EVALUATING THE EFFICIENCY OF VIETNAMESE COMMERCIAL BANKS USING DATA ENVELOPMENT ANALYSIS

Tran Thi Thu Huong
Finance, Accounting and Business Systems
Sheffield Business School, Sheffield Hallam University
Sheffield, United Kingdom
tranthithuhuong9119@gmail.com

Firoz Bhaiyat
Finance, Accounting and Business Systems
Sheffield Business School, Sheffield Hallam University
Sheffield, United Kingdom
f.bhaiyat@shu.ac.uk

Abstract — This study uses Data Envelopment Analysis (DEA) method to estimate the technical efficiency and scale efficiency of Vietnamese commercial banks. The overall technical efficiency was measured by CCR model and the technical efficiency in terms of managerial skills was evaluated by BCC model. The findings indicate larger banks functioned better than smaller banks in terms of management skills, but there was not much difference among the groups in terms of average overall technical efficiency. State-owned and listed banks obtained higher efficiency levels than non-state-owned and unlisted banks. Finally, M&A activities also showed some interesting results. The study provides strong discussion points for consideration in future policy development by practitioners and academics aiming to improve the efficiency of the banking system. A recommendation for further research is to use a different range of inputs/outputs and analyse the data using a combination of parametric and non-parametric tools.

Keywords - Banking Efficiency, Commercial Banks, DEA, Financial Sector, Vietnam.

I. INTRODUCTION

The operational efficiency of banks is crucial for development of the economy and the long-term viability of banks is associated with their efficiency levels (Erasmus and Makina 2014). According to Chen (2009), the study of bank efficiency helps reallocating sources of inefficiencies, enabling stakeholders to initiate reforms and design suitable strategic solutions, especially in developing economies such as Vietnam. Therefore, it is important to know how efficiently different banks in the banking system are operating and where they are standing on the efficiency map. Since Vietnamese commercial banks form major part of the Vietnamese banking system, this study can provide certain implications for the whole banking system of Vietnam.

The period from 2011 to 2014 is critical for the Vietnamese banking sector, as many important policies were issued by the government and State Bank of Vietnam during this period, in response to the negative impact of the global financial crisis 2008. These include policies on interest rates, foreign exchange rates management and restructuring plan, which have significantly influenced banks' operating activities and led to recent M&A activities in the banking sector. Moreover, the efficiency of Vietnamese commercial banks during this period has not been studied in previous literatures, leaving a gap for further research on this topic. Thus, it is essential to study the efficiency of the commercial banks in Vietnam during this period.

Data Envelopment Analysis (DEA), a non-parametric approach, was chosen as the research method of this paper as it has been increasingly popular and widely accepted as a powerful tool in evaluating banking efficiency. In addition, DEA was even argued by Leibenstein and Maital (1992) to be the superior method in assessing the overall technical inefficiency. With DEA approach, relative efficiency of banks can be compared by determining the efficient banks as benchmarks and measuring the inefficiencies in input combinations in other banks relative to the benchmark (Vujcic and Jemric 2001).

The aim of research is to apply the DEA method in assessing the efficiency of Vietnamese commercial banks during the period 2011 – 2014, with comparison among different groups such as state owned vs. non–state owned banks, listed vs. unlisted banks, and large / very large vs. small / medium banks. The paper also aims at identifying changes in efficiency of banks involving in merger and acquisition activities and self-restructuring, two measures of the 2011-2015 restructuring plan, to assess the impact of this plan on the banks' efficiency over the period 2011-2014.

II. THE VIETNAMESE BANKING SYSTEM DURING 2011-2014

A. Recent development of the banking sector

Based on ownership, the commercial banks in Vietnam are currently classified into four categories: state-owned banks (SOBs) (government ownership of more than 50%), joint stock commercial banks (JSBs) (above 50% private ownership), foreign banks (FBs) (foreign ownership of more than 50%), and joint venture banks (JVBs) (less than 50% foreign ownership and more than 50% of capital owned by a SOB). The last three types can be grouped as non-state -owned banks. Since the 1990 reform, the number of commercial banks have

significantly increased from 9 in 1991 to 74 after only four years, reaching more than 100 in 2011 and then decreased to 98 in 2014.Over the last few decades, Vietnamese banking system has dramatically grown in not only the number of banks but also the size of banks, the amount of deposits mobilized, the amount of domestic credit the banks provide to the economy, and other banking services. The total assets of banking sector experienced a fast growth rate of 26% during period 2001 – 2009, reaching a peak of 34% in 2010 before following a downtrend to less than 5% in 2012 due to low credit growth in a shrinking economy affected by the global crisis (Nguyen T. H. 2013). Despite sharp increase in total assets, the size of commercial banks in Vietnam was still small compared to its neighbours, with total assets of the ten largest Vietnamese banks ($13.7 billion or VND285 trillion in 2012) staying much lower than that of the leading banks in Indonesia ($60 billion) and Thailand ($66 billion) (Bezemer and Schuster 2014).

In addition, the commercial banking industry is considered to be highly concentrated at the top but very fragmented at the bottom as five SOBs accounted for 44% of total banking assets (VND 6,278 trillion or $291.99 billion) in 2014, which was higher contribution than that of 33 JSBs. Also, four out of five SOBs contributed 43% of deposits mobilised and 47% of credit provided by the banking system in 2013.

Although the state – owned commercial banks still dominate the banking industry in Vietnam, the market shares of non – state – owned commercial banks have become larger and larger over the last years. For example, from contribution of only around 10% of credit to the economy in 2002, JSBs provided more than 30% of domestic credit in 2012, showing increasing importance to the economy.

The Vietnamese banking system witnessed a very high growth of deposit and credit during the period 2001 – 2010 with average rates of 28% and 31% respectively; especially, the credit growth was much higher (22% on average) than GDP growth due to expansionary monetary policy and high investment demand during this period (Nguyen T. H. 2013). However, these indicators rapidly declined from the beginning of 2011 (the downtrend started from 2009) as Vietnamese banking sector went through tough times due to interest rate instability and many changes in credit policy in response to the global crisis.

According to Bezemer and Schuster (2014), the hot credit growth through the 2008 global financial crisis, followed by the 2011 credit squeeze and the collapse of stock and real estate markets, have led to the proliferation of non – performing loans (NPLs) in the Vietnamese banking system over the last years. The NPL ratio was reported by banks and announced by the SBV at around 4% on average during period 2011 – 2014. However, the international credit rating agencies such as Fitch and Moody's estimated that NPLs have accumulated in Vietnamese banking system at about 15%, if the debts were properly classified in accordance with IFRS (Nguyen T. H. 2013).

The largest portion (70% in 2011) of NPLs was loans to State – owned Enterprises (SOEs) which were mainly provided by SOBs, followed by NPLs from real estate and stock markets. Besides this irrational allocation of loans, poor governance of JCBs forced by their major stockholders to finance high – risk projects which they have commercial interest in, have also contributed to this problem (Bezemer and Schuster 2014). Confronted with the rising risks to the banking system, the SBV and Vietnamese government have made positive progress with a range of new policies and actions during 2011 – 2014 to improve the banking sector.

B. Critical banking policies during period 2011-2014

1) Amendment of the Law on Credit Institutions

The first important progress made during period 2011 – 2014 was the amendment of the Law on Credit Institutions, which came into effect since the beginning of 2011. The new law aims at raising the safety of credit institution system with changes focussing on five main issues. Firstly, the scope of regulation has been widened to cover the establishment, management, special supervision, consolidation and dissolution of credit institutions. Secondly, the new law sets out clear distinction between commercial banks having business functions and non – profit policy banks. The third issue regards the administration of credit institutions, with new regulations concerning corporate governance added. Another issue relates to requirements on operational safety of credit institutions, with restrictions on the amount of loans for one borrower and securities companies. Finally, the new law has provided more independence and power to the SBV, particularly on supervision of credit institutions. As commercial banks are the major and crucial part of the credit institution system, these changes directly affect their operation.

2) Issuance of new banking regulations

After the amendment of the Law on Credit Institutions, the SBV issued a flurry of new regulations during this period including but not limited to changes in interest rate, exchange rate, credit policies, with 45 circulars introduced in 2011, 38 in 2012, and 39 in 2013 (Campbell and Pham 2014). In response to high inflation and increasing risks to the banking system due to rapid credit growth, in 2011, the SBV decided to restrict lending and tighten monetary policy. The implication of interest rate cap and credit limit did help the inflation rate dramatically decline from a two-digit figure in 2011 to a single figure in 2012 and remain under control throughout 2013. The same downward trend happened to interest rate, helping commercial banks to access cheaper capital. Moreover, the exchange rate was successfully controlled due to timely adjustment by the SBV. While these policies helped restore the financial soundness of the banking system, they affect operations and profit of the commercial banks.

3) The banking restructuring plan 2011-2015

Noticeably, the most critical response by the government during this period is the comprehensive banking-restructuring plan for 2011 – 2015 which is one of three key basic components of the Socio – Economic Development Plan (SEDP) for the period 2011 – 2015. The banking-restructuring program focuses on recapitalisation of commercial banks, resolution of liquidity issues, and reduction of NPLs through consolidation (M&A activities), establishment of Vietnam Asset Management Company (VAMC) as well as changes in interest rate, foreign exchange rate and credit policies.

The roadmap of this program includes four phases, with milestone set in phase 3 (2014) when basic financial restructure was expected to complete. The first phase of the plan (2011-2012) classified commercial banks into three main groups by risk levels via assessing their operations, assets quality, and bad

debts, developing plans for reorganisation of weak banks to improve the overall banking liquidity. Then, in phase two (2013), regulations concerning safety of bank operations were revised and added to eliminate the risk of system collapse. The restructuring program aims at creating a healthy banking system, increasing the operational efficiency and capacity of Vietnamese banks and striving to have at least one regional – scale commercial bank by the end of 2015.

To enhance size and financial capability of commercial banks, mergers and acquisitions solution has been promoted and become a wave in Vietnamese banking sector recently. Following Phase one of the restructuring plan, eight out of nine commercial banks classified as "weak banks" including Habubank, SCB, TinNghiaBank, Ficombank, TrustBank, TPBank, Western Bank, and NaviBank, have been merged, acquired, or self -restructured to meet the chartered capital requirement of VND3,000 billion. The M&A activities among. GPBank, the last commercial bank in this group, is still under pressure of finding a measure to meet this capital requirement. According to the restructuring program, Vietnam aims at reducing the number of commercial banks to 20 in 2017.

Another noticeable progress was the establishment of VAMC in 2013 as a dedicated bank NPLs resolution structure. This entity purchases bad debts from commercial banks by issuing special bonds, which can be used by banks to refinance loans through the SBV. Banks with NPLs over 3% are required to sell their collateralised bad debts to VAMC, and VAMC will recover or restructure those debts and sell the collateral (Bezemer and Schuster 2014). When the special bonds come to redemption, the banks will repurchase those debts from VAMC if they have not been resolved. Via this scheme, NPLs are taken off from banks' balance sheet and banks are given more time to write off their bad debts.

These actions and policies are expected to directly affect the operations of commercial banks in Vietnam. As 2015 is the final year of the restructuring scheme, it is essential to determine how efficient Vietnamese commercial banks were operating during 2011 – 2014, and how their efficiency may have changed during this period and compared to previous years, before those changes in banking policies.

III. LITERATURE REVIEW

A. *The concept of efficiency in banking*

The concept of efficiency varies across different objectives and constraints (Trivedi 2002). Farrell (1957) classified efficiency into technical efficiency and allocative efficiency (or price efficiency). Accordingly, technical efficiency refers to the ability to avoid waste, either by utilizing technology and allowable input usage to produce the maximum outputs (output orientation) or by using minimum inputs required by technology to produce a given level of outputs (input orientation). Technical efficiency can be decomposed further into scale and pure technical efficiency (Drake and Hall 2003). Scale efficiency is measured to assess whether banks are close to their optimal size (Tabak, Fazio and Cajueiro 2011). Inappropriate size of a bank may lead to scale inefficiency which is under the form of either decreasing returns-to-scale (DRS) indicating the bank is too large to take full advantage of scale, or increasing returns-to-scale (IRS) indicating the bank is too small for its scale of operations (Kumar and Gulati 2008). Meanwhile, allocative efficiency refers to the ability to use optimal proportion of outputs and / or inputs in light of prevailing prices, so resources are allocated to use with the highest expected value (Fried, Lovell and Schmidt 2008).

Different concepts of efficiency have different approaches to measure, resulting in different results when evaluating the efficiency of banks. Therefore, it is critical to determine which concept of efficiency to use when measuring banking efficiency (Ncube 2009). This research attempts to evaluate technical efficiency (mainly) of Vietnamese commercial banks, as DEA method often focuses on measuring the overall technical efficiency (Drake and Hall 2003). Besides, the results for scale efficiency are also obtained when the technical efficiency is calculated using DEAP software.

B. *Factors affecting banking efficiency*

Previous literatures have found a number of factors that have influence on the efficiency of banks. Bank type and bank size, the two most popular ones, are considered in this study. The type of banks can be considered in two perspectives, SOB vs. NSOB (ownership structure) and Listed vs. Unlisted banks (listed status). Berger and Mester (1997) found that listed banks operated more efficiently than unlisted banks. Besides, according to Matousek, Nguyen, & Stewart (2014), small and medium banks, on average, are less efficient than large and very large banks. Since the Vietnamese banking restructuring plan involving M&A and self-restructuring measures is implemented during the study period, the impact of these two factors on the efficiency of Vietnamese commercial banks are also investigated in the research.

C. *Different approaches to measure banking efficiency*

After selection of efficiency concepts, another important step is determining a method to measure it (Berger and Mester 1997). According to Nguyen (2012), different methods to measure banking efficiency can be grouped into three main approaches: (1) accounting method using financial ratios, (2) parametric technique based on statistical and econometric techniques with knowledge of production function and (3) non – parametric technique based on linear or non – linear mathematical programming techniques without such knowledge.

Although accounting approach is considered the simplest technique in banking efficiency measurement, it has also been criticised to encounter many limitations such as not controlling input prices or product mix. Then, a measure that can incorporate all the available inputs and outputs of the bank is needed and the following two techniques meet this demand (Ncube 2009).

The parametric approach requires correct specification of production function or cost function of banks, applying a regression model with certain confidence intervals and deviation (Nguyen 2012). Meanwhile, the non – parametric approach, originating from the seminal contribution of Farrell (1957) based on linear frontiers calculated using mathematical programming techniques, is viewed to avoid any form of functional misspecification that parametric techniques suffer (Porcelli 2009). While parametric techniques involve economic optimization, the non – parametric techniques usually concentrate on technological optimization (Banerjee 2012).

DEA is viewed as the most commonly used non – parametric technique in technical efficiency measurement, especially in banking area (Banerjee 2012). In addition, while the efficiency measure in SFA is necessarily a combination of allocative and pure technical efficiency, it is possible in DEA to concentrate on the overall technical efficiency (Drake and Hall 2003). As this research applies DEA in assessing the banking efficiency, more details about DEA method will be discussed later in the paper and in methodology section.

D. Worldwide application of DEA in assessing efficiency

With many advantages over other methods, DEA has been widely applied by researchers all over the world to measure relative efficiency of different decision-making units (DMUs) in various industries, especially in the banking area.

1) Bank branches

Sherman and Gold's paper (1985) was among the first studies applying DEA as an efficiency measurement tool in banking industry, and the DMUs under their research were 14 branches of a U.S. savings bank (Nguyen 2012). From the DEA results, six branches were found to operate inefficiently compared to the others, suggesting that branch network inefficiency could be eliminated by improvements in the use of branch resources. In addition, Parkan (1987) measured efficiency of thirty five branches of a major commercial bank in Canada and found that only eleven branches were operating relatively efficiently.

2) Banks

A number of studies using DEA across the world have recently focused on measuring efficiency of banks (Ncube 2009). A literature survey of studies on efficiency and productivity of the banking sector conducted by Sharma, Sharma and Barua. (2013) showed that around 75% of the studies surveyed employed DEA in measuring banking efficiency, and a good number of studies were found in developed countries such as the USA, the UK, and Europe. According to the survey, developing countries were also found to increasingly apply DEA in this area. Fukuyama (1993) was among the first researchers in Asian countries to examine efficiency of commercial banks using DEA. He researched 143 commercial banks in Japan and found that the major source of those banks' overall technical inefficiency was purely technical inefficiency.

Drake and Hall (2003) examined technical and scale efficiency of 149 banks for the financial year ending March 1997, covering full range of ordinary banks operating in Japan including City Banks, Regional Banks, Second Association Regional Banks and certain specialised banks such as Trust Banks. They found that the smaller banks were operating more efficiently than the larger banks, questioning the logic of large – scale merger wave in Japan at that time. Besides, their research emphasized the importance of including non – interest-operating income as an output in DEA model to reflect the increasing diversification of banks around the world, moving from traditional banking business to "off – balance sheet" and fee income – generating business. This idea provides a significant contribution to the selection of inputs and outputs for this research on efficiency of Vietnamese commercial banks.

3) Banking system

DEA has also been seen as a preferable technique in measuring efficiency of the whole banking system through two ways. The first way is treating the banking system as a single DMU and using macro level data to analyse its efficiency. Ngo (2012) employed this approach to evaluate performance changes of Vietnamese banking system under financial liberalization using time trend data from 1990 to 2010. The second way is estimating individual banks' efficiency scores then averaging them into the national level. For example, Pastor, Perez and Quesada (1997) employed DEA to compare different European and American banking systems through calculating efficiency scores of banks in these countries. They found that banking systems of France, Spain, and Belgium have the highest efficiency levels, whereas UK, Austria, German, and U.S banking systems showed less efficiency. Through the second approach, this research on evaluating efficiency of Vietnamese commercial banks is expected to provide certain implications to Vietnamese banking system.

E. Application of DEA in assessing Vietnamese commercial banks

Several studies on the efficiency of Vietnamese commercial banks using the DEA method have been conducted over the last decade. One of the most recent papers among these studies was the research on bank efficiency in Vietnam from 1999 to 2009 by Matousek, Nguyen and Stewart (2014). The paper discussed some limitations of previous literatures on the research topic, regarding data set, selection of inputs and outputs, and impacts of explanatory variables on the inputs and outputs.

Firstly, the study criticised that the empirical research on efficiency of Vietnamese banks for the early period after the Reform 1986 only examined a small unrepresentative number of banks during a short period of time due to lack of data availability. For example, only 13 banks in Vietnam were selected to measure efficiency during period 2001-2003 by Nguyen (2007). Then, one year later, Nguyen and De Borger (2008) researched the efficiency of 15 Vietnamese banks over the period of 2003-2006, using Malmquist index and single bootstrap procedure. The efficiency of commercial banks in Vietnam during the next period from 2007 to 2010 was conducted by Nguyen (2012) using DEA together with Malmquist index for 20 banks, which was not mentioned by Matousek, Nguyen and Stewart (2014). The 2014 paper of these three researchers studied a more extensive data set including 48 commercial banks over the period 1999-2009. These banks were divided into different groups regarding bank type and asset size to compare their efficiency. However, none of the previous papers has studied efficiency of Vietnamese commercial banks during 2011-2014, which is a critical period and the focus of this study.

Secondly, the 2014 paper stated that it was the first study to employ all inputs and outputs as suggested by the intermediation approach (Berger and Mester 1997) to measure Vietnam banking efficiency. Accordingly, previous researchers which used staff expense, deposits as inputs, include Nguyen (2007) and Nguyen and De Borger (2008). For outputs, Nguyen (2007) and Nguyen (2012) chose interest income and non-interest income, but they did not include securities investments as an output item. Since investments in securities represent the investment activity of the banks and have

significant contribution to their non-interest income, this item was also selected as an output in the present study. Matousek, Nguyen and Stewart (2014) added purchased funds as an input and business loans as an output to their DEA model and argued that they met recommendation by Berger and Mester (1997) on selection of inputs and outputs. Nonetheless, they did not employ non-interest income, which is an increasingly important output for DEA model following intermediation approach, as indicated by Drake and Hall (2003). Meanwhile, the present research does include this factor as an output.

Finally, Matousek, Nguyen and Stewart (2014) emphasised their differentiation from previous researches in accounting for the impacts of explanatory variables (e.g. non-performing loans, branch networks, number of years since establishment) on inputs and outputs by applying the double bootstrap procedure in the second stage after running DEA in the first stage. They argued that this DEA two – stage procedure helped obtaining more reliable evidence compared to previous studies, and determining bank efficiency's determinants. However, the data of explanatory variables such as non-performing loans of commercial banks in Vietnam is still debatable as analysed in Chapter 2, so using these data announced by banks may lead to bias. Moreover, the double bootstrap procedure has also been criticised for some limitations such as high complexity and computational expensiveness (Martin 1990).

The study of Matousek, Nguyen and Stewart (2014) provided some noticeable implications from the two – stage DEA procedure's results though. For example, the results showed that smaller banks appeared to be least efficient and the larger banks had the highest level of efficiency, suggesting that restructuring the banking system through mergers and acquisitions can help improve their efficiency. This implication has been proved meaningful, as Vietnamese government has been carrying out the restructuring plan (2011 – 2015) for the banking system. Then, it would be significant to evaluate and analyse changes in efficiency of Vietnamese commercial banks over this period, particularly for the period 2011 – 2014 when the restructuring plan is almost complete.

IV. RESEARCH METHODOLOGY

Choosing positivism and deductive as research philosophy and research approach, this study employs quantitative methods to be its main research method. This method has an important advantage of high reliability and generalizability as it is conducted based on large sample size (Milne and Adler 1999). Specifically, with this approach and based on previous literatures, Data Envelopment Analysis (DEA) is adopted to achieve the research objectives. Besides, the technique of data normalisation is also applied to adjust data set for the DEA model.

A. DEA method

DEA was first proposed by Farrell (1957) to measure efficiency of production units with a simple case of single input and single output. After that, the model was extended by Charnes, Cooper and Rhodes (1978) to measure efficiency (typically technical efficiency) of decision-making units (DMUs) with multiple inputs and outputs by the following equation:

$$\text{Technical efficiency} = \frac{\sum \text{weigted outputs}}{\sum \text{weighted inputs}}$$

The idea of DEA is to yield an optimal piece-wise surface (the revealed best practice frontier with efficiency score of 1, or envelope) over the sample DMUs and project each unit onto the frontier to determine its level of inefficiency. The distance of each DMU's position to its projection on the frontier indicates its relative efficiency.

Regarding structure of returns to scale, DEA model can be either CCR model with constant returns to scale (CRS) or BCC model with variable returns to scale (VRS). The CRS model, which is considered to be a special case of the VRS model, is more restrictive and usually has a fewer number of units yielded on the efficient frontier as well as lower efficiency scores among DMUs than the VRS (Figure 3). This paper calculates efficiency of Vietnamese commercial banks based on both CCR and BCC models, and the results of these two models can be found by running with the option of input-oriented VRS model in DEAP 2.1 program.

1) CCR model

The DEA model was first used as CCR model by Charnes, Cooper, and Rhodes (1978) with assumption of constant returns to scale meaning that inputs and outputs can be linearly scaled by the producers without decreasing or increasing efficiency (Karimzadeh 2012). In other words, a proportional increase in outputs will be obtained from an increase in inputs, and all DMUs are operating at optimal scale (Fare and Lovell 1978). Thus, in CCR model, the efficiency of DMUs is considered to be constant. In addition, the input-oriented efficiency score and the inverse of output-oriented efficiency score are exactly equal when CRS exists (Karimzadeh 2012). Mathematically, the basic DEA CCR model calculates overall technical efficiency of DMUs based on the ratio of outputs and inputs by the solution below (Charnes et al. 1978).

$$\text{Max } \hat{\delta}_0 = \frac{\sum_{r=1}^{s} U_r Y_{r,0}}{\sum_{i=1}^{m} V_i X_{i,0}}$$

Subject to:

$$\frac{\sum_{r=1}^{s} U_r Y_{r,j}}{\sum_{i=1}^{m} V_i X_{i,j}} \leq 1 ; j = 1, 2, \ldots, n$$

$$U_r, V_i \geq 0 ; r = 1, 2, \ldots, s; i = 1, 2, \ldots, m$$

Where:

- n is the number of DMUs; m is the number of inputs; s is the number of outputs
- Xij is the input of the jth DMU; Yrj is the output of the jth DMU
- Ur and Vi are the weights of outputs and inputs respectively

2) BCC model

The BCC model was developed by Banker, Charnes, and Cooper (1984) considering variable returns to scale, which is more flexible than CCR model with assumption of constant returns to scale. Similar to CCR model, the name of this model was also based on the initial letters of those three researchers. However, unlike the previous model assuming all DMUs operating at optimal scale, BCC model consider both cases of increasing and decreasing to scale. In other words, an increase in the amount of inputs could lead to a higher or lower level of increase in the outputs. In BBC model, the overall technical efficiency is discomposed into pure technical efficiency and scale efficiency, and the input-oriented and output-oriented efficiency measures are different. The input-oriented BCC linear programming problem calculating efficiency of DMUs can be mathematically depicted in the following equation:

$$\text{Max} \quad h_k = \sum_{r=1}^{s} u_r y_{rk} - u_k$$

$$\text{s.t.} \quad \sum_{i=1}^{m} v_i x_{ik} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} - u_k \leqslant 0, \qquad j = 1, \ldots, n$$

$$u_r, u_i \geqslant 0, \qquad r = 1, \ldots, s, \qquad i = 1, \ldots, m \quad ($$

Where:

- n is the number of DMUs; m is the number of inputs; s is the number of outputs
- Xij is the input of the jth DMU; Yrj is the output of the jth DMU
- Ur and Vi are the weights of outputs and inputs respectively

B. Techniques to deal with negative data in DEA

The original DEA models traditionally require positive values of inputs and outputs to calculate the efficiency of DMUs, whereas some efficiency studies may incur negative inputs and / or outputs (Emrouznejad, Anouze, and Thanassoulis 2010) such as the case of this research. To address this issue, the Min-Max normalisation technique was adopted in this paper to transform negative values into positive values so that the data set can be run by the software DEAP version 2.1.

This technique has been particularly adopted in efficiency studies to deal with negative inputs / outputs. A study on measuring macroeconomic performance of Taiwanese economy by Knox Lovell (1995), for instance, having some growth indicators as outputs taking on negative values, utilised this normalisation technique to transform all the four output indicators to [0,100] scale before analysing them. The current research followed this to deal with negative values of outputs.

Mathematically speaking, the equation for the range normalisation is:

$$New\ Balance = \frac{original\ balance - \min(original\ balance)}{\max(original\ balace) - \min(original\ balance)} * 100$$

Apart from normalisation of data technique, some other alternative approaches suggested in previous literatures to deal with negative data in DEA include additive DEA model, slack-based measure (SBM), range directional measure (RDM), and semi-oriented radial measure (SORM). Different approaches could yield different efficiency results, and each technique has its own shortcomings.

All of these alternative models to deal with negative data in DEA are more complicated than the range normalisation technique and they also have their own drawbacks. Thus, this research selects the range normalisation technique to transform the negative output values.

C. Specification of inputs and outputs

Selection of inputs and outputs for DEA model is a crucial step to measure efficiency of Vietnamese commercial banks in this study. There are two main approaches (production and intermediation) to choose inputs and outputs and this study follows intermediation approach.

The intermediation approach considers banks as financial intermediaries transforming purchased funds and deposits into loans and other assets. This approach has been extensively adopted in banking efficiency studies, particularly for assessing bank-level efficiency as recommended by Berger and Humphrey (1997). Based on this and the availability of data, this paper chooses inputs and outputs as shown in Table 1.

Table 1: Selection of inputs and outputs in the study

Inputs	Outputs
1. Fixed Assets	1. Loans
2. Deposits	2. Securities Investments
3. Staff expenses	3. Non - interest income

Source: Author's work

D. Data collection and sampling

According to statistics from State Bank of Vietnam, there were 38 domestic commercial banks in Vietnam at the end of 2014. Based on the availability of data, the sample of this study includes 31 banks for the period 2011-2013 and 30 banks for the year 2014 due to lack of data in 2014 for Agribank-the largest Vietnamese commercial bank which is crucial to be included in the data set. Seven banks which are excluded from the sample include VNCB, Ocean Bank, GP Bank, Southern Bank, VietBank, BaoViet Bank, and OCB. Among these small banks, Southern Bank has been approved by SBV to merge with Sacombank and three of them (VNCB, Ocean Bank, GP Bank) have been acquired by the government with the price of zero by August 2015. The sample banks are then classified into different groups by types and by size to serve the comparison and analysis their efficiency results later.

This study uses secondary data collected from financial reports from 2011 to 2014 of 31 Vietnamese commercial banks via their websites and some other online resources such as finance.vietstock.vn. The information on fixed assets, deposits, payments to employees for inputs as well as loans, securities investments, non-interest income for outputs and the total assets of banks were taken from audited financial statements of the commercial banks. In addition, some supporting information was also taken from other sources such as SBV

reports, Vietnam banking industry report and previous studies on efficiency of Vietnamese commercial banks.

V. EMPIRICAL RESULTS

A. *Relative efficiency of Vietnamese commercial banks*

In general, the efficiency scores of Vietnamese commercial banks increased over the study period, with average CRSTE score of 0.87 and VRSTE, SCALE scores of 0.94. This suggests the efficiency improvement in operations of the commercial banks in Vietnam over the period of 2011-2014, though there was still 23% (CCR model) and 6% (BCC model) waste of input resources to produce a certain output level.

Table 2: Summary of estimated efficiency measures, 2011 - 2014

		2011	2012	2013	2014	Average
Mean	CRSTE	0.88	0.81	0.88	0.92	0.87
	VRSTE	0.92	0.93	0.94	0.95	0.94
	SCALE	0.96	0.88	0.95	0.97	0.94
Median	CRSTE	0.93	0.85	0.91	0.96	0.91
	VRSTE	1.00	1.00	1.00	1.00	1.00
	SCALE	0.99	0.95	1.00	1.00	0.98
SD	CRSTE	0.14	0.13	0.12	0.09	0.12
	VRSTE	0.13	0.09	0.11	0.08	0.10
	SCALE	0.08	0.14	0.08	0.06	0.09
Min	CRSTE	0.55	0.57	0.64	0.72	0.62
	VRSTE	0.56	0.70	0.67	0.73	0.66
	SCALE	0.58	0.57	0.64	0.74	0.63
Max	CRSTE	1.00	1.00	1.00	1.00	1.00
	VRSTE	1.00	1.00	1.00	1.00	1.00
	SCALE	1.00	1.00	1.00	1.00	1.00
Efficient DMUs	CRSTE	12	5	8	10	9
	VRSTE	18	16	20	16	18
	SCALE	12	7	13	16	12

Source: Author's estimates based on DEA results

Although the overall technical efficiency of commercial banks in Vietnam decreased slightly from 0.88 in 2011to 0.81 in 2012, it enjoyed a significant increase after that to 0.92 in 2014. Their scale efficiency also experienced the similar trend, reaching as high as 0.97 in 2014. According to the banking review conducted by Campbell and Pham (2014), the impact of the global financial crisis 2007 on Vietnamese economy began to be felt in 2011. Since then, the banking industry has gone through tough times with interest rate instability and many changes in credit policy. Especially, a large spike in non-performing loans in 2012 did exacerbate the downturn. This might partly explain for the decline in efficiency of Vietnamese commercial banks in 2012. In addition, in response to this turbulence, the State Bank of Vietnam has carried out many initiatives and issued a flurry of new regulations from 2011 to 2013 to control interest rates, foreign currency exchange rate, aiming at reducing inflation rate, non-performing loans, and strengthening the safety and soundness of the Vietnamese banking system. These policies and actions contributed to the recovery and increase in efficiency of the commercial banks in the last two years of the study period. The average VRSTE score of these banks, however, rose steadily each year from 0.92 in 2011 to 0.95 in 2014, suggesting gradual efficiency improvement in managerial skills of the banks.

The number of efficient banks each year also experienced similar trend with a decline in 2012 before increasing in the last two years. On average, about one third of the number of commercial banks in Vietnam operated efficiently. In addition, the minimum average CRSTE score of 0.62 implies that some commercial banks operated at a very low efficiency level during this period. Accordingly, the number of banks operating at constant returns to scale increased and dominated (around half of the banks) in the last year of the period. This implies that a rise in overall efficiency can be obtained if the banks continue to increase their performance scale up.

Banks with the highest average CRSTE scores during this period include two representatives of SOBs (BIDV, VCB) and some other NSOBs such as Nam A Bank, Eximbank, and TPBank. Based on VRSTE scores, on average, all SOBs except MHB were the best practice, together with some other NSOBs such as Nam A Bank, Maritime Bank and VPBank. In terms of scale efficiency, there was no representative of SOBs but some small and medium banks such as Kien Long Bank and Dong A Bank on the efficient frontier.

B. *Banking efficiency and bank size*

Based on BCC model, large and very large banks with average scores over the four-year period of 0.95 and 0.96, respectively, were more efficient than small and medium sized banks with the same mean score of 0.92. This indicates that the larger banks functioned better in terms of management skills than the smaller banks, which is in line with the research result of Matousek, Nguyen, and Stewart's study (2014) on efficiency of Vietnamese banking system during the period of 1999-2009. However, with respect to overall technical efficiency measured by CCR model, there was not much difference among these four groups of banks, with average CRSTE score of 0.88 for small and very large banks, and 0.87 for large and medium sized banks over the period of 2011-2014.

Table 3: Technical efficiency of Vietnamese commercial banks by bank size 2011-2014

Year	Small banks		Medium		Large		Very large	
	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC
2011	0.82	0.88	0.91	0.92	0.93	0.92	0.89	0.93
2012	0.90	0.92	0.77	0.91	0.71	0.95	0.85	0.96
2013	0.86	0.90	0.92	0.93	0.88	0.94	0.88	1.00
2014	0.93	0.99	0.88	0.90	0.95	0.97	0.90	0.94
Mean	0.88	0.92	0.87	0.92	0.87	0.95	0.88	0.96

Source: Author's estimates based on DEA results

Moreover, all groups of banks except small banks experienced decline in the overall technical efficiency in 2012 due to the impact of non-performing loans spike. Particularly, the large and medium sized groups were most heavily affected by this issue, leading to a sharp decrease from 0.93 (0.91) to 0.71 (0.77) for that year. In contrast, small bank efficiency was not adversely suffered from that in the same year but a year after with CCR score increasing from 0.82 in 2011 to 0.90 in 2012 before decreasing to 0.86 in 2013 and recovering in 2014.

C. *Banking efficiency and bank type*

1) *State-owned vs non-state-owned banks*

The SOB group functioned quite well over the study period with average efficiency scores of 0.92 (CCR) and 0.96 (BCC), which was higher than the average estimates of NSOB (0.87 and 0.93 for CCR and BCC models, respectively). This is opposite to the findings of Matousek, Nguyen, and Stewart (2014) comparing the average efficiency scores of these two groups over the period of 1999-2009. Furthermore, these two groups shared similar trend of decreasing efficiency in 2012 before recovering back and rising in the last two years.

Table 4: Efficiency estimates of SOB vs. NSOB banks, 2011-2014

Year	SOB		NSOB	
	CCR	BCC	CCR	BCC
2011	0.93	0.98	0.87	0.91
2012	0.86	0.94	0.80	0.93
2013	0.90	0.94	0.88	0.94
2014	0.97	0.99	0.91	0.95
Mean	0.92	0.96	0.87	0.93

Source: Author's estimates based on DEA results

2) Listed vs. unlisted banks

Aiming at increasing competition and transparency of the banking industry, the government and State Bank of Vietnam have urged Vietnamese commercial banks to become listed on the stock market. Nonetheless, there have been only nine banks in the listed group so far due to the impact of global crisis and downturn in Vietnamese stock market recently. These listed banks consist of four very large banks (Vietinbank, BIDV, VCB, and MBB), four large banks (Sacombank, ACB, SHB, and Eximbank), and a small bank (NCB). As shown in Table 5, the listed group functioned well over the study period, enjoying higher efficiency scores (over 90% in both CCR and BCC models) than the unlisted group. This result implies that the listed banks utilised banking resources such as employees, physical assets more efficiently and demonstrated better managerial skills than the unlisted banks. This finding also advocates for the government and SBV's will of increasing the number of listed banks among Vietnamese commercial banks in the next years.

Table 5: Efficiency estimates of Listed vs. Unlisted banks, 2011-2014

Year	Listed banks		Unlisted banks	
	CCR	BCC	CCR	BCC
2011	0.95	0.98	0.85	0.90
2012	0.84	0.94	0.80	0.93
2013	0.88	0.92	0.89	0.94
2014	0.94	0.97	0.91	0.94
Mean	**0.90**	**0.95**	**0.86**	**0.93**

Source: Author's estimates based on DEA results

D. Banking efficiency and M&A activities

As part of the implementation timeline for Vietnamese banking restructuring plan 2011-2015, the study period witnessed some M&A activities involving BIDV, SHB, HD Bank, SCB, PVcomBank, and LVPB. In general, the eight banks involved in the restructuring process enjoyed an increase in their level of overall technical efficiency over the period 2011-2014, except for BIDV.

Table 6: Overall technical efficiency of some M&A banks, 2011-2014

Bank	2011	2012	2013	2014
BIDV	1.00	1.00	1.00	0.94
SHB	0.90	0.73	0.97	1.00
HD Bank	0.77	0.57	1.00	0.96
SCB	0.68	0.77	0.64	0.73
PVcomBank	0.55	0.86	n/a	1.00
LVPB	0.74	0.59	0.84	0.87

Source: Author's estimates based on DEA results

BIDV was the most efficient state-owned bank and among the most efficient banks in the sample. Two branches of this bank (Chuong Duong and Ben Nghe) acquired all the assets of Lao Viet Joint Venture Bank (LVB) in 2013. BIDV was removed from the efficient frontier in 2014 as its technical efficiency score (CRSTE) fell by 6% to 0.94 in 2014, indicating the inefficiency in utilising the bank's resources including the assets acquired. Another bank experienced a decline in efficiency after an M&A activity is LVPB which was formed from the merger of Lien Viet Bank with Vietnam Postal Savings Company (VPSC) in 2011. After the merger, LVPB showed high level of inefficiency in operations with CRSTE score of 0.59, indicating a waste of input resources at a rate of more than 40%, before a substantial increase after that to 0.87 in 2014. These cases raised suspicion on the effectiveness of M&A activities as an initiative in the 2011-2015 banking restructuring plan for Vietnamese banking sector.

In contrast, the banking M&A activities did help improve the efficiency level of some Vietnamese commercial banks during this four-year period. For example, the overall technical efficiency of Saigon-Hanoi Joint Stock Commercial Bank (SHB) decreased substantially from 0.90 in 2011 to 0.73 in 2012, but then impressively rose to 0.97 in 2013 after the bank acquired Hanoi Building Joint Stock Commercial Bank (Habubank) in 2012. Similarly, from being one of the most inefficient banks in the first two years of the study period, HD Bank took a significant step to stay on the efficient frontier in 2013 after this bank acquired Société Générale Viet Finance (SGVF) and DaiABank in 2013. However, the bank's overall technical efficiency slightly decreased by 4% in 2014, and this might be due to the burden of a big amount of non-performing loans from DaiABank. Another bank enjoyed improvement in efficiency after carrying out M&A activity is PVcomBank which was established from the merger between Western Bank and Petrovietnam Finance Corporation (PVFC) in 2013.

These two opposite results of banking efficiency after M&A activities among Vietnamese commercial banks support the findings of previous literatures on this popular topic that almost half of acquisitions can be considered unsuccessful against the initial objectives set for them, and that acquisitions continue to produce negative average returns as seen before (Cartwright and Schoenberg 2006). Thus, M&A approach does not always lead to positive effects.

E. Banking efficiency and banking self-restructuring

Besides mergers and acquisitions, voluntary or compulsory self-restructuring is another measure to handle with weak banks in the project "Restructuring the system of credit institutions during the period 2011-2015." Within the study period, NCB (originally Navibank) and TPBank were two representatives in the sample that have gone through self-restructuring process.

Table 7: Efficiency estimates of self-restructuring banks, 2011-2014

Bank	2011		2012		2013		2014	
	CCR	BCC	CCR	BCC	CCR	BCC	CCR	BCC
NCB	1.00	1.00	0.92	0.93	0.67	0.67	1.00	1.00
TPBank	n/a	n/a	1.00	1.00	1.00	1.00	0.81	0.82

Source: Author's estimates based on DEA results

National Citizen Bank (NCB) was originally Nam Viet Bank (Navibank) before this bank changed its name in 2013 as the start of self-restructuring process. The efficiency results in Table 7 showed that NCB had operated at both technically

inefficiency level and low management skills in 2013 before became efficient in 2014. Furthermore, TPBank was on efficient frontier in two consecutive years (2012 and 2013) after successfully implementing its self-restructuring plan in 2011. However, the banks' efficiency score dropped drastically by 20% in 2014 due to relatively high increase in the inputs (staff expenses and fixed assets) used to produce the same level of outputs. On one hand, these two cases demonstrate the positive results of self-restructuring initiative proposed in the project of restructuring Vietnamese banking system 2011-2015. On the other hand, this also implies that the banking self-restructuring could bring a short-term positive impact on the bank's efficiency, but it is not easy or simple to maintain that in the long term.

VI. Conclusion and Recommendation

A. Conclusion

The results showed that the average overall technical efficiency of Vietnamese commercial banks over the period 2011 - 2014 was 0.87, indicating that the banks were operating at 13% waste of banking resources. The banks experienced a decline of overall technical efficiency in 2012 before recovering and increasing over the last years of the study period. In addition, large and very large banks functioned better than small and medium banks in terms of management skills, but there was not much difference among these groups in terms of average overall technical efficiency over the four year period. State - owned and listed banks obtained higher efficiency levels (in both CCR and BCC models) than non - state - owned and unlisted banks. Finally, while self - restructuring resulted in positive effect on efficiency of two involving banks in the sample, the M & A activities showed ambiguous impact on the efficiency of the participating commercial banks during the study period.

B. Recommendation

1) Policy implications for improving the efficiency of Vietnamese commercial banks

Firstly, the spike in non-performing loans (NPLs) in 2012 led to the decline in efficiency of Vietnamese commercial banks in that year. The average NPL ratio during the period of 2011-2014 was reported by banks at around 4%, but the real ratio according to Fitch and Moody's was estimated at approximately 15% which was among the highest ratios in Southeast Asia. Thus, to improve the banks' efficiency, reducing the ratio of NPLs in the banking system should be highly concerned and focused.

Secondly, listed banks showed better performance than unlisted banks over the study period (in both CCR and BCC models). However, due to the downturn in Vietnamese stock market recently, there have been only nine banks in the listed group so far including four very large banks (Vietinbank, BIDV, VCB, and MBB), four large banks (Sacombank, ACB, SHB, and Eximbank), and a small bank (NCB). Hence, to achieve the aim of increasing the number of listed banks, the government should also concentrate on recovering the stock market and provide stimulus for those planning to go public. The increase in the number of listed banks also helps promote transparency as well as quality and availability of banks' reported financial reports.

Finally, as the findings in this study suggested, there was not much difference in average efficiency scores over the period 2011-2014 among small, medium, large, and very large banks. Besides, while the merger and acquisition activity brought positive impact on several banks, it did have adverse effect on some other banks. Meanwhile, two banks in the sample did enjoy substantial efficiency improvement after carrying out their self-restructuring plans. Therefore, the 2011-2015 banking restructuring plan is expected to help improve the efficiency of Vietnamese commercial banks, but it should be implemented with thorough consideration and continuous assessment.

2) Research limitation and recommendation for further research

Although this study has carefully considered and selected the most appropriate research approach, there still exist some limitations due to time and budget restrictions. Some drawbacks of the research method regarding DEA method, Min-Max normalisation technique, data collection, and sample, were addressed and analysed in details earlier in the Methodology chapter. Accordingly, one of the biggest limitations of this method was the relative estimation of efficiency based on the benchmark of the most efficient one in the sample, not with certain standard (absolute) efficiency. In addition, the results may change with different selection of inputs and outputs. Besides, due to lack of data, the sample excluded some small banks which were included in the group of weak banks. Thus, the average efficiency scores of the sample may not accurately reflect the efficiency of the Vietnamese commercial banking system.

Based on limitations of the research, some recommendations are made for further research in the future, aiming at overcoming the limitations and extending the scope of research. Firstly, the future research may adopt parametric approach such as SFA or a combination of DEA and a parametric method or another technique such as Malmquist, Double bootstrap, or Tobi regression. Moreover, besides DEAP 2.1, other computer software programs can be applied to run the DEA model. Secondly, the future research may try different selection of inputs and outputs or other techniques to deal negative data such as additive DEA model, SBM, RDM, and SORM. Thirdly, by adding more banks into the sample, the overall efficiency of Vietnamese banking system can be better pictured. Moreover, the scope of research can be extended to also include other types of banks such as foreign commercial banks in Vietnam. Then, the efficiency of the whole banking system in Vietnam can be evaluated. Finally, the future research can be conducted in a longer period to compare and analyse the efficiency changes of Vietnamese commercial banks before and after implementation of the banking restructuring plan 2011-2015.

Acknowledgment

We would like to express our sincere gratitude to Nguyen Thanh Tung and Yousif Hussin for helpful comments on an earlier version of this paper.

REFERENCE

[1] B. Banerjee, "'Banking Sector Efficiency in New EU Member States: A Survey of Cross-Country Evidence," Eastern European Economics, vol. 50, no. 6, pp. 81-115.

[2] R.D. Banker, A. Charnes and W.W. Cooper, "'Some models for estimating technical and scale inefficiencies in data envelopment analysis," Management science, vol. 30, no. 9, pp. 1078-1092.

[3] A.N. Berger and D.B. Humphrey, "'Efficiency of financial institutions: International survey and directions for future research," Eur.J.Oper.Res., vol. 98, no. 2, pp. 175-212.

[4] A.N. Berger and L.J. Mester, "'Inside the black box: What explains differences in the efficiencies of financial institutions?" Journal of Banking & Finance, vol. 21, no. 7, pp. 895-947.

[5] M. Bezemer and S. Schuster, "'Viet Nam: Financial Sector Assessment, Strategy, and Road Map | Asian Development Bank ", vol. 2016, no. 2/12/2016.

[6] S. Campbell and B.D. Pham, "'Vietnam Chapter | Banking Regulation | Gide Loyrette Nouel ", vol. 2016, no. 2/12/2016.

[7] A. Charnes, W.W. Cooper, A.Y. Lewin and L.M. Seiford, "'Data envelopment analysis: Theory, methodology, and applications,", 2013.

[8] A. Charnes, W.W. Cooper and E. Rhodes, "'Measuring the efficiency of decision making units," Eur.J.Oper.Res., vol. 2, no. 6, pp. 429-444.

[9] C. Chen, "'Bank efficiency in Sub-Saharan African middle income countries," IMF Working Papers, pp. 1-32.

[10] N. Dang-Thanh, "'Measuring the performance of the banking system: case of Vietnam (1990-2010)," Journal of applied finance and banking, vol. 2, no. 2, pp. 289-312.

[11] L. Drake and M. Hall, "'Efficiency in Japanese Banking: An Empirical Analysis,", 2001.

[12] A. Emrouznejad, A.L. Anouze and E. Thanassoulis, "'A semi-oriented radial measure for measuring the efficiency of decision making units with negative data, using DEA," Eur.J.Oper.Res., vol. 200, no. 1, pp. 297-304.

[13] C. Erasmus and D. Makina, "'An Empirical Study of Bank Efficiency in South Africa Using the Standard and Alternative Approaches to Data Envelopment Analysis (DEA)," Journal of Economics and Behavioral Studies, vol. 6, no. 4, pp. 310.

[14] R. Färe and C.K. Lovell, "'Measuring the technical efficiency of production," J.Econ.Theory, vol. 19, no. 1, pp. 150-162.

[15] M.J. Farrell, "'The measurement of productive efficiency," Journal of the Royal Statistical Society.Series A (General), vol. 120, no. 3, pp. 253-290.

[16] H.O. Fried, C.K. Lovell and S.S. Schmidt, "'Efficiency and productivity," The measurement of productive efficiency and productivity growth, vol. 3, pp. 3-91.

[17] H. Fukuyama, "'Technical and scale efficiency of Japanese commerical banks: a non-parametric approach," Appl.Econ., vol. 25, no. 8, pp. 1101-1112.

[18] N.V. Hùng, "'Measuring Efficiency of Vietnamese Commercial Banks: An Application of Data Envelopment Analysis (DEA)‖," Technical Efficiency and Productivity Growth in Vietnam, pp. 60-70.

[19] M. Karimzadeh, "'Efficiency analysis by using Data Envelop Analysis model: evidence from Indian banks," International Journal of Latest Trends in Finance and Economic Sciences, vol. 2, no. 3, pp. 228-237.

[20] S. Kumar and R. Gulati, "'An examination of technical, pure technical, and scale efficiencies in Indian public sector banks using data envelopment analysis," Eurasian Journal of Business and Economics, vol. 1, no. 2, pp. 33-69.

[21] H. Leibenstein and S. Maital, "'Empirical estimation and partitioning of X-inefficiency: a data-envelopment approach," Am.Econ.Rev., vol. 82, no. 2, pp. 428-433.

[22] C.K. Lovell, "'Measuring the macroeconomic performance of the Taiwanese economy," Int J Prod Econ, vol. 39, no. 1, pp. 165-178.

[23] M.A. Martin, "'On the double bootstrap,", 1992.

[25] M.J. Milne and R.W. Adler, "'Exploring the reliability of social and environmental disclosures content analysis," Accounting, Auditing & Accountability Journal, vol. 12, no. 2, pp. 237-256.

[26] M. Ncube, "'Efficiency of the banking sector in South Africa," University of the Witwatersrand, pp. 1-44.

[27] H.T. Nguyen, "'Commercial banking in Vietnam,".

[28] T.H.V. Nguyen, "'Evaluating the efficiency and productivity of Vietnamese commercial banks: A data envelopment analysis and Malmquist index,".

[29] X. Nguyen and B. De Borger, "'Bootstrapping efficiency and Malmquist productivity indices: An application to Vietnamese commercial banks,".

[30] J. Pastor, F. Perez and J. Quesada, "'Efficiency analysis in banking firms: An international comparison," Eur.J.Oper.Res., vol. 98, no. 2, pp. 395-407.

[31] F. Porcelli, "'Measurement of Technical Efficiency. A brief survey on parametric and non-parametric techniques," University of Warwick, vol. 11.

[32] D. Sharma, A.K. Sharma and M.K. Barua, "'Efficiency and productivity of banking sector: A critical analysis of literature and design of conceptual model," Qualitative Research in Financial Markets, vol. 5, no. 2, pp. 195-224.

[33] H.D. Sherman and F. Gold, "'Bank branch operating efficiency: Evaluation with data envelopment analysis," Journal of banking & finance, vol. 9, no. 2, pp. 297-315.

[34] C. Stewart, R. Matousek and T.N. Nguyen, "'Efficiency in the Vietnamese banking system: A DEA double bootstrap approach," Research in International Business and Finance, vol. 36, pp. 96-111.

[35] B.M. Tabak, D.M. Fazio and D.O. Cajueiro, Profit, Cost and Scale Efficiency for Latin American Banks: concentration-performance relationship.

[36] M. Trivedi, "'Managerial Economics: Theory and Applications,", 2002.

[37] B. Vujčić and I. Jemrić, "'Efficiency of banks in transition: A DEA approach,".