berger et al. 1993; Berger and Humphrey, 1997) as well as EU countries (Bikker, 2001; Becalli, et al., 2006; Liadaki & Gaganis, 2010). Despite a large amount of literature on banking efficiency, there have been only a few studies taking into account the efficiency of Indonesian banking system linked to market performance. Among others are studies by Hadad et al. (2011) and Eltivia et al. (2014).

Hadad et al (2011) empirically investigated the monthly profit-based technical efficiency and productivity of Indonesian banks that are listed on the Jakarta Stock Exchange during 2003-2007 by applying the non-parametric DEA model, Slacks-Based model (SBM) and super-efficiency SBM to estimate bank efficiency. Over the sample period, it was found that listed Indonesian banks have a wide range of efficiency with the lowest score of 34% and the highest efficiency score of 97%. In relation to truncated regression analysis, the result exhibited a positive correlation between bank's efficiency scores and the share price and return on equity in all models. With respect to bank's ownership, it appears that foreign ownership was negatively significant in the super-efficiency modelling. This also suggests that foreign ownership of banks in Indonesia tend to be less efficient compared to domestic banks.

In another study, Eltivia et al. (2014) examined the effect of cost efficiency on stock performance of listed banks in Indonesia. Their population consists of Indonesian banks that are listed on the Indonesia Stock Exchange (IDX) during 2004 to 2011. Using DEA to derive cost frontier, intermediation approach was adopted to determine the inputs and outputs. Abnormal return is used as a measure of market performance. The abnormal return was regressed on the efficiency score using OLS and found that cost efficiency was not significant to the abnormal return. This result indicates that regardless of the score of cost efficiency, it will not affect the abnormal return.

4 Data Collection and Methodology

4.1 Data

This research considers the population of Indonesian commercial banks, which are listed on the Indonesia Stock Exchange (IDX). The data set is comprised over the year of 2006 to 2013. The bank-specific annual financial accounting data such as balance sheet, income statement and accounting ratios are manually collected from Bankscope database published by Bureau van Dijk's company. Annual stock prices of all listed banks are taken from Datastream, while the macroeconomic variables are obtained from the World Bank database.

All accounting data are reported in the Indonesian Rupiah (IDR) as the local currency and has been corrected for inflation according to the Indonesian GDP deflator which was reported in World Bank.

In this dataset the initial sample consists of 31 banks for the period of 8 years. The banks have to be classified as Indonesian listed commercial banks in the Bankscope database and are required to have available data for at least 4 years to be included in the dataset. Several criteria are set to choose the banks. Banks must have obtainable data of total assets, input elements (i.e. personnel expense, total interest expense, other operating expense), output elements (i.e. gross loans, other earning assets, total non-interest operating income) and market price. Banks that do not have data for all inputs and outputs that will be used in the model of this study are not included in the dataset. The selection process provides an unbalanced panel data since not all banks had available data over the sample period. The final dataset in this study consists of 27 banks with 191 observations over 8-year period. Table 4.1 represents the list of banks that are selected and included in the sample.

Table 4.1 Name of bank selected in the sample

No.	Name of Bank	No.	Name of Bank
1.	Bank Artha Graha Internasional Tbk	15.	Bank Negara Indonesia (Persero) - BNI
2.	Bank Bukopin	16.	Bank Nusantara Parahyangan
3.	Bank Bumi Arta	17.	Bank OCBC NISP Tbk
4.	Bank Central Asia	18.	Bank Of India Indonesia Tbk
5.	Bank CIMB Niaga Tbk	19.	Bank Pan Indonesia Tbk PT-Panin Bank
6.	Bank Danamon Indonesia Tbk	20.	Bank Permata Tbk
7.	Bank Ekonomi Rahardja	21.	Bank QNB Kesawan
8.	Bank Himpunan Saudara 1906	22.	Bank Rakyat Indonesia (Persero) Tbk
9.	Bank ICB Bumiputera	23.	Bank Rakyat Indonesia Agroniaga Tbk
10.	Bank Internasional Indonesia Tbk	24.	Bank Sinarmas
11.	Bank Mandiri (Persero) Tbk	25.	Bank Tabungan Negara (Persero)
12.	Bank Mayapada Internasional TBK	26.	Bank Victoria International TBK (PT)
13.	Bank Mega TBK	27.	BPD Jawa Barat dan Banten Tbk
14.	Bank Mutiara Tbk		

4.2 Methodology

Following Becalli et al. (2006) in generating information needed for analysis, this study comprises three stages. The first stage is to measure the annual efficiency scores for individual banks included in the sample by utilising the translog function to estimate efficient frontier. The second stage is to calculate the annual return of share price. The final stage is to regress bank stock performance on the yearly changes in efficiency to see the relationship in the estimated model.

4.2.1 Techniques in Efficiency Estimation

4.2.1.1 The Stochastic Frontier Analysis (SFA)

Efficiency scores can be measured by depicting a frontier which reflects the performance of the banks to a best practice efficient frontier. Firms that operate on the frontier are identified as technically efficient, otherwise they are not technically efficient (Coelli, et al., 2005). From the literature review in the previous chapter, the two most commonly used techniques for estimating efficiency in banking literature are non-parametric methods (i.e. DEA) and parametric methods (i.e. SFA or DFA).

According to Coelli et al. (2005), DEA method requires a simple calculation and does not require us to know the algebraic form of the relationship between inputs and outputs. Constructed from the observed inputs and outputs, it does not permit any shocks to production and cost. The main shortcoming of this model is that it considers any deviation from the frontier as inefficiency. It does not identify the difference between technical efficiency and random error. Moreover, there is no standard statistical test to ascertain whether the correct set of uncontrollable inputs or outputs have been employed (Drake, et al., 2006).

A mathematical form can explain the shortcoming of DEA model that was first proposed by Aigner and Chu (1968). Cobb-Douglas production frontier was used and takes the form as follows:

$$ln q_i = x'_i\beta - e_i \ , \ i = 1, 2, \ldots, N \qquad (4.1)$$

The q_i defines the output for the *i-th* firm while x_i represents a (K×1) vector consisting the logarithms of the input quantities. β is a vector of the unknown parameters, while e_i is a non-negative random error which determines technical inefficiency. The output values (q_i) of this model are determined from the non-stochastic quantity, exp$(x'_i\beta)$. There is no decomposition of error that takes into account the measurement of errors (inefficiency) and other statistical noise.

On the other hand, SFA involves functional form of the linear relationship between inputs and outputs. For instance, it utilises the technique of maximum likelihood to calculate extensive variety of stochastic frontier based on Cobb-Douglas normalised quadratic and translog functional forms which employ econometric techniques and hence needs extra calculation than DEA. The SFA model was first introduced in 1970s on three literatures that have been done by Aigner et al. (1977), Battese and Corra (1977) and Meeusen and Vanden (1977). Although SFA requires more complicated computation, it has some advantages that make the complexities in the involvement of econometric techniques worthwhile (Coelli, et al., 2005). SFA provides a breakdown of random error into a symmetric random error (statistical noise) and technical inefficiency to measure efficiency (Liadaki & Gaganis, 2010). It allows to distinguish inefficiency and other stochastic shocks (Yildirim & Philippatos, 2007). Consequently, any deviations from the efficiency frontier are technical inefficiencies (Spulbar & Nitoi, 2014). Moreover, this model also controlling for heterogeneity within the banks in the sample (Kumbhakar & Lovell, 2003).

SFA frontier is considered superior over the non-parametric frontiers because it distinguishes two components in the error term, two-sided standard noise and one sided non-negative random variable which represents inefficiency (Vardar, 2013). In addition, this method appoint the best practice bank which is the most efficient bank, then determine the efficiency level for other banks included in the sample relative to the best bank specified (Khatri, 2004).

The stochastic production frontier functional form can be defined by the following:

$$lnq_i = x'_i\beta + v_i - u_i \text{ , } i= 1, 2,\ldots,N \qquad (4.2)$$

lnq_i is the logarithm of the output for the *i-th* firm. $f(x'_i\beta)$ is a production frontier where x_i represents a (K×1) row vector consisting the logarithm of the input quantities and β is a vector of the unknown parameters. Random error contains two components: v_i and u_i. v_i is a symmetric random variable to account for random noise whereas u_i denotes a non-negative random error that determines and associated with technical inefficiency.

Knowing that the production function is $f(x'_i\beta)$ and the error term is $e_i = v_i - u_i$, Coelli et al. (2005) described three forms of Cobb-Douglas stochastic frontier model as follows:

$$lnq_i = \beta_0 + \beta_1 lnx_i + v_i - u_i \qquad (4.3)$$

Or $$q_i = \exp(\beta_0 + \beta_1 lnx_i + v_i - u_i) \qquad (4.4)$$

Or $$q_i = \exp(\beta_0 + \beta_1 lnx_i) \times \exp(v_i) \times \exp(-u_i) \qquad (4.5)$$

The link between the production frontier and its error can be written as:

$$q_i = f(x'_i\beta) \times \exp(v_i - u_i)\text{, where } u_i \geq 0 \qquad (4.6)$$

Disintegrating the equation above (equation 4.5), it can be explained that deterministic factor is represented by the $\exp(\beta_0 + \beta_1 lnx_i)$, statistical noise is defined by $\exp(v_i)$; and inefficiency is expressed by the $\exp(-u_i)$.

Stochastic model allows us to distinguish the effect of statistical noise and inefficiency; hence, it is important to present the basic statistical assumption for the error components. The stochastic frontier model asserts that the error is made up from two independent elements of errors: 1) v_i that is distributed as a two-sided normal distribution with zero mean and variance = σ_u^2; and 2) u_i that is a non-negative value which follows a one-sided distribution. The noise v_i is assumed to be independently and identically distributed (i.i.d), symmetric and independently distributed to u_i. Therefore, the combined error is asymmetric since $e_i = v_i - u_i$ where $u_i \geq 0$. These distributional assumptions of the inefficiency term are needed to estimate the technical inefficiency itself.

The majority of econometrics frontier analysis is used to predict the effect of inefficiencies. The most notable output-oriented measure of technical efficiency (TE) is the ratio of observed output to the corresponding stochastic frontier output:

$$TE = \left(\frac{Observed\ Output}{Potential\ Maximum\ Output}\right) \tag{4.7}$$

$$TE = \left(\frac{q_i}{\exp(x'_i\beta + v_i)}\right) = \left(\frac{\exp(x'_i\beta + v_i - u_i)}{\exp(x'_i\beta + v_i)}\right) = \exp(-u_i) \tag{4.8}$$

The value of TE is ranged from 0 to 1. A value of 1 means that the firm is fully efficient in production activity and the observed output $q_i$reaches its maximum value. A value of TE below 1 measures inefficiency in production activity from the observed outputs from the maximum possible output.

To get a better understanding of how random error explains inefficiency in the SFA, Coelli et al (2005) assume there are two firms; firm A and firm B, which produce one output q_i using a single input x_i. Firm A consumes

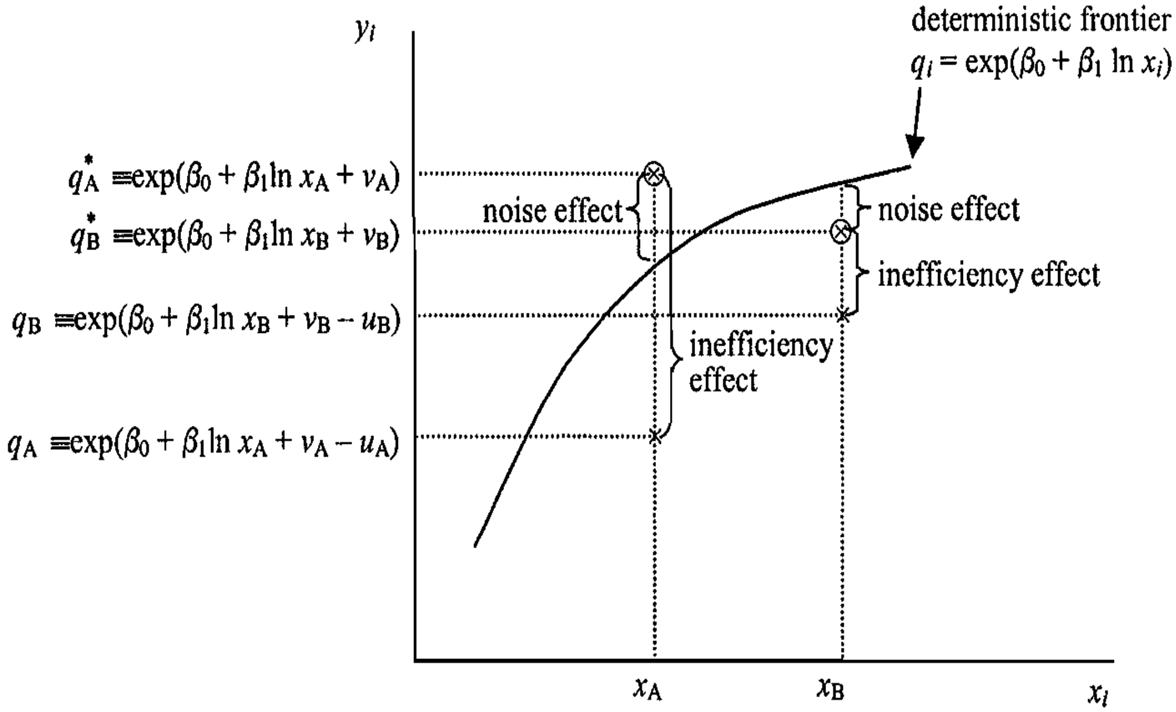
x_A as the quantity of input to produce one unit of output q_A, whereas firm B utilises the quantity of input x_B to produce a single output q_B. In Figure 4.1, the observed dependent variable values q_A and q_B are indicated by X. Values of the input lie beyond the horizontal axis while outputs are measured along the vertical axis. If there are no inefficiency effects ($u_A = 0$ and $u_B = 0$), then referring equation 4.4, the equation for frontier outputs for firm A and firm B would be expressed as below:

$$q_A{}^* = \exp(\beta_0 + \beta_1 ln x_A + v_A) \qquad (4.9)$$

$$q_B{}^* = \exp(\beta_0 + \beta_1 ln x_B + v_B) \qquad (4.10)$$

These frontier values $q_A{}^*$ and $q_B{}^*$ are marked by $\otimes$ in Figure 4.1.

Figure 4.1 Random noise and inefficiency effects in SFA production frontier



Source: Coelli et al., (2005)

The frontier Figure 4.1 is plotted based on the input and output of firm A and B. From the frontier above, it can be seen that without inefficiency effect, the frontier output for firm A is above the deterministic part of the frontier $q_i = \exp(\beta_0 + \beta_1 ln x_i)$ as a result of the positive value of noise effect (i.e $v_A \geq 0$), while the frontier output for firm B lies below the deterministic part of the production frontier due to the value of noise effect is negative (i.e $v_B < 0$). Taking into account inefficiency effect, the observed output for firm A occur below the deterministic part of the frontier because of the total of statistical noise and inefficiency effects is negative (i.e $v_A - u_A < 0$) (Coelli, et al., 2005).

Aforementioned before, the random error for equation 4.3 consists of (v_i) and (u_i). This model assumes that the errors are independently distributed of each other and both errors are not correlated with the explanatory variables x_i. Moreover, it is assumed that:

$E(v_i) = 0$ (zero mean)
$E({v_i}^2) = {\sigma_v}^2$ (homoskedastic)
$E(v_i v_j) = 0$, for all i ≠ j (uncorrelated)
$E({u_i}^2) =$ constant
$E(u_i u_j) = 0$, for all i ≠ j (uncorrelated)

4.2.1.2 The Cost Frontier

Technical and allocative efficiencies lead to profit maximisation or cost minimisation and therefore, inefficiency from the error term or any deviation from a profit or cost frontier can be used to measure performance (Coelli, et al., 2005). A cost frontier is used to obtain the efficiency scores of banks in Indonesia. This study employs a stochastic frontier function model for panel data developed by Battese and Coelli (1995). This model allows estimating the efficiency in a single step while take into account the impact of exogenous variables. Adopting the model from production frontier as discussed in sub-chapter 4.2.1.1 and implementing the SFA general mathematical form; added a subscript '*t*' to represent time in a cost frontier can be written as a cost functional model shown below:

$$TC_{it} = TC(y_{it}, p_{it}; \beta) + \varepsilon_{it} \text{ , } i = 1, 2, \ldots, N \text{ and } t = 1, 2, \ldots, T \tag{4.11}$$

where TC_{it} is the observed dependent variable, that measures bank's total production cost of the *i-th* firm in the *t-th* period which includes operating and financial costs, while y_{it} and p_{it} are vectors of outputs and inputs prices of the *i-th* firm in the *t-th* period, respectively. Vectors of unknown parameters to be estimated are represented by β; ε_{it} stands for an error term (Liadaki & Gaganis, 2010).

Expressing the cost function into logarithmic form, the equation can be written as follows:

$$\ln TC_{it} = f(y_{it}, p_{it}; \beta) + \ln \varepsilon_{it} \tag{4.12}$$

Where *f* denotes a functional form after particular cost function has been estimated. The error term above $(ln\varepsilon_{it})$ can be decomposed into two components.

$$ln\varepsilon_{it} = lnu_{it} + lnv_{it}$$

lnu_{it} stands for one-sided error term and is assumed to be non-negative random variables. It estimates deviation from a frontier or x-efficiencies for each bank *i* at time *t*, the aberration above the minimum cost frontier (x-inefficiency) associated with either technical inefficiency, i.e. excessive use of inputs in the production of outputs or allocative inefficiency (Berger & Humphrey, 1992). $lnu_{it}$is independently distributed inefficiency effects; it is attained from truncated distribution at zero of normal distribution

$N(m_{it}, \sigma_u^2)$, where m_{it} assign to as $m_{it} = z_{it}\delta$. Notation z_{it} is a vector of variances that affect the efficiency of the *i-th* firm in the *t-th* period. δ is the vector of the parameters to be measured (Liadaki & Gaganis, 2010). If lnu_{it} is equal to zero, a company is said to be technically efficient, while if it is greater than zero, a firm is technically inefficient (Tran, et al., 2008).

The stochastic random error component (lnv_{it}) has symmetrical normal distribution and assumed to be independent and identically distributed across observation with mean zero and constant variance ($v_{it} \sim N(0, \sigma_v^2)$. Moreover, lnv_{it} and lnu_{it} have to be statistically independent of each other.

The cost efficiency for bank *i* is measured by the ratio between minimum cost (C_{min}) necessary to produce the bank's output and the actual cost (C_{it}). It can be expressed as follows (Yildirim & Philippatos, 2007):

$$COSTEFF_i = \frac{C_{min}}{C_{it}} = \frac{exp[f(y_{it}, p_{it}; \beta)]x\ exp(lnu_{min})}{exp[f(y_{it}, p_{it}; \beta)x\ exp(lnu_{it})]} = \frac{u_{min}}{u_{it}} \qquad (4.13)$$

Where u_{min} is the minimum u_{it} within all banks in the samples. Under this equation, an efficiency estimation score of 0.90 means that the bank is 90% cost efficient from the actual costs operate in the cost frontier (Yildirim & Philippatos, 2007).

4.2.1.3 Translog functional form

Parametric technique employs a frontier from a functional form such as translog function. This study includes three inputs and three outputs; hence, a multiproduct translog cost function is used. Following Becalli, et al. (2006) and Kwan & Eisenbeis (1996), the cost frontier translog function can be expressed as follows:

$$lnTC_n = \alpha_0 + \sum_{i=1}^{3} \alpha_i lnY_i + \sum_{j=1}^{3} \beta_j lnP_j + \frac{1}{2}\left[\sum_{i=1}^{3}\sum_{j=1}^{3} \delta_{ij} lnY_i lnY_j + \sum_{i=1}^{3}\sum_{j=1}^{3} \gamma_{ij} lnP_i lnP_j\right] + \sum_{i=1}^{3}\sum_{j=1}^{3} \rho_{ij} lnY_j lnP_i + \varepsilon_n$$

This cost function should satisfy standard symmetry and linear restrictions. As a consequence, TC, P1 and P2 are normalised by the price of capital (P3). The standard symmetry is fulfilled when $\delta_{ij} = \delta_{jt}$ and $\gamma_{ij} = \gamma_{jt}$. The linear homogeneity condition in factor prices are satisfied when,

$\sum_{j=1}^{3} \beta_j = 1$ $\quad\quad$ $\sum_{i=1}^{3} \gamma_{ij} = 0$ $\quad\quad$ $\sum_{j=1}^{3} \rho_{ij} = 0$

The dependent variable (lnTC) is the natural log of total cost. Total cost is the total of personnel expenses, interest expenses and other operating expenses. There are three outputs (Y_i) and three inputs prices (P_j) included in this study. The outputs are gross loans (Y_1), other earning asset (Y_2) and total non-interest operating income (Y_3). The inputs prices are composed by price of labour (P_1), price of borrowed fund (P_2) and price of capital (P_3), while ε_n represents two-component stochastic error term.

The inputs and outputs variables that are used to estimate cost efficiency are selected based on the intermediation approach proposed by Sealey & Lindley (1977) as cited in the studies of Liadaki & Gaganis (2010). This approach considers banks as intermediaries of financial services where banks collect purchased funds and transform them into loans, investments and other assets (Burki & Ahmad, 2010). Intermediation approach is when asset in the balance sheet are treated as ouputs and the inputs consist of liabilites and physical factors of production such as labor, physical capital and deposits (Hughes & Mester, 2008). Since it considers deposit as inputs, it considers interest on deposits as a component of total cost together with labour and capital expenses and defined loan and investments as outputs (Yildirim & Philippatos, 2007). Elyasiani and Mehdian (1990) argue that the intermediary approach is more appropriate of total banking cost because the interest expenses associated with deposits and other liabilities are included in cost; hence it appropriately categorises deposits as inputs. Furthermore, Drake et al. (2006) pointed out that the intermediation approach concerns on the technical efficiency of the financial intermediation process.

Accordingly, three input and three output variables are chosen.

Input Prices Variables

1. Price of Labour (P_1)

   Burki and Ahmad (2010) calculated the price of labour by dividing total expenditure on employees' salary including directors' fees divided by the total number of employees. However, because of the data on number of emloyees is not available for all banks included in dataset, therefore P_1 is calculated as the ratio of personnel expenses over total asset. This estimation is common in the studies that used BankScope dataset (Yildirim & Philippatos, 2007; Liadaki & Gaganis, 2010; Vardar, 2013). Majority of studies in bank efficiency used this variable as firms' function associated with labour to deliver services.

2. Price of Funds (P_2)

   Price of funds is determined as the ratio of total interest expense to total funding. Total funding is the summary of deposit and short term funding and other interest bearing liabilities. Consistent with previous studies by Yildirim & Philippatos (2007) and Liadaki & Gaganis (2010), price of funds is selected as an input variable.

3. Price of Capital (P_3)

   The price of capital is computed by dividing other operating expense to fixed assets. This cost is vital to be considered in the banking industry as pointed out by several previous studies. For example Sufian (2011) has employed this input to examine the efficiency of multinational banks operating in the Malaysian banking sector from 1995 to 2007, whilst Becalli et al (2006) have used this element in the efficiency of European banking industry and Vardar (2013) who have considered this variable to estimate efficiency of banks in transition countries.

<u>Outputs Variables</u>

1. Gross Loans

   Gross loans is the most commonly used variable in the study of bank efficiency since it is often the main product that is produced by the banks. Several papers have used this variable as the output, among others Becalli et al. (2006), (Yildirim & Philippatos (2007) and Vardar (2013).

2. Other Earning Assets

   Other earning assets refer to the investment securities other than loan to customers, including bonds, certificates of deposit (CDs) and other interest or dividend earning accounts or instruments. Income-producing assets are considered to be included as an output variable as emphasised in several previous studies such as Liadaki & Gaganis (2010), Vardar (2013) and Spulbar & Nitoi (2014).

3. Total Non-Interest Operating Income
   Banks charge fees that provide non-interest income as a way of generating revenue to ensure that they have sufficient liquidity in the event of increased default rates. These include deposit and transaction fees, insufficient funds (NSF) fees, annual fees, monthly account service charges, inactivity fees, check and deposit slip fees.

The summary of input prices and outputs can be seen in the Table 4.2 below.

Table 4.2 Descriptive statistics for outputs, inputs, and input prices

Variables	Minimum	Maximum	Mean	Standard Deviation
Y1 = Gross Loans	457,500	471,815,400	56,519,921	84,988,581
Y2 = Other Earning Asset	138,600	216,610,000	29,048,900	46,280,513
Y3 = Total Non Interest Operating Income	1,612	16,568,600	1,514,055	2,732,633
X1 = Personel Expense	15,600	12,232,000	1,488,977	2,211,440
X2 = Total Interest Expense	68,900	17,432,200	3,225,698	3,829,960
X3 = Other Operating Expense	12,200	11,506,000	1,628,868	2,336,986
P1 = Price of Labour	0.0037	0.0348	0.0160	0.0056
P2 = Price of Funds	0.0188	0.1165	0.0548	0.0167
P3 = Price of Capital	0.2431	7.2840	1.6201	1.2215

Source: Computed by authors using data from Bankscope database.
Note: Y and X quantities are in million IDR
outputs (Y), inputs (X), and input prices (P)

4.2.2 Stock Performance and Bank Efficiency - Panel data models

In econometrics, the term panel dataset is a combination of cross sections and time series data. It contains observations of group of cross-sectional subjects or units such as firms, states, countries or industry, which are observed at several points of time (Greene, 2012). The number of cross-sectional units or individuals is denoted by N while T denotes the number of the observed time period. Panel data allows us to take into account the unobserved individual effects or heterogeneity (Hill, et al., 2012).

This study uses an unbalanced panel data which individuals in the sample have a varying number of observations (i.e the amount of year observed is different across banks). Specifically in banking industry, panel data associates with several econometric issues. Firstly, banking industry is potentially to be modelled as heterogeneous cross-sectional units, however, estimation in this study is conducted supposing homogeneity. This approach is vindicated on the assumption that parameters are homogeneous across banks (Majid & Sufian, 2008). Furthermore, when the sample is observed for a short period of time, homogeneous panel estimation appears to be a preferable approach compared to heterogeneous panel data estimation (Baltagi et al. in Majid & Sufian, 2008).

Secondly, there are three methods that need to be considered when working on panel data. These are pooled model, fixed effects model and random effects model. The basic equation for panel data set is a regression model, which takes the following form (Greene, 2012):

$$y_{it} = z_i'\alpha + x_{it}'\beta + u_{it} \quad i = 1,2,\ldots.N;\ t = 1,2,\ldots.T_i$$

Where the subscript i for individuals and t represents time. y_{it} stands for dependent variable, x_{it} represents explanatory variables and excluding a constant term, while $z_i'\alpha$ is individual effect (heterogeneity) in which z_i includes a constant term and a set of other variables that may be observed or unobserved.

The estimators for panel data then can be differentiated as follows:

1. Pooled regression

An Ordinary Least Squares (OLS) can be used for panel data and provides a consistent and efficient estimation of α and the slope vector β if z_i only consists a constant term (Greene, 2012). The data on different individuals are simply pooled together without provision for individual differences that might lead to different coefficient. The coefficients in pooled model are assumed to be constant for all individuals in all time periods and do not allow for individual heterogeneity.

$$y_{it} = \alpha + x_{it}'\beta + u_{it}, \qquad u_{it} \sim iid\ N(0, \sigma_u^2)$$

2. Fixed Effects

If differences exist between cross sectional individuals, z_i cannot be assumed as constant. If z_i correlated with regressors, the OLS estimate is not consistent, which is known as heterogeneity bias. Thus, fixed effects panel data model can be used. Fixed effects model allows for individual heterogeneity and the differences between these individuals are assumed to be captured in the α_i. Note that $\alpha_i = z_i'\alpha$.

$$y_{it} = \alpha_i + x_{it}'\beta + u_{it}$$

3. Random Effects

Another condition is when z_i is not correlated with regressors, the OLS estimates are consistent but not efficient. The $\alpha_i$is part of disturbances together with group specific random element or random effect (v_{it}). In random effects model, individual differences are assumed to be captured by the intercept and are treated as random.

$$y_{it} = \alpha_i + x_{it}^{'}\beta + \varepsilon_{it}$$

Where $\varepsilon_{it} = u_{it} + v_{it}$. The error term $\varepsilon_{it}$is composed of a component v_{it}that represents a random individual effect and the component of u_{it} that represents the usual regression random error.

Becalli et al., (2006) employed OLS for one year analysis of bank efficiency and share performance. OLS regression does not take into account for the possible endogeneity. In a dataset observed more than one year, observations within individuals (banks) may be correlated, hence, the standard errors often have a substantial downward bias. As a consequence, independence characteristics of OLS may be violated and the resulting pooled OLS estimator may be biased (Pasiouras, et al., 2008; Vardar, 2013). In this paper, the efficiency scores and stock returns are observed over the period of 2006 to 2013. The use of fixed effects or random effects are considered to be more appropriate instead of using OLS. The main assumption in random effects model is that the random individual differences are not correlated across individuals (Hill, et al., 2012). However, this model is appropriate for a sample with individuals that are selected randomly from a large population (Pasiouras, et al., 2008). As mentioned in Judge et al. (1988) and Gizycki (2001), "*A fixed effects model is a natural choice since our estimation sample is identical to the population of interest"* (Pasiouras, et al., 2008). In addition, fixed effects model allows individual errors in different time periods to be correlated, while individual heterogeneity are assumed to be captured by the intercept (Hill, et al., 2012). The sample in this research includes all commercial banks that are listed in IDX rather than a random sample from the population of financial institutions in Indonesia, hence, a fixed effects model is used.

For the purpose of this study, adopting the model proposed by Pasiouras et al. (2008), this research employs panel data analysis to identify the relationship between stock performance and bank efficiency. Looking at the characteristics of the dataset, a two-way fixed effects panel regression approach is utilised to take into account time specific as well as individual specific fixed effects, which ought to be controlled for in estimation. Dummy variables for banks and years are included in the regression. One of the bank and time dummies are dropped to prevent perfect collinearity among dummy variables. White heteroskedastic (robust standard errors) is also used in the estimated model to control for cross-section heteroskedasticity with corrected degrees of freedom (Pasiouras, et al., 2008; Vardar, 2013). The general two-way fixed effects estimation can be written in the following (Pasiouras, et al., 2008):

$$y_{it} = \alpha + x_{it}\beta + \gamma_i + \delta_t + \varepsilon_{it}$$

The notation y_{it} is the dependent variable (annual return) where i denotes the cross-section identifier (in our case banks) while t represents the time period. The α stands for the overall constant in the model and x_{it} is a *k*-vector of independent variables (i.e annual change in efficiency (dte), SIZE, ROAE and EQAS for bank i in year t). The γ_i and δ_t represent cross-section specific effect and time specific effects, respectively. The ε_{it} are the error terms for $i = 1,2, \dots N$ cross-sectional units (i.e banks) observed for t period, $t = 1,2, \dots T$ (i.e 2006-2013).

The complete specification of the estimated models is:

Model 1: $y_{it} = \alpha + \beta_1 dte_{it} + \beta_2 SIZE_{it} + \beta_3 dROAE_{it} + \beta_4 dEQAS_{it} + u_{it}$

4.2.3 Dependent Variable

In order to analyse market performance and efficiency, annual stock price returns as dependent variable needs to be calculated. Following Chu & Lim (1998), this study use year-end stock prices to compute the annual stock returns, using the following equation:

$$\text{Annual Stock return in year t} = \frac{\text{stock price (t)} - \text{stock price(t}-1)}{\text{stock price (t)}}$$

4.2.4 Independent Variables

Independent variables consist of bank-specific factors which reflect the size, profitability and risk of the bank.

4.2.4.1 Technical Efficiency (*dte*)

The annual percentage change of cost efficiency is used in the regression. Efficient banks operate in a way that they use their resources to produce maximum amount of product and services. By pressing the budget to the feasible minimum cost, they could generate more profit, hence create more shareholders value. Previous studies examined the relationship between technical efficiency and stock returns (Becalli et al, 2006; Chu & Lim, 1998; Liadaki & Gaganis, 2010; Pasiouras et al, 2008). Efficiency changed is used because the change between year t and t-1 is seen as publicly available information by the shareholders and potential investors who have interest and aim to make investments on bank stocks. It is expected that the change in cost efficiency has a positive relationship to stock returns (Becalli, et al., 2006; Vardar, 2013).

4.2.4.2 Size

Studies in banking industry often use total assets of the bank as a proxy for its size to account for size-related economies or diseconomies of scale. The size of bank is calculated by taking the natural log of total asset of the bank (Becalli, et al., 2006; Nguyen, et al., 2012). According to Kosmidou (2008), this variable is an important factor to determine bank performance. For instance, large size firm may result in economies of scale that will reduce the cost of gathering and processing information, hence reflects better performance.

4.2.4.3 Return on Average Equity (*dROAE*)

ROE is considered to be the most important indicator of banks' profitability and growth. This study uses the ratio of return on average equity (ROAE) as a measure of bank profitability. Return on equity is the net income divided by shareholders' equity. This rate indicates the rate of returns to shareholders or the return generated from the money that shareholders have invested in the bank. The higher the ratio of ROE the better bank performance is. Potential investor and shareholders rely on ROE trends to predict banks' future performance (Casu, et al., 2006). Average equity is being used in this study, in order to capture any differences that occurred in equity during the fiscal year. The annual percentage change of return on average equity (*dROAE*) is used in the regression. This variable is expected to have a positive impact on stock returns.

4.2.4.4 Equity over Asset (*dEQAS*)

EQAS is a measure of capital strength or capital adequacy which can be calculated by dividing average equity to average assets. A high capital to asset ratios is assumed to be an indicator of low leverage and therefore lower risk (Kosmidou, 2008). As a measure of capital adequacy, this ratio refers to the sufficiency of the amount of equity to absorb any shocks that the bank may face in the future. It is expected that the higher the equity to assets ratio, the lower the need to external funding and therefore the higher the profitability of the bank. Moreover, well-capitalized banks have lower probability of going bankrupt which lessen their costs of funding (Brealey , et al., 2014). The annual percentage change of EQAS (*dEQAS*) is used in the regression.

5 Empirical findings

5.1 Cost Efficiency estimation

In this study, cost efficiency is derived from a parametric techniques namely SFA. The coefficients of the cost frontier and technical inefficiency effects model can be measured using the maximum likelihood method under the assumption of a normal distribution for u_{it} (Coelli, et al., 2005). Maximum likelihood estimation is used to take into consideration the asymmetric distribution of the inefficiency term. Gamma distribution is the only distribution that provides a maximum likelihood estimator with all appropriate properties (Greene , 1980). Nonetheless, following Van den Broeck et al. (1994) this study uses truncated distribution functions because it is proficient to distinguish statistical noise and inefficiency terms (Mastromarco, 2008).

Aforesaid above, maximum likelihood estimation considers the asymmetric distribution of the inefficiency term. The degree of asymmetry can be represented by the parameter namely lambda (λ). Lambda is calculated by the following equation (Aigner, et al., 1977):

$$\lambda^2 = \frac{\sigma_u^2}{\sigma_v^2} \geq 0$$

If $\lambda = 0$, there are no technical inefficiency effects and all deviations from the frontier attributed to random noise. However, the two parameters affiliated with the normal and half-normal distribution are gamma (γ) and sigma square (σ^2) instead of lambda (λ) and sigma (σ). This is because the original frontier package re-parameterize the log-likelihood function (Battese and Corra,1977 in Perlis, 2013). The value of gamma signifies the proportion of variation in the model that is due to capacity utilization.

The suitability of stochastic frontier approach can be verified by estimating the value of gamma (γ) (Battese & Corra, 1977; Coelli et al., 2005). Gamma can be calculated by taking the following form (Battese & Corra 1977; Coelli et al. 2005):

$$\gamma = \frac{\sigma_u^2}{\sigma^2}$$

where $\sigma^2 = \sigma_v^2 + \sigma_u^2$

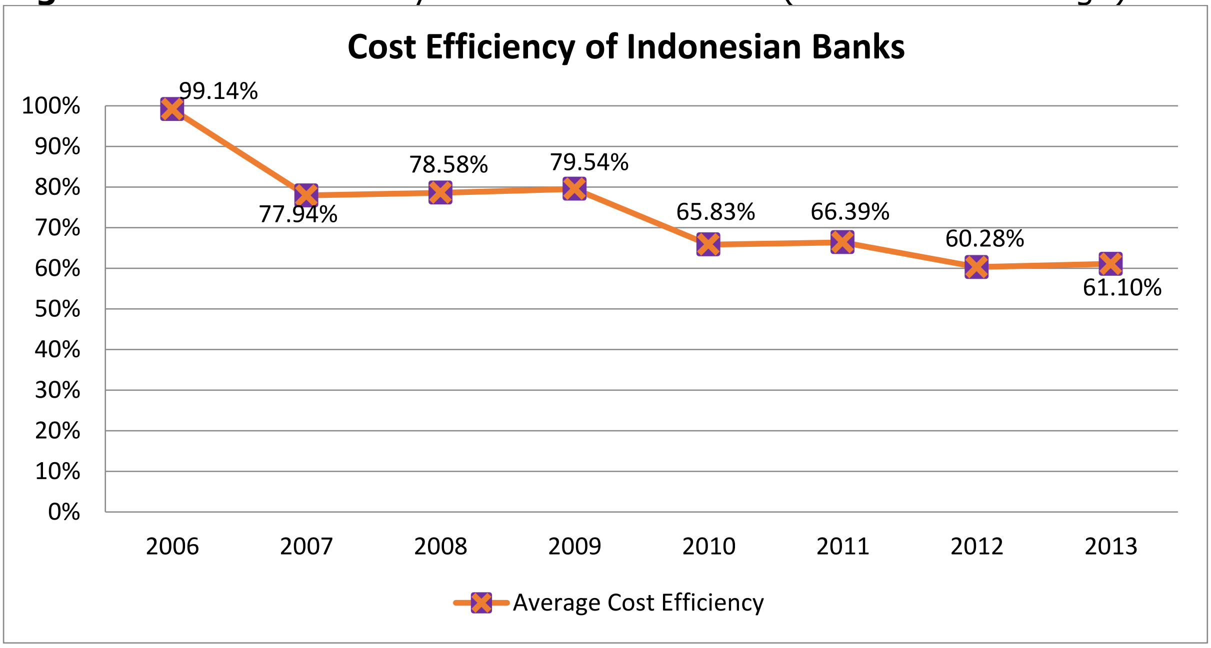
σ_v^2 and σ_u^2 are variances of the noise and inefficiency effects. A value of gamma ranged between 0 and 1, in which the value near to zero means any aberrations from the frontier are ascribed to random noise, whereas a value close to one signifies that all deviations are attributed to technical inefficiency (Tran et al., 2008; Charoenrat & Harvie, 2013).

The econometric package STATA 13 allows us to obtain parameter u_i which is used to estimate SFA. The STATA output showed the value of gamma 0.4739 (Appendix A2), indicates that almost half of the variance in the combination of error term is caused by inefficiency component.

5.1.1 Cost Efficiency scores

This section provides the result of the cost efficiency score. As it can be observed in Figure 5.1, the technical efficiency scores of banks in Indonesia have been deteriorating gradually and showed a downward trend over 8 years. Prior to the GFC in 2006, most of the commercial Indonesian banks were costs efficient. This can be explained by looking at the post Asian financial crisis in 1997. Aforementioned in chapter 2, after the Asian economic crisis, Indonesian banking sector had recovered and achieved good performance as a result of restructuring and the consolidation process. Evidence from a research by Harada & Ito (2005) revealed that the capital injection and bank consolidation had improved the efficiency in the management of the banks. Private banks that did not receive any capital injection after the Asian crisis performed well while state banks had recovered their efficiency since 2000 to 2003. Overall, the finding showed that the Indonesian banking industry has been improving slowly but steadily.

Figure 5.1 Cost Efficiency of Indonesian Banks (2006-2013 average)



Source: Based on authors' calculation

In 2007, cost efficiency in Indonesia dropped more than 20% from the level of 99.14% in 2006. This condition is similar to a study that has been done by Sun & Chang (2011) who found that the cost efficiency in Indonesia was highly volatile and this might happen as a result of high volatility of interest rate and exchange rate. The incisive falloff in domestic currency had negative effects on the important banks' balance sheet (Sufian & Habibullah, 2010).

This result is also consistent with the results of earlier study by Liu & Chen (2012) who compared the bank efficiencies in South-East Asia countries such as Indonesia, Malaysia and Thailand for the period of 2002 to 2009. The key finding from the paper is that efficiency in Indonesian banks were enhanced after the financial crisis in 1997 but then appeared to be declining from the year 2006 to 2009.

Another research by Soetanto & Ricky (2011) discovered a decline in the technical efficiency of banks in Indonesia. The average of technical efficiency obtained by intermediation approach ranged between 92% in 2006 to 88% in 2009. The overall mean during this period was equal to 0.895 (89.5%) which indicates that to be fully efficient, banks could have saved 10.5% of inputs in order to produce the same level of output. They argued that the rationale reason for this circumstance could be the global financial crisis that hit the economy during those years.

Another significant decline in cost efficiency occurred in 2010. There is not much evidence from the earlier studies to explain why cost efficiency in Indonesian banks declined during 2010 to 2013. However, refering to Indonesian Banking Survey 2013 that has been conducted by PwC Indonesia, operational risk is the most concerning risk in 2013 from the perspective of senior executive of the banks. Some of the banks reported that they had exceeded their budget which indicates inefficiency. The occurrence of inefficiency is most likely as a result of unqualified and inexperienced staff on lending and IT area (PwC Indonesia, 2013). As an intermediary in the financial system, banks are required to be more efficient, hence, they need to increase supporting infrastructure such as excellent human resources and enhance the IT systems. They argue that growth in business without the rise in talents and IT systems lead to a high operational risk (PwC Indonesia, 2013). Liu & Chen (2012) gave the same suggestion for Indonesian banking in favour of being more cost efficient. They recommended the banks to adopt more superior technology by using new software or introducing new financial product to expand income sources and endorse cost reduction programs.

From the survey, PwC Indonesia (2013) found that more than 50% respondents (banks' senior executive) managed to exceed the budget by more than 10% due to the change in market environment. With regards to human resources, in reference to more sophisticated business models and risks undertaken by banks, they need more qualified and experienced staffs to run the business. Whereas in IT sector, the enhancement in IT infrastructure is not only needed for business operations, but also for accelerating the effectiveness of risk management, information analysis and compliance.

5.1.2 Cost Efficiency Estimates and the Size of Assets

In banking studies, the size of bank is often included as a relevant indicator of bank efficiency. This variable is believed to influence bank performance as small banks and large banks may apply different resources to create the same services such as loans which are one of the main outputs of banks. For example, large banks may provide huge amount of loans based on particular assessment and precise evaluation of firm's investments portfolio strategy, whilst smaller loans may usually produced by small banks through screening procedures or long-term relationship with their clients (Han, et al., 2012).

As banks grow larger, they should enjoy scale economies because a larger portfolio of loans and a larger base of deposits makes bank becomes better diversified. Diversification makes it possible for larger banks to manage risk with fewer resources. In addition, *the overhead costs, especially those associated with information technology, could be considered as another source of scale economies* (Hughes & Mester, 2013).

Most of the past papers use total assets as a proxy of bank size (Maudos, 1998; Han, et al., 2012). For the purpose of examining how size and efficiency in banks related, adopting the study of Mohan (2005) and Das & Ghosh (2009), the commercial Indonesian banks that are included in the sample are classified into 3 asset size categories. Group 1 consists of large banks with average total assets more than IDR 100,000,000 mil; Group 2 is for medium banks which have average total asset between IDR 50,000,000 mil – 100,000,000 mil and Group 3 comprises small banks having average total assets below IDR 50,000,000 mil. Table 5.1 presents the average of cost efficiency scores relative to the size of asset for banks included in the sample.

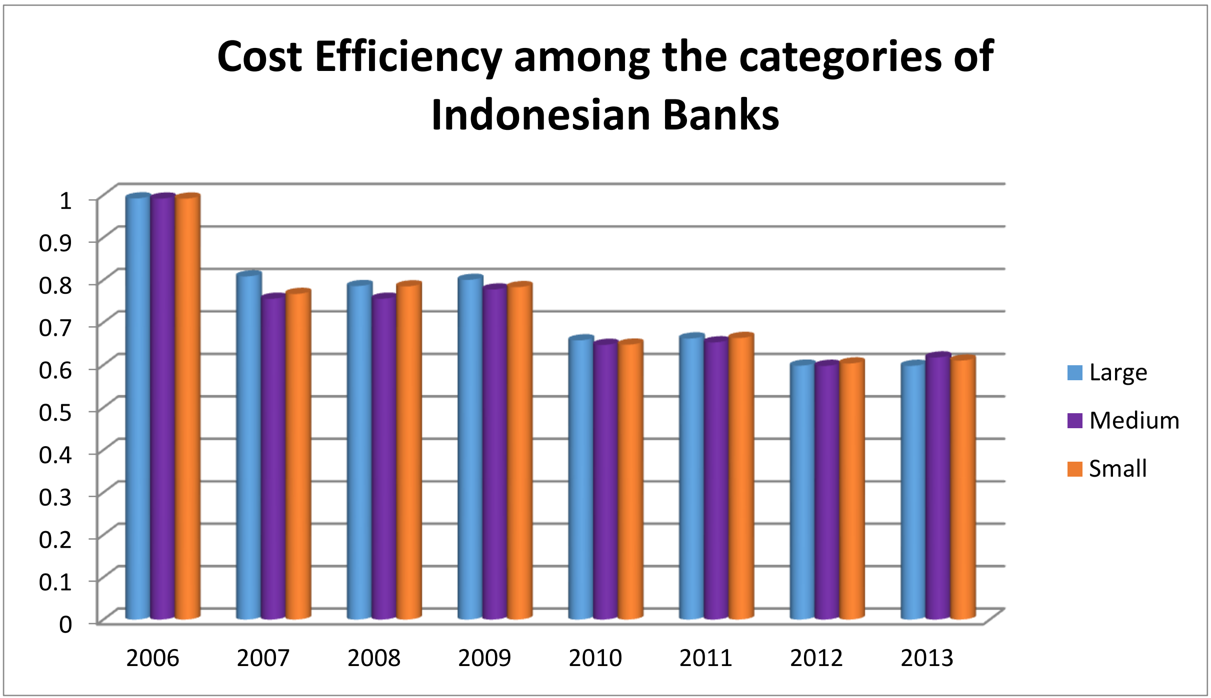
Table 5.1 Cost Efficiency Scores in regard to the category of asset

	2006	2007	2008	2009	2010	2011	2012	2013
Large	0.9919	0.8083	0.7856	0.8002	0.6578	0.6622	0.5982	0.5978
Medium	0.9915	0.7557	0.7557	0.7775	0.6472	0.6531	0.5978	0.6175
Small	0.9915	0.7671	0.7849	0.7831	0.6477	0.6634	0.6034	0.6102
Average	0.9916	0.7770	0.7754	0.7869	0.6509	0.6595	0.5998	0.6085

Source: Based on authors' calculation

Overall, the average efficiency scores do not seem to show much difference between asset categories. It can be observed that during 2006 to 2010, large banks were more cost efficient compared to the other two assets categories. However, from 2011 to 2013 small banks became more efficient relative to the other two asset classes. Previous studies found an identical result and suggested that economies of scale are mainly located within the largest and smallest banks (Hadad, et al., 2013).

Figure 5.2 Cost Efficiency based on the category of asset

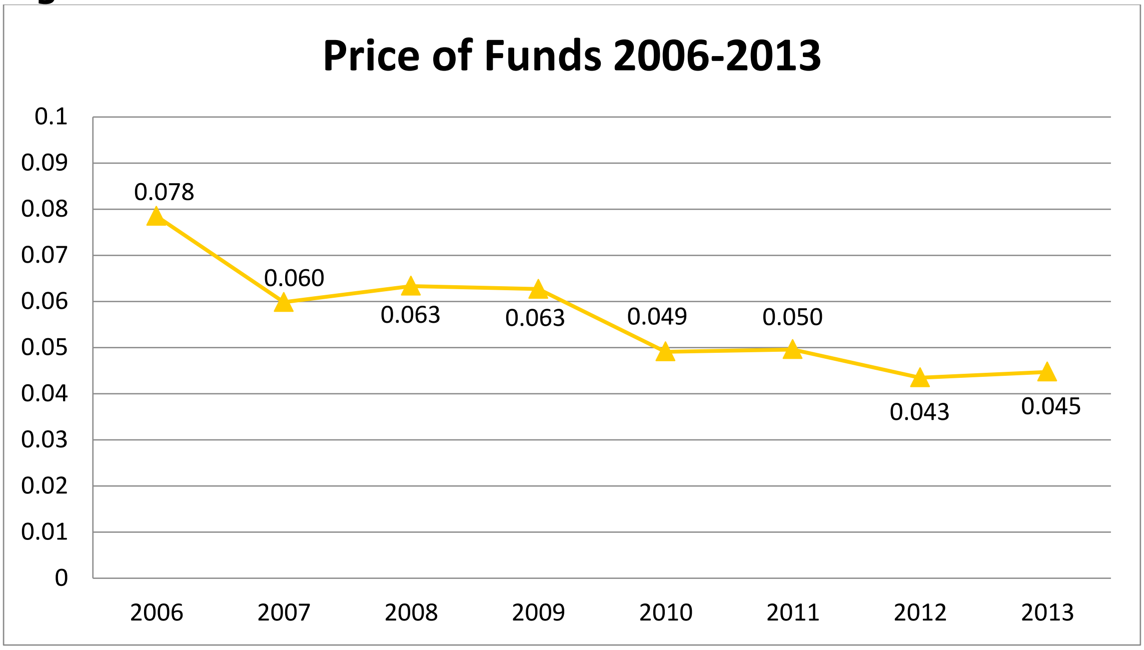


Source: authors' calculation

Figure 5.3 Price of Labour in Indonesian Banks

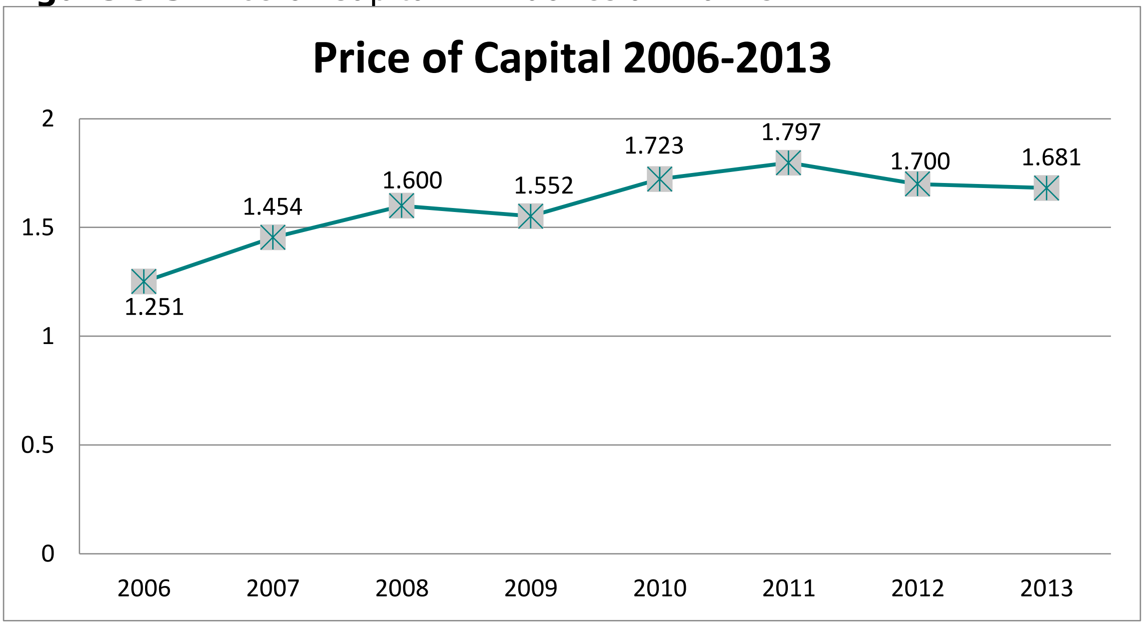
Source: authors' calculation

Figure 5.4 Price of Funds in Indonesian Banks



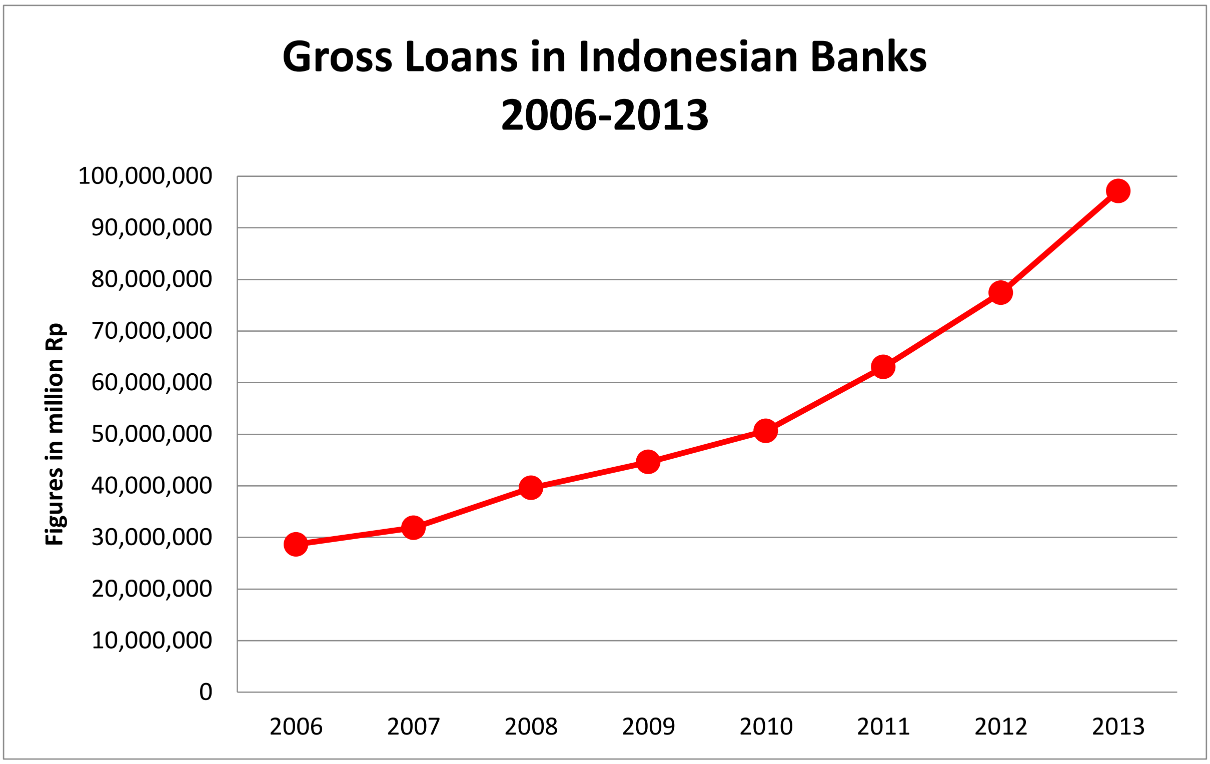
Source: authors' calculation

Figure 5.5 Price of Capital in Indonesian Banks



Source: authors' calculation

Figure 5.6 Gross Loans in Indonesian Banks

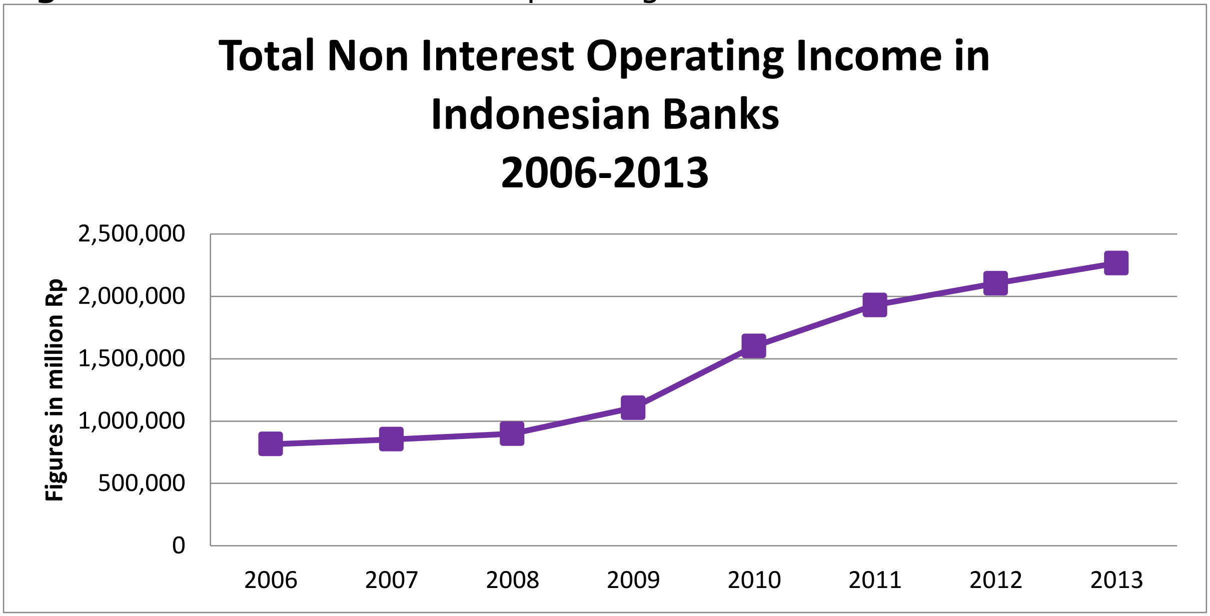


Source: authors' calculation

Figure 5.7 Other Earning Asset in Indonesian Banks

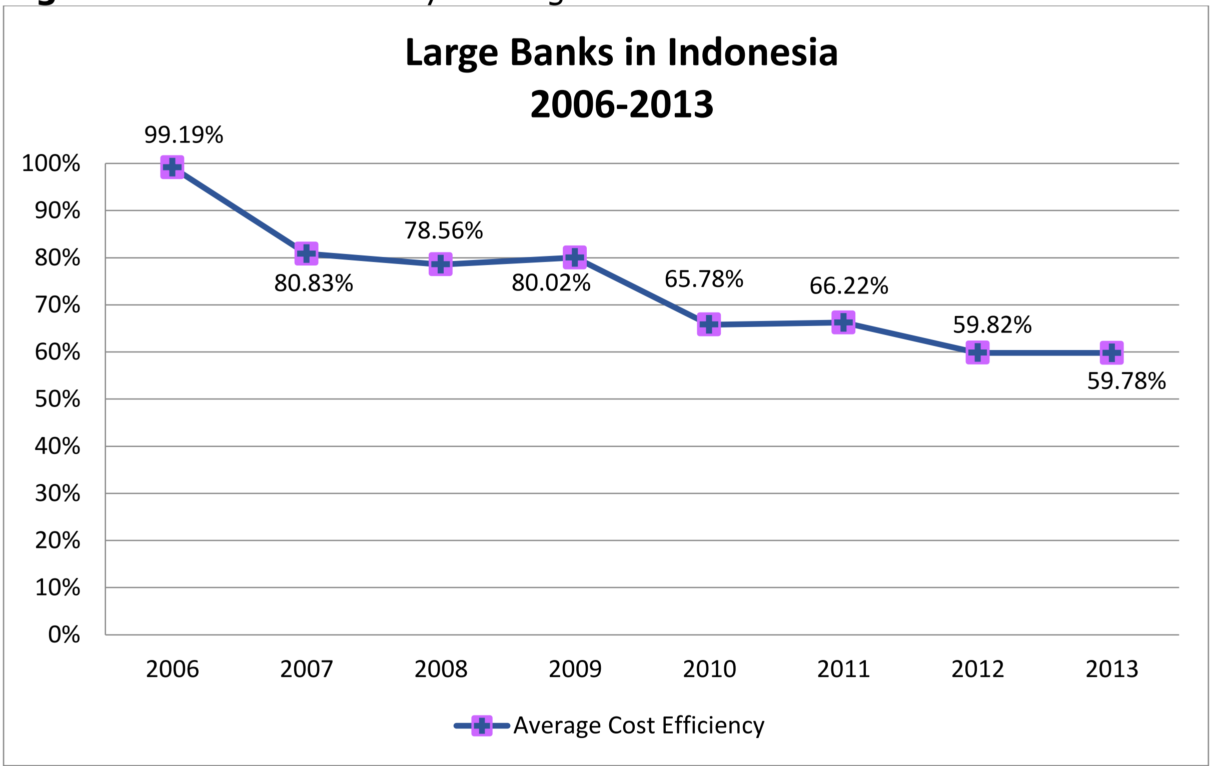
Source: authors' calculation

Figure 5.8 Total Non Interest Operating Income in Indonesian Banks



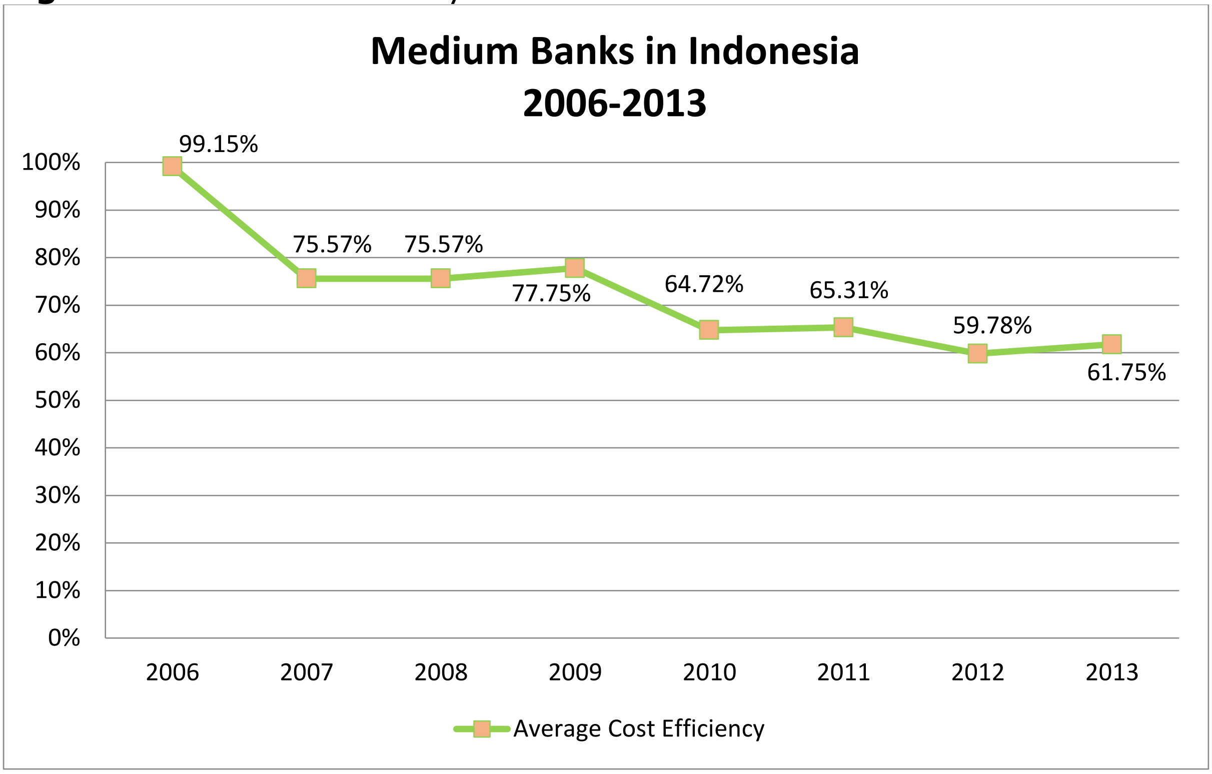
Source: authors' calculation

Figure 5.9 Cost Efficiency of Large Indonesian Banks



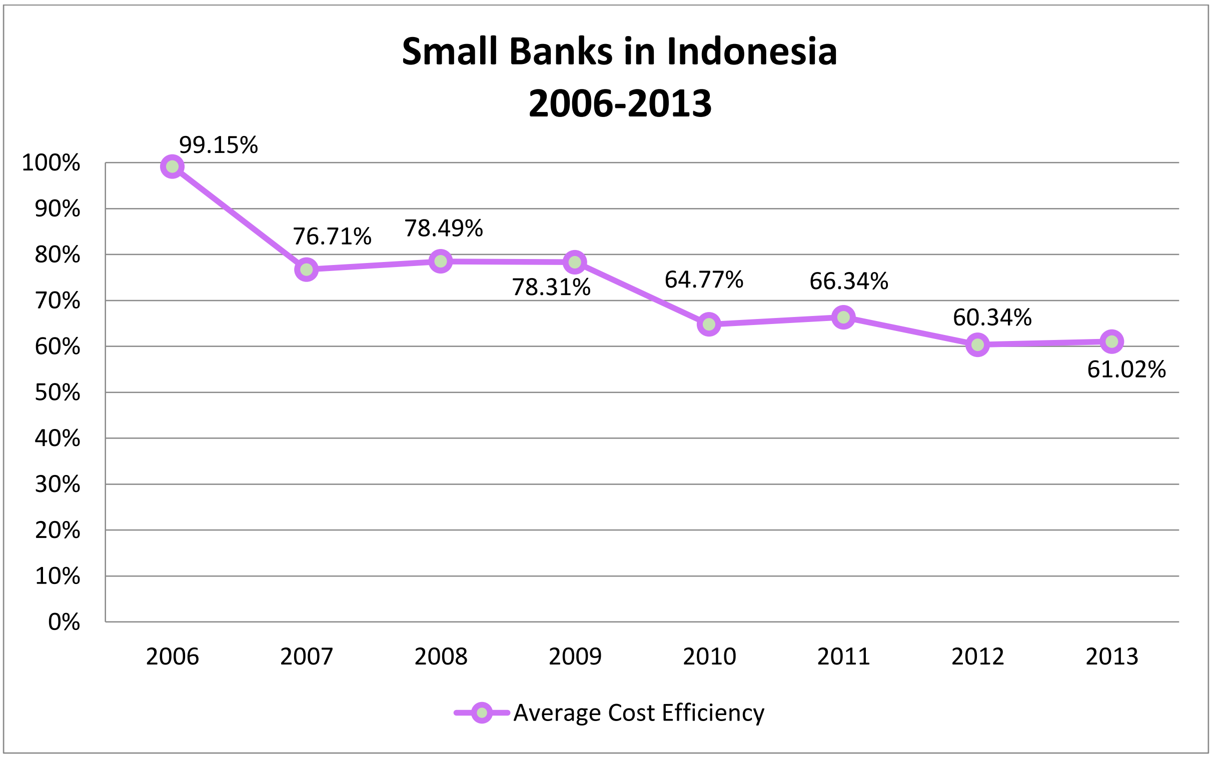
Source: authors' calculation

Figure 5.10 Cost Efficiency of Medium Indonesian Banks



Source: authors' calculation

Figure 5.11 Cost Efficiency of Small Indonesian Banks



Source: authors' calculation

5.2 Regression Results for Stock Performance

This section provides the results of the regression analysis to estimate the impact of the change in bank efficiency to banks' stock returns. A two-way fixed effects methods with white's standard error are implemented.

As we can see from the table 5.2, the value of R-squared is 0.2797. It means that the explanatory power of the cost changes and cost to income ratio changes in the variability of stock returns is approximately 28%.

Table 5.2 Regression Results

	Model 1
VARIABLES	dsp
dte	-1.3431**
	(0.6261)
SIZE	0.0875
	(0.2641)
dROAE	0.0059**
	(0.0025)
dEQAS	0.3067
	(0.2815)
Constant	-1.5817
	(4.230)
Observations	189
R-squared	0.2797

Robust standard errors in parentheses, ** at 5 percent level; regressions are run in STATA 13. The models using fixed effects panel regression methods include bank and time fixed effects with robust standard errors to control for cross-section heteroscedasticity. The dependent variable is the annual stock returns.

The results for the estimated models are:

Model 1: $y_{it} = -1.5817 - 1.3431dte_{it} + 0.0875SIZE_{it} + 0.0059dROAE_{it} + 0.3067dEQAS_{it}$

The result shows that the coefficient on *dte* is negative and significant at the 5% level, which is somewhat different to what was predicted. It signifies that the share prices incorporate the relevant information about the cost of the bank which provides signal to the shareholders regarding the future dividends to some extent consistent with the studies conducted by Viverita & Ariff (2011), Liadaki & Gaganis (2010) and Pasiouras, et al. (2008). However, a negative relationship implies that the more efficient the bank in their operation will reduce the annual return. This result is contradictory with the results of previous studies such as Becalli, et al., (2006), Sufian & Majid (2006) and Liadaki & Gaganis (2010). Nevertheless, Vardar (2013) who empirically investigated the profit and cost efficiencies of Central and Eastern European (CEE) Countries found an identical result to this study. Cost efficiency scores, which in this case measured by technical efficiency (TE), provides a signal or information of managers' capability in managing cost. Regardless of a better cost management can be observed by public and reflected in the share price, rational shareholders or potential investors do not perceive the cost efficiency changes positively (Vardar, 2013). Moreover this indicates that shares of cost efficient banks are not likely to outperform stocks of inefficient banks.

This condition could be relevant with the findings by Soetanto & Ricky (2011), who investigate the technical efficiency of the Indonesian commercial banks. They found the evidence that technical efficiency was negatively correlated to banks' profitability which was measured by return on assets (ROA). Considering the relationship of profitability and stock return in our model, it can be seen that *dROAE* has a positive impact to the annual stock returns. The former and current findings are related in a way that when the technical efficiency increases, the profitability decreases and hence reduces the return to shareholders. Soetanto & Ricky (2011) explain this circumstance by referring to the regulation from the central Bank of Indonesia which was trying to increase the Loan to

Deposit ratio (LDR) by imposing Reserve Requirement (RR) regulation. Bank with a high LDR with inadequate liquidity will be penalised with higher RR ratio. For instance, if LDR is above 100% and capital adequacy ratio (CAR) below 14% the bank is required an additional reserve requirement of their third party funds (ICRA Indonesia, 2010). This is a strong indicator that the returns earned by banks in Indonesia were not coming from their intermediary function in the economy, but attaining the return from other source such as financial market investment and placing their funds in Bank of Indonesia.

The coefficient on *dROAE* ratio is as predicted, being positive and statistically significant at 95% level of confidence which indicates that banks with higher return on equity tend to have higher share price. The ROAE is an indicator for shareholders to find out if the funds they have invested in the bank have been efficiently utilised and how much return or profit has been yielded from them. To the management of the company, this is an indicator of how well they have managed these funds. *ROAE* is the complete measurement that also includes *ROA* and net interest margin (*NIM*) which is a better substitution to represents bank's profitability and growth potential (Casu, et al., 2006).

Among the explanatory variables to describe the influence of efficiency change on the stock returns, the result indicates that the measurement of bank *size* and *dEQAS* are not statistically significant, hence, these two variables do not seem to contribute in the explanation of changes in share price.

6 Conclusion

6.1 Summary of the Study

As the importance of bank as the facilitator of economic development in Indonesia is increasing and one of the critical functions of bank in Indonesia is performing as financial intermediary, therefore evaluating the performance of listed Indonesian commercial banks becomes crucial. Considering the tool in measuring performance, financial ratio is often used by bank management, while measurement of performance in most of bank literature has shifted from accounting-based measure i.e. accounting ratio to economics-based measure i.e. efficiency. This paper estimates the technical efficiency of Indonesian commercial banks from the period of 2006 to 2013 from the perspective of intermediary role as well as finds the link between the efficiency of listed commercial Indonesian banks relative to their stock performance.

In the analysis, three stages procedure are carried out. First, cost efficiency score is estimated using SFA with unbalanced panel data of 27 banks from 2006 to 2013. The intermediation approach is used to select the input and the output. The inputs consists of personnel expense, total interest expense and other operating expense, while the output comprises of gross loans, other earning assets and total non-interest operating income to calculate the technical efficiency (TE). Then, the annual stock returns for each bank per year are calculated. Finally, the annual stock returns against the change in efficiency are regressed using two-way fixed effects estimation, with taking into account the bank specific factors in the regression.

The empirical result indicated that overall cost efficiency of the Indonesian banking sector were deteriorated during the period under consideration. Before the global financial crisis, all listed commercial banks in Indonesia were efficient in respect of their cost. This might happen due to the imminent implementation of the change in regulation. However, there were two major declining within an 8-year period which occurred in 2007 and 2010. It was suspected that GFC might have an impact to Indonesian banks and the volatility of the interest rate and exchange rate. The second cutback in bank efficiency was speculated as a result of internal factors, which are the lack of qualified human resources and IT systems might cause inefficiency. A closer look to the relationship between bank efficiency and the size of asset, the bank were classified into three groups (i.e large, medium and small) and it can be concluded that large banks were slightly more cost efficient compared to the other two categories.

With regards to the link between bank efficiency and the stock returns, the annual stock returns was regressed against the change in cost efficiency, the size of banks, profitability performance and risk. The result revealed that the changes in cost efficiency of Indonesian banks were statistically significant to the stock returns. It implied that the share price incorporates relevant information regarding the cost management of the banks; however, the correlation was negative. ROAE as a parameter of profitability had a positive and significant relationship with the stock returns. It is suggested that the higher the profit, the more the returns to shareholders. On the other hand, size of banks and risk did not have any significant relationship to stock returns.

6.2 Limitation of this Study and Recommendation for Future Studies

This present paper only included the commercial listed banks while an extensive study can include another type of banks such as Islamic banks. A larger observations and a longer period may resulted in a better picture of bank efficiency as a whole.

Possible further research could involve profit efficiency in the Indonesian banking sector, hence allowing to compare the profit and cost efficiency. Additionally, the current study only estimates technical efficiency, future research might consider allocative efficiency in analysing the efficiency in order to further understand the total efficiency of banks as overall operational efficiency.

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A.1. STATA 13 output: SFA techniques for cost frontier

```
Inefficiency effects model (truncated-normal)     Number of obs      =       191
Group variable: bankid                            Number of groups   =        27
Time variable: Year                               Obs per group: min =         4
                                                                 avg =       7.1
                                                                 max =         8

                                                  Prob > chi2        =    0.0000
Log likelihood =    130.7660                      Wald chi2(20)      =    1690.8
> 5
```

LTCP1	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
LP21	.3570237	.4311567	0.83	0.408	-.4880279	1.202075
LP31	.1278727	.3082125	0.41	0.678	-.4762127	.7319582
LP21LP21	.3511958	.0751121	4.68	0.000	.2039789	.4984127
LP31LP31	-.0932286	.0352379	-2.65	0.008	-.1622936	-.0241636
LP21LP31	.0131659	.0322281	0.41	0.683	-.0499999	.0763318
LY1	-.4605219	.4902157	-0.94	0.348	-1.421327	.5002832
LY2	-.0279296	.3491144	-0.08	0.936	-.7121812	.6563221
LY3	.2349465	.2911086	0.81	0.420	-.3356158	.8055088
LY1LY1	.097406	.0778259	1.25	0.211	-.0551299	.2499419
LY2LY2	.1129856	.0527883	2.14	0.032	.0095224	.2164488
LY3LY3	.0078915	.0125938	0.63	0.531	-.0167919	.0325749
LY1LY2	-.0777006	.0542952	-1.43	0.152	-.1841173	.0287161
LY1LY3	-.0129612	.0317631	-0.41	0.683	-.0752156	.0492933
LY2LY3	-.0109329	.0372615	-0.29	0.769	-.0839641	.0620983
LY1LP21	.1626484	.0560307	2.90	0.004	.0528302	.2724666
LY1LP31	-.0057364	.0309357	-0.19	0.853	-.0663693	.0548965
LY2LP21	-.211192	.046378	-4.55	0.000	-.3020913	-.1202928
LY2LP31	.0262495	.0255361	1.03	0.304	-.0238004	.0762993
LY3LP21	.0410346	.0383628	1.07	0.285	-.0341551	.1162243
LY3LP31	.0012974	.0227401	0.06	0.955	-.0432725	.0458673
_cons	7.061369	2.136894	3.30	0.001	2.873134	11.2496
Mu						
GDPGR	-.1022047	.0249082	-4.10	0.000	-.1510239	-.0533855
INF	-.1169264	.0236498	-4.94	0.000	-.1632791	-.0705737
ASSGDP	.0977243	.0139553	7.00	0.000	.0703724	.1250762
RealI	-.0922795	.018486	-4.99	0.000	-.1285114	-.0560475
_cons	-1.192184	.194414	-6.13	0.000	-1.573229	-.8111399
Usigma						
_cons	-4.906521	.4141879	-11.85	0.000	-5.718314	-4.094727
Vsigma						
_cons	-4.80219	.3287368	-14.61	0.000	-5.446502	-4.157877
sigma_u	.0860127	.0178127	4.83	0.000	.0573171	.1290747
sigma_v	.0906187	.0148948	6.08	0.000	.0656609	.1250629
lambda	.9491717	.0313902	30.24	0.000	.8876481	1.010695

A.2. STATA 13 output: sigma and gamma for SFA

```
scalar li sigma2
  sigma2 =  .01560993

scalar li gamma
   gamma =  .47394087
```

A.3. STATA 13 output: Technical Efficiency (te)

Variable	Obs	Mean	Std. Dev.	Min	Max
te	191	.7174907	.1166637	.5213743	.9927717
te1	191	.7174907	.1166637	.5213743	.9927717
te1_LB95	190	.6394725	.1199219	.4604711	.9732224
te1_UB95	190	.7979754	.1096916	.5880398	.9997903

A.4. STATA 13 output: two-way fixed effects regression result

```
. reg dsp dte SIZE dROAE dEQAS i.bankid i.Year, robust

Linear regression                                      Number of obs =     189
                                                       F( 37,   151) =    1.81
                                                       Prob > F      =  0.0069
                                                       R-squared     =  0.2797
                                                       Root MSE      =  .46876

------------------------------------------------------------------------------
             |               Robust
         dsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         dte |  -1.343064    .626082    -2.15   0.034    -2.580077   -.1060523
        SIZE |   .0874828   .2640761     0.33   0.741    -.4342784    .6092439
       dROAE |   .0059103   .0025375     2.33   0.021     .0008966    .0109239
       dEQAS |   .3066631   .2815439     1.09   0.278     -.249611    .8629372
             |
      bankid |
          2  |    .149439   .5069012     0.29   0.769    -.8520959    1.150974
          3  |  -.0590794    .794256    -0.07   0.941     -1.62837    1.510211
          4  |  -.0844577   .5475495    -0.15   0.878    -1.166305      .99739
          5  |   .0977201   .2361742     0.41   0.680    -.3689125    .5643528
          6  |   .3299451   .3089804     1.07   0.287     -.280538    .9404282
          7  |   .0540903   .4996563     0.11   0.914      -.93313    1.041311
          8  |  -.0540344   .8883723    -0.06   0.952    -1.809279    1.701211
          9  |   .0897461   .3313097     0.27   0.787    -.5648552    .7443474
         10  |  -.2753096   .2420017    -1.14   0.257    -.7534563    .2028371
         11  |    .015306   .7409003     0.02   0.984    -1.448564    1.479176
         12  |   .2826608   .3789952     0.75   0.457    -.4661576    1.031479
         13  |  -.0072172   .3128576    -0.02   0.982    -.6253609    .6109264
         14  |  -.0543596   .4812438    -0.11   0.910    -1.005201    .8964815
         15  |   .0753312   .4713874     0.16   0.873    -.8560355    1.006698
         16  |   .3178071   .4800664     0.66   0.509    -.6307077    1.266322
         17  |  -.1336785   .8168885    -0.16   0.870    -1.747686    1.480329
         18  |  -.0535522    .205883    -0.26   0.795    -.4603356    .3532312
         19  |   -.239218   .4225411    -0.57   0.572    -1.074074    .5956382
         20  |   .0912469   .2218186     0.41   0.681     -.347022    .5295158
         21  |  -.0429355   .3189762    -0.13   0.893    -.6731683    .5872973
         22  |  -.0613692   .5371889    -0.11   0.909    -1.122746    1.000008
         23  |   .6286964   .5827463     1.08   0.282    -.5226931    1.780086
         24  |   .7160877   .4724225     1.52   0.132    -.2173243      1.6495
         25  |   .4605098   .6383056     0.72   0.472    -.8006538    1.721673
         26  |   .0378474   .4424451     0.09   0.932    -.8363352    .9120299
         27  |  -.0672013   .3234763    -0.21   0.836    -.7063253    .5719227
             |
        Year |
       2007  |   .3585946   .1619851     2.21   0.028     .0385446    .6786446
       2008  |   .0412486   .1508082     0.27   0.785    -.2567182    .3392153
       2009  |   .1245155   .1265676     0.98   0.327    -.1255567    .3745877
       2010  |   .0381778   .2070132     0.18   0.854    -.3708388    .4471943
       2011  |    .185413    .197214     0.94   0.349    -.2042422    .5750681
       2012  |  -.0460835   .2571206    -0.18   0.858    -.5541021    .4619352
       2013  |  -.0159422   .2856091    -0.06   0.956    -.5802484     .548364
             |
       _cons |  -1.581746   4.230025    -0.37   0.709    -9.939425    6.775932
------------------------------------------------------------------------------
```