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**EFFICIENCY OF THE BANKING SYSTEM IN VIETNAM
UNDER FINANCIAL LIBERALIZATION**

A thesis presented in partial fulfilment of the requirements for

the degree of

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in

Banking Studies

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Abstract

The thesis reviews the (triangular) relationship between financial liberalization, economic growth, and banking development. It points out the causality effect where financial liberalization could improve the efficiency of the banking sector, but on the other hand, it also could lead to instability in the banking system. The recent Global Financial Crisis raised questions as to how and at what level financial liberalization could be done so that for banking development, improvements are achieved but instabilities are avoided. The thesis answers these questions employing a new sample (the Vietnamese banking system), covering a long period (1990-2010), and consistently applying different approaches and models. Three different approaches are used, namely ratio analysis, stochastic frontier analysis (SFA), and data envelopment analysis (DEA).

Our findings suggest that the performance of the Vietnamese banking system generally improved during 1990-2002, worsened during 2003-2008, and recovered in 2009-2010. However, there was no statistical association between this performance and the regional or global financial crises in 1997 and 2007/08. Although future studies are needed (since our sample was small and thus, the results may not be accurate), there was evidence that the state-owned commercial banks were less efficient than the joint-stock commercial banks and hence, equitization of the state-owned commercial banks should be speeded up in order to transform their ownership, reducing their size, and improving their performance.

There are consistencies between these approaches in terms of defining the efficiency scores, trends, and best and worst performers. Our findings also suggested that the time-trend-DEA, as well as the Fisher Index-DEA models, could be an alternative to the panel-DEA and Malmquist Index-DEA models since they could provide additional information on the performance measures, especially in case of data limitation. However, we could not find consistent results between the ratio analysis model and the ratio-based DEA ones (Panel- and Malmquist Index-DEA) in terms of scores, trends, and determinants.

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Publication during candidature

Some of the preliminary publications are not part of the thesis per se, but they were undertaken in the progress of me doing my thesis, which in turn enlighten aspects of this work.

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List of Abbreviations

ADB	Asian Development Bank
ATM	Auto Teller Machine
BCC	Banker, Charnes and Cooper (1984)
BFOB	Branch of Foreign-Owned Bank
BIS	Bank for International Settlements
BMI	Business Monitor Inc.
BRC	Bank Restructuring Committee
CAMELS	Capital adequacy, Asset quality, Management quality, Earnings ability, Liquidity, and Sensitivity to market risks
CCR	Charnes, Cooper and Rhodes (1978)
CE	Cost Efficiency
CES	Cost Elasticity
CIR	Cost-to-Income Ratio
COLS	Corrected Ordinal Least Squares
CRS	Constant Returns To Scale
DEA	Data Envelopment Analysis
DFA	Distribution Free Analysis
DMU	Decision Making Unit
DRTS	Decreasing Returns To Scale
EF	Efficiency score

EOS	Economies Of Scale
FDH	Free Disposal Hull
FDIC	Federal Deposit Insurance Corporation
FF	Fourier Flexible function
FI	Fisher Index
FR	FitchRatings
GDP	Gross Domestic Product
GNP	Gross National Product
GSO	General Statistics Office of Vietnam
HASTC	Hanoi Securities Trading Centre
HOSE	Hochiminh Stock Exchange
HSTC	Hochiminh City Securities Trading Centre
IMF	International Monetary Fund
IRTS	Increasing Returns To Scale
JLMS	Jondrow, Lovell, Materov and Schmidt (1982)
JSCB	Joint-Stock Commercial Bank
JVB	Joint-Venture Bank
LML	Local Maximum Likelihood
MI	Malmquist Index
MIS	Moody's Investor Service
MOLS	Modified Ordinary Least Squares

MPSS	Most Productive Scale Size
NIM	Net Interest Margin
NPL	Non-Performing Loan
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
OTC	Over-The-Counter
PCA	Principal Component Analysis
PI	Performance Index
RA	Ratio Analysis
ROA	Returns On Average Assets
ROE	Returns On Average Equity
S&L	Savings and Loan
SBM	Slacks-Based Measure
SBV	State Bank of Vietnam
SFA	Stochastic Frontier Analysis
SOCB	State-Owned Commercial Bank
SWIFT	Society for Worldwide Interbank Financial Telecommunication
TE	Technical Efficiency
TFA	Thick Frontier Analysis
TFP	Total Factor Productivity
U.S.	United States

UPCOM	Unlisted Public Company Market
VAMC	Vietnamese Asset Management Company
VCP	Vietnam Communist Party
VRS	Variable Returns To Scale
WB	World Bank
WTO	World Trade Organization

1 Introduction

In the early twentieth century, Schumpeter (see 1911) argued that the role of financial intermediaries in savings mobilization, project evaluation and selection, risk management, monitoring of entrepreneurs, and facilitating transactions is important to technological innovation and economic growth. By having a cost advantage for acquiring and processing information about firms and managers, financial intermediaries can alter the path of economic progress via resources re-allocation as “... the carrying into effect of an innovation involves, not primarily an increase in existing factors of production, but the shifting of existing factors from old to new uses” (Schumpeter, 1939, p. 110).

After the rapid development of new industrial economies such as Japan, South Korea, etc. in the 1960s – 1970s, there was renewed interest in the relationship between financial and economic growth. Following Schumpeter’s argument, Goldsmith (1969), Shaw (1973), McKinnon (1973) and other leading economists used cross-country data from the 1960s – 1970s to emphasize the positive role of the financial sector in economic development. They suggested that the financial sector should be liberalized to raise saving, capital accumulation, and hence economic growth (McKinnon, 1973; Shaw, 1973; World Bank, 1989), as government intervention in the financial system has a negative effect on economic development (King & Levine, 1993a, b).

In 1969, Goldsmith pointed out that the financial superstructure of an economy can accelerate economic growth and, therefore, improves the economic performance to an extent that it allocates funds to the best user. Despite the conclusion that “a rough parallelism can be observed between economics and financial development”, however, Goldsmith also found that it is difficult to tell “whether financial factors were responsible

for the acceleration of economic development or whether financial development reflected economic growth whose mainsprings must be sought elsewhere” (Goldsmith, 1969, p. 48). This conclusion may relate to the difficulties in assembling comparable data of the finance sector (Goldsmith examined only thirty-five countries with data prior to 1963). Hence, researchers continued to provide additional findings in order to strengthen the above statement.

In the World Development Report 1989, the World Bank (WB) recognized the biggest contribution to growth of the financial sector was its ability to increase efficiency in trade, saving, and investment (World Bank, 1989). Later, Greenwood and Jovanovic (1990) emphasized that, “through a research-type process, intermediaries collect and analyze information that allows investors’ resources to flow to their most profitable use. By investing through an intermediary, individuals gain access... to a wealth of experience of others... (and) obtain both a higher and a safer return” (p. 1078).

Using ordinary least squares (OLS) regression, King and Levine (1993a) showed that “finance seems importantly to lead economic growth” as the (initial) level of financial sector development is positively and significantly correlated with subsequent economic growth (pp. 730-733). King and Levine (1993b) later took this finding a step further figuring that,

“Thus, a more-developed financial system fosters productivity improvement by choosing higher quality entrepreneurs and projects, by more effectively mobilizing external financing for these entrepreneurs, by providing superior vehicles for diversifying the risk of innovative activities, and by revealing more accurately the potentially large profits associated with the uncertain business of innovation. In these

ways, better financial systems stimulate economic growth by accelerating the rate of productivity enhancement” (p. 540).

This enhancement effect, according to De Gregorio and Guidotti (1995), was more than 75 percent explained by the improved efficiency of investment. Even though this effect varied across countries and over time, for developing countries in general, when the volume of investment was included in the model, the effect of financial development on the volume of investment was relatively small (De Gregorio & Guidotti, 1995).

In 2000, Beck, Demirgüç-Kunt, and Levine made a big contribution to the Schumpeter and Goldsmith analysis by introducing a financial development and structure database comprising almost 150 countries.¹ The database, as the authors suggested, was the first “systemic compilation of data” providing indicators on market structure, size, activities, ownership, etc. that “capture the development and structure of the financial sector across countries and over time along many different dimensions” (Beck *et al.*, 2000, p. 18). Based on that, Demirgüç-Kunt and Levine (2001) showed that, overall, the “financial development tends to accelerate economic growth, facilitate new firm formation, ease firm access to external financing, and boost firm growth” (p. 11). This lift of the data barrier by the above database as well as other financial datasets allowed the booming of studies on the finance-growth nexus later.² Additional evidence supporting the positive linkage between finance and growth have been found by Kroszner, Laeven, & Klingebiel (2007), Brissimis, Delis, & Papanikolaou (2008), and Chang, Jia, & Wang (2010), among others.

¹ This database was last updated in November 2013 with 31 indicators for 203 countries covering the period of 1960-2011 (<http://go.worldbank.org/X23UD9QUX0>).

² According to ScienceDirect.com, there were more than 2,150 research articles on the finance-growth nexus after 2000, while there were about 600 articles on the same topic prior to that year (reported on 08/02/2013).

The balance from the work of previous researchers that finance can facilitate economic growth also supports financial deregulation or liberalization. Patrick (1966, p. 182) argued that “the more perfect are financial markets, the more nearly optimum allocation of investment is achieved”. Hence, financial liberalization is needed, as it can “increase the supply and improve the allocation of funds for investment”, according to Laeven (2003, p. 6). He also realized that, while financial liberalization can boost economic development, it also can improve the political system of the nation as well (Laeven, 2003, p. 25). Hence, deregulating and liberalizing the financial system is a multi-purpose program. This was consistent with McKinnon (1973) and Shaw (1973) when they found out that interest rate liberalization is likely to lead to an increase in interest rates which later motivates household savings and increases funds for investment. Moreover, they argued that as interest rate ceilings and direct credit programs may result in distorting or misallocating of funds, financial liberalization therefore should be favored.

Consequently, new evidence for the financial liberalization and economic growth linkage is important to contribute to the literature. In their paper, Ranciere *et al.* (2006) examined the dual effects of financial liberalization by dividing it into direct effect – financial liberalization tends to relax borrowing constrain, hence, it leads to investment enhancement and then higher economic growth; and indirect effect – the likelihood of crises as financial liberalization also encourages risk-taking activities and hence, generates financial fragility.³ They found that the direct effect is always greater than one, which means financial liberalization can contribute at least 1% to annual per capita GDP growth. Meanwhile, the indirect effect is negative and smaller than -0.2% in annual growth, indicating that the

³ The financial liberalization variable, according to these authors, is a de facto index that signals the year when a country liberalized its financial market. For more details, see Appendix B (Ranciere *et al.*, 2006, p. 3345).

negative side of financial liberalization is about five times smaller than its positive one. Levchenko *et al.* (2009) provided more details on the dual effect of financial liberalization by pointing out that the positive effect comes from increased entry of firms, higher capital accumulation, and expansion of total employment; while the negative effect, or volatility as termed by the authors, depends on a country's level of industrial diversification. Using China as a case study, Hasan *et al.* (2009b) also found that the development of financial markets, alongside legal environment, awareness of property rights and political pluralism, is positively associated with economic growth. Law *et al.* (2013) conducted a cross-country analysis of 85 countries from 1980 to 2008 showing that the impact of finance on growth is positive and significant only after a certain threshold level of institutional development has been attained. They suggested that the financial-growth nexus is contingent on the level of institutional quality, thus better finance is potent in delivering long-run economic development.

Although the financial system has a critical role in economic growth, it can be a source of fragility. Since mid-1950s, many economists believed that the role of the financial sector in economic growth was over-emphasized, including Robinson (1952), Lucas (1988) and Chandavarkar (1992). In their arguments, finance is unimportant with passive effects on economic growth. Normally "enterprise leads, finance follows" (Robinson, 1952, p. 52); and therefore, the financial sector should be developed after economic development (Kitchen, 1986). In 1989, Tobin argued that the financial system itself is a monopolistic system, in which, financial intermediaries "seek the custom of depositors and borrowers by trying to differentiate their products as well as by offering attractive interest rates and terms... (hence) the financial services differ only trivially" (p. 293). Rajan and Zingales

(1998), in a search for industry-level evidence of the finance-growth nexus, realized that “the *ex ante* development of financial markets facilitates the *ex post* growth of sectors dependent on external finance” (p. 560) but finance itself was just “a lubricant... but not a substitute for the machine” (p. 561). This was emphasized further when Easterly, Islam, & Stiglitz (2000) found out that a developed financial market can offer opportunities for growth volatility stabilization, meanwhile it also implies higher risk and lower stability. Hence, “the existence of a deep financial system might reduce growth volatility, particularly when shocks are small, on average, but up to a limit” (Easterly *et al.*, 2000, p. 202).

The recent Global Financial Crisis of 2007/08 (GFC) also required a re-examination of the relation between financial (liberalization) and economic growth. Beck (2012a, b) argued that the maturity and liquidity transformation from short-term savings and deposit facilities into long-term investments could render the system susceptible to shocks, with the possibilities of bank and liquidity runs. Consequently, the failure of financial institutions, including the banking sectors, can result in significant negative externalities beyond the private costs of failure to the banks themselves – the costs of systemic banking distress in some cases can be substantial reaching over 50 percent of GDP in fiscal costs and over 100 percent in output loss (Laeven & Valencia, 2013). It is therefore the need of a safety net in the financial sectors to protect depositors or even non-depositors and equity holders. On the other hand, this safety net subsidy induces aggressive risk-taking by financial institutions in multiple country-level and cross-country studies (see, for example, Demirgüç-Kunt & Kane, 2002).

Similar to the debate on the finance-growth nexus, there are researchers who argue against financial liberalization, including van Wijnbergen (1983), Devereux & Smith (1994), and Gertler & Rose (1994). Even if interest rates are liberalized, as van Wijnbergen (1983) argued, the informal credit market that exists in underdeveloped countries still can eliminate the effect of saving accumulation, hence the supply of funds to firms may fall overall. In addition, a rise in interest rates (due to liberalization) may also increase financial risks (Devereux & Smith, 1994) and the cost of borrowing (Gertler & Rose, 1994), thereby reducing the total funds for investment. Goyal (2012) even argued that one reason for the GFC to happen was due to ideology – people’s belief that the market is efficient and self-regulated where failures do not occur. Markets as well as regulators failed, however, implying that regulatory interventions are still needed.

Apparently, this finance-growth nexus requires more analysis on the causal effect between finance (and financial liberalization) and economic development. Studying the changes in financial intermediaries and their relationship with economic development under a financial liberalization process can contribute to the debate.

1.1 Banking development under financial liberalization

Banks are the core of the financial system. They accept deposits from savers and lend them to borrowers. They hold liquid reserves which allow predictable withdrawal demand. They issue liabilities that are more liquid than their primary assets. They also reduce (or sometimes eliminate) the need for self-financing (Bencivenga & Smith, 1991). The intermediation services of banks, i.e. transferring funds from savers to borrowers, allow banks to be “in the center of the process by which the economy chooses its real activities

and the way those activities are financed” (Fama, 1980, p. 44). Thus, researching the banking system somewhat means researching the financial system.

According to Schiffman (1993), for emerging economies, a sound banking system will hold a very important role in providing credit to restructure large state-owned enterprises (which are still undergoing reform), investing in financial and other markets to boost the economy, or increasing savings and investment ratios by attracting domestic and foreign customers. In contrast, a bad banking system can ruin the whole economy, leading to national and regional financial crisis, as it did in 1997 (Corsetti *et al.*, 1999). This two-sided effect of the banking system suggests that a “*positive relationship between financial intermediation and economic growth*” can be achieved only if the banking system is efficient (De Gregorio & Guidotti, 1995). Levine (1997) also agreed that the efficacy of financial intermediation can affect economic growth.

Patrick (1966) argued that, at the early state of financial liberalization, banking reform is not important. Apparently, bank offices are expensive for large numbers of relatively poor people in rural areas or small towns in underdeveloped countries. Hence, a postal savings program or the informal credit market may play some role in the beginning of financial liberalization, although more financial market competition, flexible exchange rate policy, and domestic price control are required in the end (Patrick, 1966, pp. 187-188). In contrast, Sametz (1991) argued that the financial infrastructure should be ready for any other social/political liberalization in a transition economy (i.e., China) because once prices of finance are operational, prices of inputs and outputs in the goods and services market are measured effectively. Changing financial tags and signals, hence, will then “lead to change in the behavior of government officials, households, and business managers quickly and

compatibly without vast multidirectional deregulation, re-regulation, and other reform activities” (Sametz, 1991, p. 339). Thus, the banking reform, including reforming the Central Bank and creating new competitive commercial banks, should be dealt with at first hand.

Regardless of the order of banking system liberalization, i.e. whether banking restructuring needs to be done at the beginning or end of the financial liberalization, researchers acknowledge the relationship between bank’s efficiency and financial development and economic growth. Demetriades and Luintel (1996) offered evidence from the Indian banking sector for 31 years, from 1961 to 1991. Their results suggested that in India, the bi-directional causality between financial deepening and economic growth do exist, and hence, policy makers could affect financial deepening by changing the bank’s willingness to attract deposits (Demetriades & Luintel, 1996). Bhattacharyya, Lovell, and Sahay (1997) supported this view arguing that the efficiency improvement of Indian banks was seen in foreign-owned banks only, which suggested that liberalization will enhance the development of migrated institutions. Leightner and Lovell (1998) also found that the total factor productivity (TFP) of Thai banks during the financial liberalization of 1989-1994 decreased for domestic banks and increased for foreign ones.⁴ Denizler, Dinc, and Tarimcilar (2007) suggested that after financial liberalization in Turkey, there was a decline in efficiency of the Turkish banking system. There are also arguments that banks only support for greater deregulation under which they were individually rewarded for engaging in increasingly risky lending practices. Particularly, for the pre-GFC period, many of the banks’ instruments are observed as valuable means of hedging and spreading risks that

⁴ TFP of Thai banks decreased when Bank of Thailand objectives were used in the research model; however, it rapidly increased if bank objectives were used. Ways to distinguish the two objectives can be found in Leightner and Lovell (1998, p. 123).

needs to be regulated rather than letting free (Mayes & Morgan, 2012). When the financial bubble burst, the banking sector fell into crisis (Kingsbury et al., 2012).

On the other hand, Ataullah, Cockerill, and Le (2004) found that the overall (technical) efficiency of banking sectors in India⁵ and Pakistan gradually improved over the period 1988-1998, especially at the post-liberalization period (1995-1998). Patti and Hardy (2005), by examining the bank privatization process in Pakistan in the period 1981-2002, showed that after the banking sector's reform, privatized banks' profit efficiency had increased and new private domestic banks generally proved to be on the efficiency frontier and sometimes out-performed foreign banks. When looking at a large sample of 4,000 banks in ten emerging countries in the Latin America and Asia regions (from 1991 to 2000), Hermes and Vu (2007) found evidence for the improvement of bank efficiency under financial liberalization. More evidence was found in the case of Turkish banks (Isik & Hassan, 2003; Isik, 2007), Romanian banks (Asaftei & Kumbhakar, 2008), Egyptian banks (Fethi *et al.*, 2011), and Taiwanese banks (Hsiao *et al.*, 2010). Delis, Molyneux, and Pasiouras (2011) reported that banks in 20 transition economies (in a total of 22 countries) experienced significant TFP growth, representative of banking systems experiencing major reforms. A recent study by Chortareas, Girardone, and Ventouri (2013) on a large sample of commercial banks operating in 27 European Union members showed that the higher the degree of an economy's financial freedom, the higher the benefits for banks in terms of cost advantages and overall efficiency.

In a similar manner but from different point of view, Hasan *et al.* (2009a) presented evidence of a positive relation between banking quality (efficiency) and economic growth

⁵ An extended analysis for the Indian banks during 1992-2004 by Das and Ghosh (2009) also confirmed that the liberalization in the banking sector had generally improved the cost and profit efficiencies of banks.

in several regions within 11 European Union countries, comprising Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxemburg, Spain, and Sweden. Focused on Germany only, (Koetter & Wedow, 2010) also found that the bank-specific efficiency has a significantly positive effect on growth.

Although there is no theoretical model explicitly analyzing the role of financial liberalization on bank efficiency, to the best of our knowledge, the analysis of banking efficiency has been considered in various contexts, with some contributions focusing on the effects of the bank-specific characteristics or the institutional environment within which banks operate. La Porta et al. (2002) found that state ownership of the bank tend to reduce its efficiency. Demirgüç-Kunt *et al.* (2004) documented that tighter regulations on banking services and activities increase the costs of financial intermediations. Barth et al. (2006), however, pointed out that capital adequacy regulations are believed to play a crucial role in aligning the bank activities with more careful lending and better bank performance. Chortareas *et al.* (2012) showed that private sector monitoring and restricting bank activities can result in higher bank inefficiency levels. Barth *et al.* (2013) also suggested that tighter restrictions on bank activities are negatively associated with bank efficiency. That evidence suggests that economic, regulatory, and institutional differences play an important, if not crucial, role in the efficiency of banks, and can explain the discrepancies in efficiency among banks in different countries.

To summarize, previous studies suggest that financial liberalization could support economic growth when institutions meet a certain quality; elsewhere liberalization could lead to more risky lending if supervision and monitoring are missing. Consequently, these institutional factors, as well as the bank-specific characteristics, can affect the bank's

efficiency. Additional evidence could therefore contribute to the above argument. The contribution is important if (i) new data is provided; (ii) longer period is covered; and (iii) different approaches are assessed. Hence, our study will employ both traditional and modern techniques to evaluate the efficiency of the Vietnamese banking system during its liberalization period of over 20 years, from 1990 to 2010. The results are expected to be consistent to each other in showing that the efficiency of Vietnamese banks increased after liberalization.⁶ We also propose some new measures to evaluate the efficiency of Vietnamese banks, for example, the measure that combines traditional technique (i.e. ratio analysis) and modern technique (i.e. data envelopment analysis), or the Fisher ideal total factor productivity index. Along with expected findings from evaluating the Vietnamese banking sector, these issues are also reflected in the following section.

1.2 Background on the Vietnamese banking sector and the expected findings

1.2.1 The financial liberalization process in Vietnam⁷

Before 1986, Vietnam's economy had no market principles. Thus, the financial markets did not really exist. There was no money market or capital market. The banking system had no commercial banks, and the central bank did all activities alone ("mono-bank" system). In addition, the banking system worked under direct control of the government through government order, without regard to market forces.

The Vietnam Government then significantly relaxed regulation following the Vietnam Communist Party (VCP) formally endorsing a program of "renovation", also known as

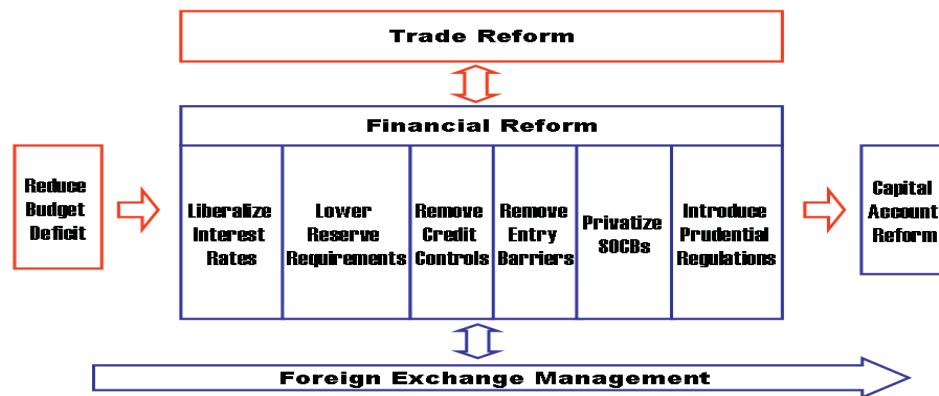
⁶ Gambacorta *et al.* (2014) suggested that in more advanced countries with more developed financial systems, this relationship is unwinding, with the recent GFC as an evidence. This effect would not be expected to be observed in Vietnam, however, because of the relative underdevelopment of its financial system and the ample remaining scope to enhance economic prosperity.

⁷ This part is an extension of Ngo (2004).

“Doi Moi”, at its Sixth National Congress in 1986. Central planning was relaxed, prices were freed, public sector spending declined, and restraints were loosened on business activity. Agricultural co-operatives were disbanded; farmers were given land-use rights and - in a similar way to China's transitional period - were allowed to market whatever output was left after they had fulfilled state contracts. In the financial and banking sector, the effects of “Doi Moi” resulted in a financial liberalization.

According to Shaw (1973) and McKinnon (1973), in transition economies, the order of economic liberalization should be started by balancing the government’s finances, then followed with the financial liberalization (together with trade and foreign currency liberalization), and ended with the opening of the capital account. We could also analyze the financial liberalization process in Vietnam following this order as in Figure 1.

Figure 1. Financial liberalization sequencing



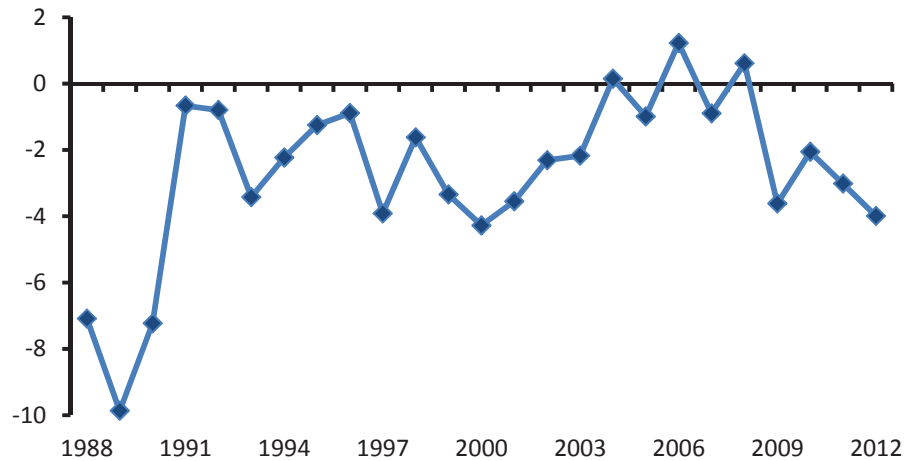
Source: Summarized from McKinnon (1973) and Laeven (2003)

1.2.1.1 State budget

After “Doi Moi” was launched, the budget deficit improved sharply. The budget deficit which was higher than 7% in the pre-1986 period was reduced to 4.3% in the 1991-1995 period and continued to reduce into acceptable rates in the 2000s. In the 2009-2012 period,

however, the budget deficits became larger due to the effect of the global financial crisis as well as the Government stimulus spending in response to it.

Figure 2. Budget deficit over GDP (%)



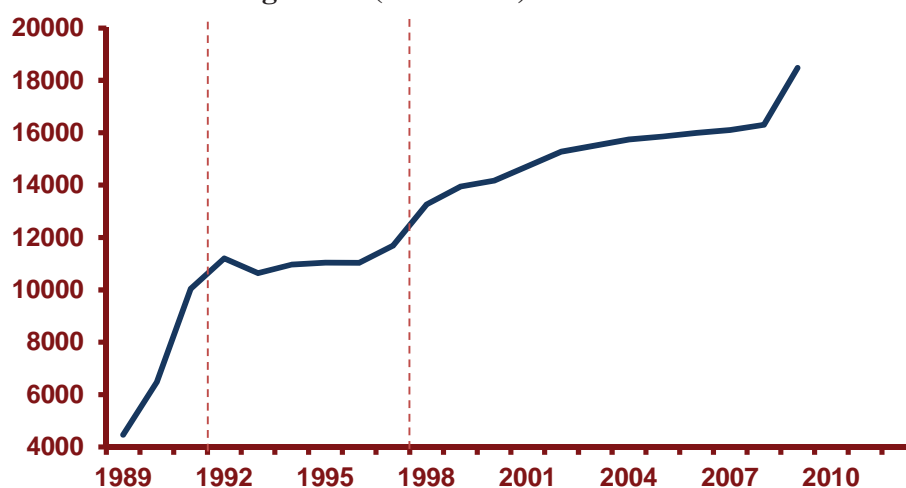
Source: ADB

1.2.1.2 Monetary, interest rate and foreign exchange rate

Instead of being dependent on the fiscal policy as was the case before 1990, monetary policy has become a typical macroeconomic instrument with an overall objective of controlling inflation and promoting economic growth. Currently, the making and influencing of monetary policy by the State Bank is based on market principles; market factors are respected and taken as the basis for the State Bank to make decision on adjustment to achieve macroeconomic objectives. The process of reforming monetary policy was done step by step, under control and linked to the reform of monetary policy instruments and reform in the institutional structure. Since 2000, indirect monetary policy instruments such as open market operations, rediscounting, and SWAP arrangements for foreign exchange, etc. have been replacing direct monetary control and administrative measures.

In parallel, interest rates have been liberalized. The SBV only influences the interest rate and exchange rate through money market and monetary policy instruments. Therefore, interest rates and exchange rates currently reflect more closely the value of the Vietnam Dong, and follow the development of the international and domestic money market. Interest rates were gradually liberalized in sequence and with caution. First of all, the real positive interest rate principle was introduced in 1992. Deposit interest rates were liberalized in 1996, and lending interest rates have been determined through negotiation since June 2002. After “Doi Moi”, Vietnam opened its economy to other countries. As a consequence, the Vietnam Dong was allowed to exchange with other currencies. Up to now, the exchange rate policies of Vietnam has experienced 3 periods: period of free exchange rate (1989-1991), period of fixed exchange rate (1992-1997) and controlled-floating exchange rate (1998-present).⁸

Figure 3. USD/VND exchange rates (1989-2012)



Source: ADB

⁸ Nguyen (2009) divided the period after 1997 into two sub-periods from 1997 to 2004 and from 2004 to recent, in which the first sub-period was affected by the 1997 Asian financial crisis (AFC) and the second was recovery period. Thus, the floating (ceiling and floor) barriers are different between these two periods but they still are Government controlled.

1.2.1.3 Securities market

The opening of the Hochiminh City Securities Trading Centre (HSTC) in July 2000 marked a milestone in Vietnam's efforts in its economic reforms and reaffirmed Vietnam's determination in developing a market economy.

After 10 years of operating the stock market, Vietnam has reached many achievements in the initial stage, generalized as follows: (1) successfully organized and operated the Hochiminh Stock Exchange (HOSE) and Hanoi Securities Trading Centre (HASTC); (2) ensured principles of the securities market; (3) gradually created more goods for the market, strengthening the management of listed firms and clarifying information on the market; (4) expanded operations of intermediary organizations on the market and improved service quality; (5) built domestic and foreign investor system; (6) developed the UPCOM (Unlisted Public Company Market) and OTC market; etc. At the end of 2010, there were 326 securities listed on the HOSE, accounted for nearly 6.834 billion U.S. dollars (around 8% of 2009 GDP).⁹ In the HASTC, the respective numbers were 977 listed securities with a value of 12.582 billion U.S. dollars (nearly 15% of 2009 GDP).¹⁰ OTC and UPCOM market had also developed. Vietnam's total stock market capitalization reached 19,542 U.S.\$ million in 2007 and reduced in 2008-2010 due to the global financial crisis (ADB, 2009b). The number of security trading accounts in HOSE had remarkably increased from 5,000 in 2000 to 106,393 accounts in 2006 and 822,869 accounts in 2009, in which 12,696 are from foreign investors (HOSE, 2009). This was a record which surprised even international investors. It led to the booming of the Vietnamese securities market in 2006-

⁹ HOSE's market scale (Retrieved from http://www.hsx.vn/hsx_en/Modules/Statistic/OMNY.aspx on 03/12/2010).

¹⁰ HASTC's market scale (Retrieved from http://en.hnx.vn/Quymo_niemyet.asp?stocktype=2 on 3/12/2010).

2007. However, the VN-Index decreased rapidly in 2008-2009 due to the global crisis; it has shown some partial recovery in 2010.

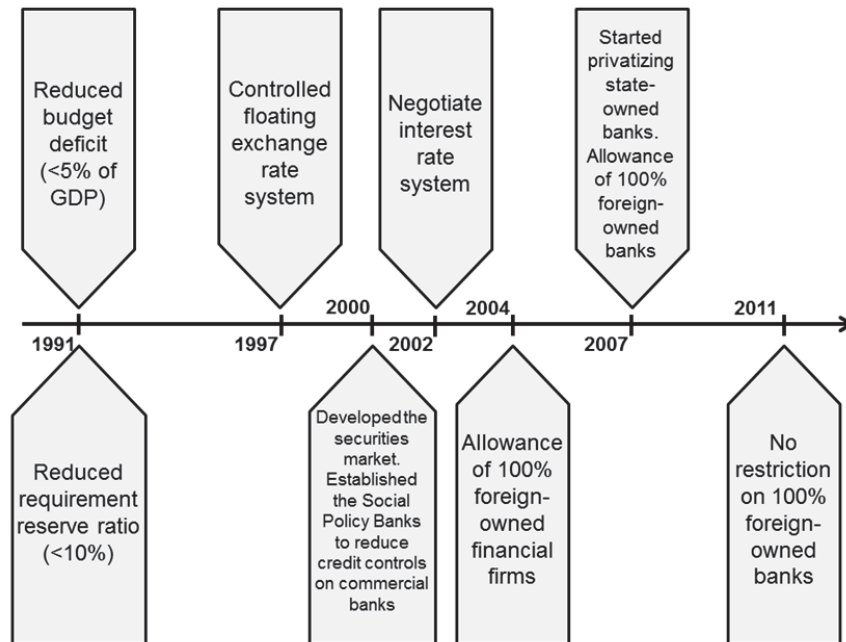
Figure 4. Time series of the VN-index (2006-2010)



Source: Vietcombank Securities (VCBS)

According to the financial liberalization sequencing of McKinnon, the financial liberalization follows, but not restrict to, a certain order. For example, the budget deficit should be dealt with at first hand, followed by the liberalization of interest rates and the deregulation in the banking sector (see Figure 1). By summarizing some of the important dates of the liberalization progress in Vietnam as in Figure 5, it is clear that Vietnam somewhat follows that order as well. First, the budget deficit issue was dealt with in 1991. Other deregulation policy regarding the banking system, exchange rates, and interest rates then followed. At the same time, the securities market was built up and developed. The final stage concerns the involvement of foreigners in the banking and insurance markets.

Figure 5. Financial liberalization in Vietnam



Source: Adapted from Ngo (2005)

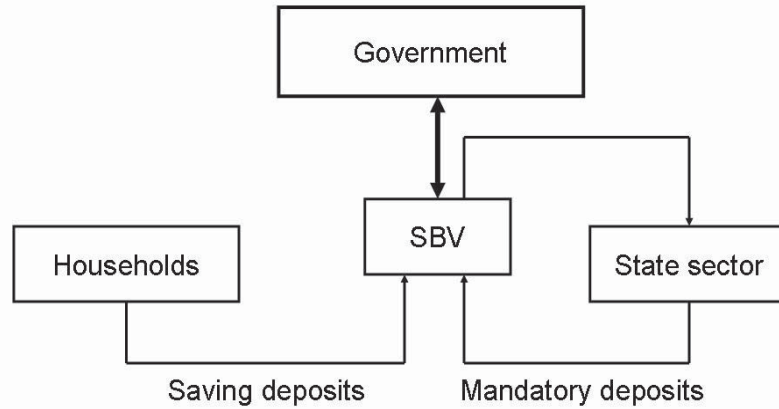
1.2.2 Development of the banking system in Vietnam

1.2.2.1 Vietnamese financial and banking system before 1990

After the wartime period, from 1975 to 1986, there was only one institution in the banking system of Vietnam: the State Bank of Vietnam (SBV).¹¹ SBV’s activities included issuing banknotes, currency revaluation, budget distribution, lending, etc. to fulfill its missions of managing state funds, serving the state sector, and financing the state budget (Nguyen, 2001).

¹¹ The SBV was established on 06/05/1951 under the Order 15/SL, signed by president Ho Chi Minh.

Figure 6. Role of the SBV before financial liberalization



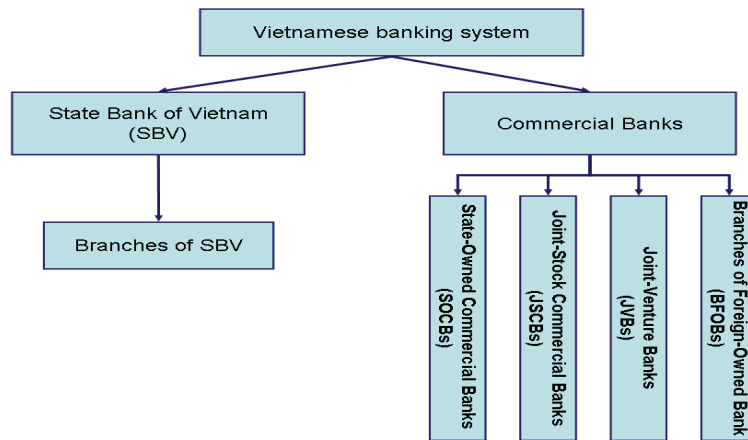
Source: Adapted from Tran (2001, p. 7)

This one-tier system may have some advantages of finance concentration in the wartime (for supporting the war); however, it was not suitable for economic development in the postwar period. Thus, in 1985-86, the SBV faced difficulties due to hyperinflation,¹² lack of human resources in the banking sector, and collapses of the cooperative credit unions,¹³ etc. This situation put decision makers under high pressure, leading them to try converting the SBV into a two-tier system (July 1987 and then March 1988). The big improvement, however, was not made until two important decrees, the “Decree on the State Bank of Vietnam” and the “Decree on Banks, Credit cooperative and Financial companies”, were announced in 1990 and applied in 1991 (Vietnamese Council of State, 1990b, a).

¹² The inflation reached its peak at 774 percent in 1986 (Abuza, 2002).

¹³ The main purpose of these cooperatives was to collect small deposits and provide credit to individuals, household farms, small businesses and production cooperatives. However, due to carelessness in issuing certificates for opening a credit union and the weakness in monitoring and supervision from the SBV, as well as the weakness of the working staff of these credit unions (Thu Hang, 2012), more than 7,000 rural and 500 urban credit unions collapsed in 1989-1990 (Nguyen, 2008).

Figure 7. Structure of the two-tier banking system in Vietnam (after May 1990)



Source: Vietnamese Council of State (1990b)

These decrees transformed the Vietnamese banking system into a two-tier one, which allowing the presence of commercial banks alongside the SBV. This enabling legislation facilitated the development of the State-owned commercial banks (SOCBs), Joint-stock commercial banks (JSCBs), Joint-venture banks (JVBs) and Branches of foreign-owned banks (BFOBs),¹⁴ based on equal treatment to create a sound competitive environment, transparency, and publicity in banking operations.

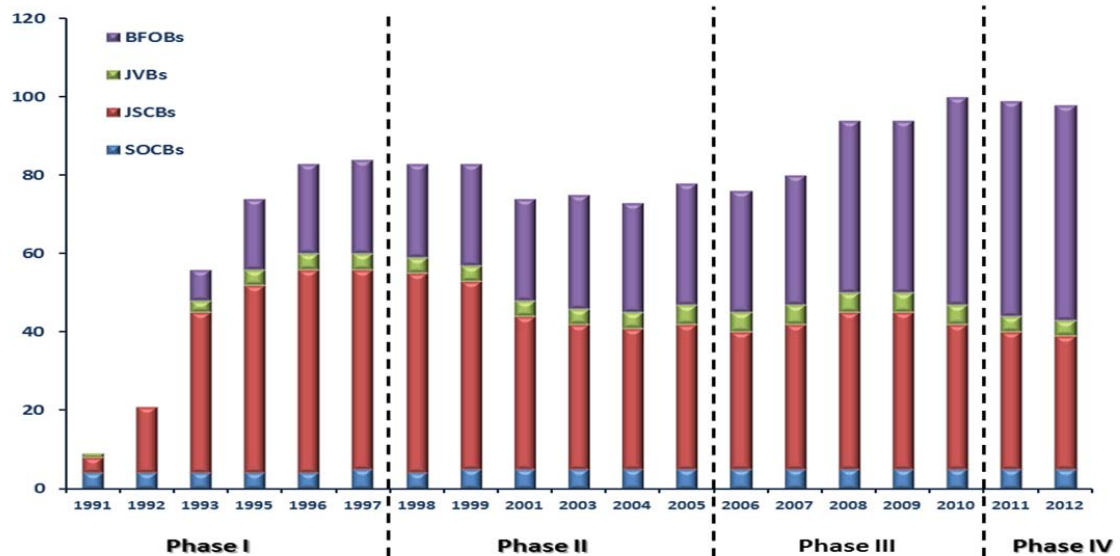
It is noticeable that over the decades, the participation of foreign banks and their branches in the system has increased, while the number of domestic banks, especially the JSCBs, had decreased (Figure 8). This was the result of financial liberalization, which is consistent with experiences from other countries (Bhattacharyya *et al.*, 1997; Leightner & Lovell, 1998).

By examining the size of the Vietnamese banking sector (i.e. number of banks, as in Figure 8), as well as considering the condition of the economy (e.g. the AFC in 1997 or the booming of the economy in 2006), one could notice that the Vietnamese banking system has experienced four development phases. Phase I (1990-1997) was a ‘booming’ phase

¹⁴ After 2007, BOFBs also included fully owned foreign banks as they were now allowed to operate, as a result of the WTO commitment from Vietnam.

thanks to the introduction of the two-tier system and the implementation of financial liberalization.¹⁵ Phase II (1998-2005) was for ‘evaluating and modifying’ after the effects of the AFC. Phase III (2006-2010) was a ‘prosperity’ period where a rapid development was seen in the banking sector. The last phase (2011-current) is a period of ‘contracting and restructuring’ with bankruptcies, mergers and acquisitions of banks, etc. due to the effects from the burst of the domestic securities and real estate bubbles in 2007 (Hoang, 2014), as well as effects from the GFC. Note that the growing trend of the banking sector as well as its restructuring may relate to the development of the (internal and external) financial system, which could be assessed via the first expected finding in the following section.

Figure 8. Number of banking institutions in Vietnam



Source: SBV

¹⁵ One could argue that this phase should instead end in 1998. We also test for the lag-effect of the AFC 1997 in section 4 below.

1.2.2.2 Financial liberalization and the Vietnamese banking system (1990-now)

The first phase covers the period of 1990-1996. Initially, the World Bank (1990) reported that the existence of the credit plan (from the government) did not give the Vietnamese banks and their branches the authority to refuse borrowing requests from (problem) firms and thus, banks were not playing much of a role in credit allocation. However, improvement was seen for both the SOCBs and JSCBs. Assets and loans increased, while returns over assets (ROA) grew significantly in the 1991-1994 period, from 1.1% and 1.0% in 1991 respectively for SOCBs and JSCBs, to 1.4% for both in 1994 (World Bank, 1995). This was consistent with findings from the International Monetary Fund (IMF). Two of the IMF's economists, Lipworth and Spittaller (1993), reported that the reform of the banking sector had "enhanced prospects of intensifying financial and commercial relations, increased the scope for private domestic and foreign ownership, and created conditions favoring substantial gains in efficiency" for the Vietnamese commercial banks. The result was, in this phase, banking became the sector with the fastest growth in the services economy (World Bank, 1997).¹⁶

In this period, the autonomy and accountability of the commercial banks for their business had been institutionalized and enhanced in practice. First, the SBV gave commercial banks the right to decide on deposit and lending interest rates, as well as selecting the form of loan security. In the meantime, directed credit (or policy-oriented lending) was gradually separated from the commercial credit. The international principles and standards for commercial banking (e.g. accounting and auditing, risk management, credit analysis, investment, foreign exchange, loan classification and provisioning) was introduced. By

¹⁶ The average annual growth rate of financial sector (with banking as the core) for the period 1990-1996 was 16.8%, while it was 9.5% for the whole service sector (see GSO, 1997).

introducing modern technology, especially information technology, the banks could provide more features to their customers, including the substantial improvement in the depth and quality of the banking payment system (for example, some e-banking and automatic transaction systems were built such as ATM, e-account, home banking, credit card, etc.). Such remarkable progress of the banking payment system was further marked by the participation in the SWIFT system (in March 1995), allowing banks to develop wholesale and retail banking through Vietnam, and to connect to the international payment system. This helped the payment system of Vietnam reach the average level of the region; money transfers and payment through banks in the country would take only a few seconds, instead of hours or even days as before. Within 6 years (1991 – 1996), the number of banks in the sector increased rapidly from nine to 83, in which JSCBs had the highest growth (average 237 percent annually). Market shares, however, were still dominated by SOCBs, as shown in Table 1.

Table 1. Market shares in the banking sector (1993-1996)

Bank types	Market shares in deposits (%)				Market shares in credit (%)			
	1993	1994	1995	1996	1993	1994	1995	1996
SOCBs	91	88	80	76	89	85	75	74
JSCBs	6	8	9	10	7	11	15	14
JVBs	1	2	3	3	1	2	3	5
BFOBs	2	2	8	11	3	2	7	7

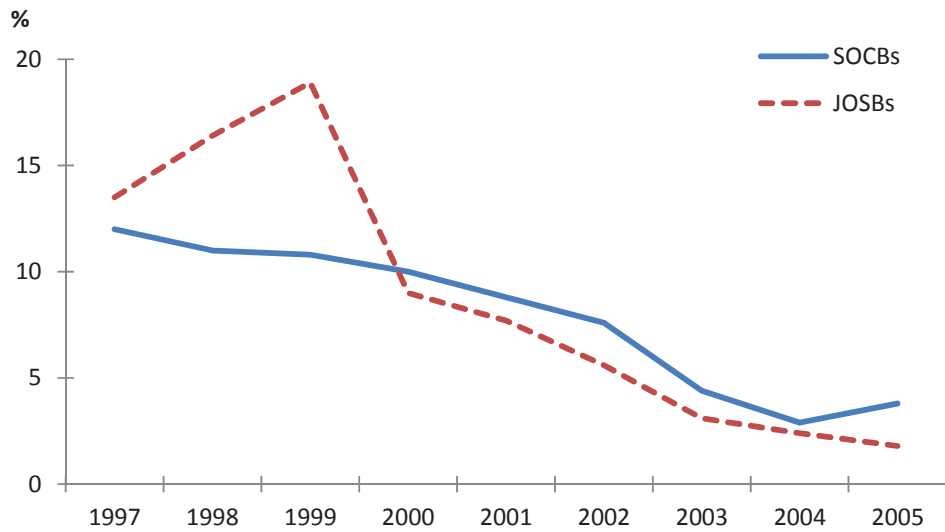
Source: SBV

At the end of 1996 and early 1997, more signs of fragility were observed in the Vietnamese banking system. Bank overdue loans rose quite substantially after the end of 1995, especially between March 1997 and June 1997. Defaults on letters of credit or payment delay were seen in several small JSCBs and even in a SOCB, Vietcombank. The rapid growth of credit under a weak risk assessment and monitoring skills in the past, combined

with the problems from neighboring countries such as Thailand or Philippines, put the system at risk (see World Bank, 1997, for more details). As a result, two banking laws were approved in November 1997 (revised and developed from the two banking decrees in 1990) and the Bank Restructuring Committee (BRC) was established in April 1998. The BRC was in charge of restructuring the JSCBs and SOCBs; improving the regulatory, supervisory and legal framework; leveling the playing field for all banks; and developing human capacity and resources in the banking sector. By putting banks under “special control” or “special supervision”, the BRC successfully closed, and/or merged, as well as audited the Vietnamese banks (under international accounting standards using international auditors) and hence, restructured the banking sector in term of operational reform, debt workouts, and recapitalization (World Bank, 1999). It led to a slowdown in growth of the financial sector in phase II (1998-2005);¹⁷ however, credit risk assessment was also taken care of, since the loans overdue ratio dropped from 11-12% at the end of phase I (International Monetary Fund, 1999) to under 4% in 2005 (SBV, 2006). However, as can be seen in Figure 9, a question is raised regarding the difference in performances of the SOCBs and JSCBs, which needs further examination (see the second expected finding in the following section).

¹⁷ The average annual growth rate of the financial sector dropped from 52% (1990-1996) to 13% (1997-2005). Meanwhile, domestic credit growth also slowed to 24.7% in 2005, compared to the peak of 73.3% in 2000 (ADB, 2010).

Figure 9. Overdue loans (% of total loans) in Vietnam by types of bank



Source: IMF, SBV

Phase III (2006-2010) started with a rapid growth in the Vietnamese securities market. The VN-Index rose by about 144 percent in 2006 and by another 56 percent in the first two months of 2007, equivalent to a total increase of 281 percent since the end of 2005 (International Monetary Fund, 2007).¹⁸ After its peak of 1,170.67 points on March 12, 2007, the VN-Index entered a period of consolidation and thus, money started to transfer from the stock market into the real estate sector. The banking system became a channel for these funds. Fitch Ratings (2008) argued that the banking sector in Vietnam would continue to offer good opportunities for foreign investors over the medium- to longer term. The Business Monitor International also agreed the Vietnamese banking system would continue its “strong expansion” if it could deal with the “troubled short-term horizon” of “distressed loan portfolios, low capital bases, fierce competition and expected monetary tightening”

¹⁸ Factors accounting for this boom included the increasing of portfolio investments as the Investment Law had been effective since July 1, 2006; the increasing of listed firms as a result of the tax reduction policy; the establishing of securities companies as the Securities Law was officially approved on June 23, 2006; among others (International Monetary Fund, 2007).

(2009, p. 24).¹⁹ Actual performance of the banking sector showed that the average assets of the Vietnamese banks (compared with GDP) in this phase was about three times higher than in phase II. Credit provided to the economy grew at nearly 25% annually²⁰ while overdue loans were kept at around 2 percent.

Table 2. “Prosperity” achievements of Vietnamese banks in phase III

	2005	2006	2007	2008	2009	2010	Average
All banks’ assets (% of GDP)	66.99	74.38	85.68	94.98	109.63	121.75	92.24
Credit growth (%)	24.5	16.3	38.7	4.6	37.3	26.6	24.7
Overdue loans (% of total loans)	3.2	2.7	1.5	2.1	1.9	2.0	2.2

Source: WB, IMF

According to business cycle theory, the fourth phase (2010-present) is a period of ‘contracting and restructuring’ with bankruptcies, mergers and acquisitions of banks, etc. There is evidence that the Vietnamese banking system is currently in trouble, especially with the increase of nonperforming loans (ADB, 2013) which led to the establishment of the Vietnamese Asset Management Company (VAMC, or “bad bank”) in July, 2013. The VAMC will help to restart lending in the banking sector; however, according to a recent report from the Business Monitor International, the high level of government debt risks could trigger a fiscal crisis which in turn undermines confidence in the banking sector. The state-directed lending in the property sector could also worsen the NPLs problem and thus, created further downside risks to Vietnamese banks (Business Monitor International, 2013). The banking sector may remain stable for a while with 75% possibility, however, the probability of a downtrend is high at 25% (FitchRatings, 2013).

¹⁹ This was strengthened once again in the Q2/2010 report (Business Monitor International, 2010, p. 27).

²⁰ We used deflated domestic credit (with 1994 as base year) in order to calculate the growth rates. If using current prices, the average growth rates could reach 38%. Nevertheless, that rapid growth resulted in a sharp rise in inflation as well as other macroeconomic instability, thus, since 2011 the government has had to limit the credit growth and broad money to no more than 20% and 16% respectively (OECD, 2013).

1.2.3 Expected findings

Since the fourth phase is underway, examining and evaluating the three previous phases are becoming important in measuring the efficiency of the Vietnamese banking system. As discussed above in each phase, the findings are expected to be found in the Vietnamese banking system during financial liberalization:

Expected finding 1 (E1): The efficiency or performance of Vietnamese banks generally increased during the 1990-2010 periods; however, with stagnation around critical times in 1997 and 2007.

Berger and Humphrey (1997) reported that deregulation could typically improve the performance of the banking and financial sector. This argument has been strengthened by empirical evidence from Turkey (Isik & Hassan, 2003; Isik, 2007), India and Pakistan (Ataullah *et al.*, 2004; Das & Ghosh, 2009), Romania (Asaftei & Kumbhakar, 2008), Egypt (Fethi *et al.*, 2011), and Taiwan (Hsiao *et al.*, 2010). However, evidence also suggests that the performance of the banking system could be (negatively) affected by fragility or crises inside or outside the country. This may include a direct effect on the stability of the banking (and financial) system as well as an indirect effect via slowdown of economic growth and trade (BIS, 2009; BOT, 2010).

Expected finding 2 (E2): The performance of the State-Owned Commercial Banks (SOCBs) in Vietnam was lower than that of the Joint-Stock Commercial Banks (JSCBs) during financial liberalization.

The governmental ownership was suggested as politicizing the resource allocation process and reducing efficiency of the banks (La Porta *et al.*, 2002). Especially in transition economies, government-owned banks were proven to be normally less efficient than

private-owned banks (Bonin *et al.*, 2005b). Since our study analyzes the liberalization period, i.e. the privatization period that SOCBs were being transformed into JSCBs in order to improve their efficiency, performances of the JSCBs therefore are expected to be higher than the SOCBs. This also relates to the sizes of the banks, where smaller banks are usually privately owned while SOCBs are bigger.²¹ We, however, notice that in some cases, the state-owned banks can perform better than the private ones (e.g. Karas *et al.*, 2010; Du & Girma, 2011).

Expected finding 3 (E3): The efficiencies of Vietnamese banks are consistent through different measurement approaches, namely ratio analysis, stochastic frontier analysis, and data envelopment analysis.

Bauer, Berger, Ferrier, and Humphrey (1998, p. 87) argued that, “efficiency estimates derived from the different approaches should be consistent in their efficiency levels, rankings, and identification of best and worst firms, consistent over time and with competitive conditions in the market, and consistent with standard non-frontier measures of performance”. Therefore, we expect that results from the three approaches above would meet the consistency conditions proposed by Bauer *et al.* (1998).

Expected finding 4 (E4): Results from the new model (a combination of ratio analysis and data envelopment analysis) are more robust than individual results from the ratio analysis or data envelopment analysis themselves.

Sherman and Gold (1985) noticed that DEA results if analyzed in conjunction with other analytic techniques could help identify and develop ways to improve the bank’s performance. Thanassoulis, Boussofiane, and Dyson (1996) emphasized that ratio analysis

²¹ In fact, the four SOCBs included in our study are called “the Big Four” as they are the four biggest banks in Vietnam.

and DEA can complement each other and thus, they should be seen as complementary instruments of performance assessment. Hence, a model that can combine ratio analysis and DEA is expected to also combine the advantages of both ratio analysis (using simple but essential ratios) and DEA (multi-dimensional performance evaluation).

1.3 Research objectives and the expected outcomes

Despite the fact that many institutions and individuals have studied financial liberalization and the banking system's development in Vietnam, there is still a relative lack of research on the efficiency of the banking sector and its development under financial liberalization. Therefore, this research will be the first major study on how the performance of the Vietnamese banking system has changed under the effects of the liberalization process in financial markets generally and in the banking sector particularly.

Within the scope of the research and under different methods which will be used in the research, this dissertation seeks to compare, contrast and combine the results obtained, in order to achieve some expected outcomes as below:

- A systematic assessment of previous studies on both absolute and relative efficiency of Vietnamese banks.
- A comparison of different approaches and methods used in evaluating the efficiency of Vietnamese banks.
- A proposed method for combining traditional and X-efficiency approaches for the DEA model, and applying this to the Vietnamese banks.

1.4 Outline of the dissertation

The rest of this dissertation is constructed as follows. Chapter Two provides a review of literature on the traditional approach (Ratio Analysis - RA) and X-efficiency approach

(Stochastic Frontier Analysis – SFA; and Data Envelopment Analysis - DEA) in evaluating the performance of banks as well as reviewing previous studies on the efficiency of the banking system in Vietnam. Chapter Three outlines the methodologies which will be used in this research as well as describing the data used for research. Chapter Four gives a deeper view on the efficiency of Vietnamese banks based on different approaches (namely RA, SFA, DEA and RA-DEA approaches). The last chapter will offer some conclusions and propose some suggestions for further studies on related areas.

2 Literature review

2.1 Ratio Analysis approach in evaluating banks' efficiency

Efficiency is a term popularly used in many fields of technology and social science. It is important to measure efficiency, according to Berger and Humphrey (1997), because:

“The information obtained [from efficiency measurement] can be used either: (1) to inform government policy by assessing the effects of deregulation, mergers, or market structure on efficiency; (2) to address research issues by describing the efficiency of an industry, ranking its firms, or checking how measured efficiency may be related to the different efficiency techniques employed; or (3) to improve managerial performance by identifying ‘best practices’ and ‘worst practices’ associated with high and low measured efficiency, respectively, and encouraging the former practices while discouraging the latter” (p. 175).

Fried, Lovell, and Schmidt (2008) summarized the three reasons above into two major ones: (1) it can be used to explore hypotheses concerning the sources of efficiency or productivity differentials; and (2) it can provide the indicators or performance metrics by which producers are evaluated, not only in financial but production aspects as well.

However, it is difficult to measure bank efficiency and its improvements. One can compare the bank spreads before and after a certain time or take a comparative study on bank spreads across countries (Hanson & Rocha, 1986; Vittas, 1991; Demirgüç-Kunt & Huizinga, 1999). Researchers can also use better alternatives like value added (Humphrey, 1990; Kimball, 1998; Widodo, 2008), or an independent index of bank outputs/prices (Fixler & Zieschang, 1999; Inklaar & Wang, 2012) in order to measure bank productivity. Nevertheless, these methods face the difficulty of laborious data collection or data

unavailability; and sometimes, the difficulty of defining input/output variables.²² Thus, most analysts resort to measuring bank efficiency via accounting data on bank margins, costs, and profits. In this case, the financial statements of firms are analyzed in order to reveal various relationships between different items reported in the statements (Edmonds *et al.*, 2011). The way of using financial ratios (between two indicators from the financial statement) to define the performance and efficiency of a firm belongs to the (financial) ratio analysis approach. According to Whittington (1980), the basic use of financial ratios is to compare the observed ratio with some standard or benchmark ones to evaluate whether it is high or low and thus, determining the efficiency.^{23,24} In addition, one could use ratios to predict or forecast changes in one of the two components, the numerator or denominator, of the related ratio, when the other component changes. Beaver (1966, 1968) and Altman (1968), among many other scholars, argued that financial ratios can provide meaningful information on these changes in the past and thus has the ability to predict bankruptcy. Consequently, the use of financial ratios continues to flourish (Barnes, 1987) and ratio analysis has become the standard tool to examine performance at all levels (Paradi & Zhu, 2013). Regulators also use financial ratios to monitor the operation of banks (Avkiran, 2011), and investors continue to use them as references for their decisions.

According to Barnes (1987), there are two major reasons for using financial ratios, and hence, ratio analysis. Firstly, ratio analysis can control the size effect of financial variables

²² For example, Mester (1993) argued that, for savings and loans institutions, inputs included labour, capital, and deposits. Hancock (1985), however, found that a particular banking activity is considered an output or input according to its sign in the banking profit function and hence, time deposits are inputs but demand deposits are outputs.

²³ In this case, the benchmark ratios should be based on a theoretical foundation or it may be based on past-experience of the examined firm or on comparison with other firms (Whittington, 1980).

²⁴ Hughes and Mester (2008) defined it as the nonstructural approach of measuring technology and explaining performance, in order to differentiate it from the structural approach of frontier analysis.

being examined as it analyses the relationship between the numerator indicator (e.g., income) and the denominator size indicator (e.g., equity). Secondly, one can use ratio analysis to control for the industry-wide factors; therefore, use ratio analysis to compare a subject firm and its industry and help predict firms at risk of failure.²⁵ In addition, ratio analysis is simple to use, and the ease of accessing financial statements from firms²⁶ makes ratio analysis popular, as such:

“A need does exist for analytical devices which will enable analysts to compare financial statements between firms and over time periods. The ratio fills that need as a simple, quick method of comparison. In addition, the available evidence suggests that ratios do have predictive value... thus, the ratio is a very admirable device because it is simple and it has predictive value” (Horrigan, 1968, p. 294).

Salmi and Martikainen (1994) defined a financial ratio as a fraction of X/Y, where X and Y are derived from the financial statements or other sources of financial information of a firm. Based on the origin of X and Y, financial ratios can be categorized in different ways. For example, they could be treated as profitability, managerial performance, or solvency ratios (Courtis, 1978). Bird and McHugh (1977) divided them into liquidity, financial structure, and operating efficiency ratios. Olson and Zoubi (2008) disaggregated the financial ratios in the banking industry into five general categories: profitability, efficiency, asset quality, liquidity, and risk; while Lee and Rose (2010), Koch and MacDonald (2010) rearranged them into ratios on profitability, management quality, income and expenses, and risk

²⁵ Beaver (1968) was among the first ones to emphasize the predictive power of financial ratios. Other researchers who had interest in this topic include Altman (1968), Johnson (1970), and Edmister (1972).

²⁶ Foulke (1968, p. 181) indicated that one can trace back data for financial statements and balance sheets of U.S. firms from 1891, hence, RA could be applied for large quantities of data.

management. Meanwhile, Avkiran (2011) differentiated them through strength and soundness, growth, credit quality, profitability, and valuation.

Nevertheless, the ratio analysis approach faces several problems. The main one lies on its single-dimension perspective, i.e., a ratio only reflects the relation between its numerator and denominator, and thus fails to reflect the multi-dimensional nature of bank activities. Other problems relate to the large number of ratios, their implicit assumption of constant returns to scale, and that they do not set targets for improvement for inefficient banks (Paradi & Zhu, 2013).

Due to their single-dimensional characteristic, in order to examine the bank more precisely, the number of ratios used in ratio analysis has been increased. Curtis (1978) reported that previous studies used up to 79 ratios, while Laurent (1979) rearranged them into 45,²⁷ and Chen and Shimerda (1981) found more than 65 accounting ratios. Popular ratios currently used in banking performance evaluation include, but are not limited to, the net interest margin (NIM), returns on average assets (ROA), returns on average equity (ROE), nonperforming loans over total loans (NPL), cost-income ratio (CIR).

Consequently, there have been numerous debates in the literature as to which ratios are most useful among hundreds that can be calculated from the extensive financial statements that banks publish.²⁸ There is thus a need to narrow the range of ratios to be used²⁹ with reduction methods, including discriminant analysis (Altman, 1968), factor analysis (Pinches *et al.*, 1973; Yeh, 1996), or principal component analysis (Laurent, 1979; Canbas *et al.*, 2005).

²⁷ Laurent's ratios did not cover Curtis' administration aspect.

²⁸ A review of financial ratios used in previous studies can be found in Salmi and Martikainen (1994).

²⁹ Salmi and Martikainen (1994) argued that 4 to 7 essential ratios were justified for a RA study. However, there is no standard on how to choose them.

Principal component analysis (PCA) is a popular tool for multivariate analysis (Jolliffe, 2002) which can extract a few principal components from the original data without losing much information, or in another words, PCA has the ability of dimension reduction (Rao, 1964).³⁰ Pinches, Mingo, & Carruthers (1973) reduced a set of 48 financial ratios into a seven factor set containing around 90% of the original information. Stevens (1973) used six factors to represent 82% of the total variance of 20 original variables. Laurent (1979) combined ten factors from 45 original ratios while maintaining over 80% of the information. Chen and Shimerda (1981) classified the financial ratios into twelve useful factors and then shrank them into seven major ones, because some of the twelve in the literature differed by name only. The seven factors are financial leverage, capital turnover, return on investment, inventory investment, receivable turnover, short-term liquidity, and cash position.

Since PCA requires some basic knowledge on statistics, one could use a simpler way of choosing the essential ratios to be used by the CAMELS rating system (Cole & Gunther, 1998; DeYoung *et al.*, 2001; Dzeawuni & Tanko, 2008; Cooper, 2009; Hays *et al.*, 2009; Männasoo & Mayes, 2009). Originally, CAMELS was a supervisory device used for evaluating banks' overall financial condition after an on-site bank examination; however, it is now used for both on-site and off-site monitoring. According to the Federal Deposit Insurance Corporation (FDIC, 1997, p. 752), the Uniform Financial Institutions Rating System (the official name of CAMELS) has proven to be “an effective internal supervisory tool for evaluating the soundness of financial institutions on a uniform basis and for identifying those institutions requiring special attention or concern”.

³⁰ It is important to notice that PCA is different from factor analysis. While factor analysis helps estimating new variables (or factors) from the observed data, PCA reduces the number of variables (Suhr, 2005) and thus, will be more appropriate in our case.

CAMELS is an acronym for the six components of bank safety and soundness, including Capital adequacy, Asset quality, Management quality, Earnings ability, Liquidity, and Sensitivity to market risks. Each of the above components has its own role and meaning in measuring the soundness of a bank. Within the CAMELS system, the capital adequacy determines the robustness of a bank under a financial shock. Meanwhile, the asset quality measures the impairment of assets in term of monitoring credit risks and loan portfolios. The capability of the board of directors and managers in monitoring and controlling the bank is assessed by management quality. The earnings ability measures the financial performance of the institution through indicators of profitability; while the level of Liquidity influences the ability of a bank to withstand shocks. Lastly, Sensitivity to market risk monitors the exposure level of the bank to market risks such as interest rate, exchange rate, equity price, and commodity price risks.

Despite CAMELS analysis seeming to (i) offer ease of calculation, (ii) be popular, (iii) use fewer but essential ratios, and (iv) have predictive ability; it also reveals some weaknesses. First, banking performance analysis using CAMELS still faces the same difficulty of choosing variables as with other financial ratios approaches. Although the Basel Committee on Banking Supervision (BIS, 1998, 2006) provided a methodology for CAMELS measurement³¹ thus reducing the number of ratios used, there is no standard for defining these variables.³² Second, in each category or dimension of CAMELS, banks are rated on a scale of 1 to 5, varying from fundamentally strong to fundamentally weak. Consequently, a composite rating is defined, also under the scale from 1 to 5, where banks that are sound in

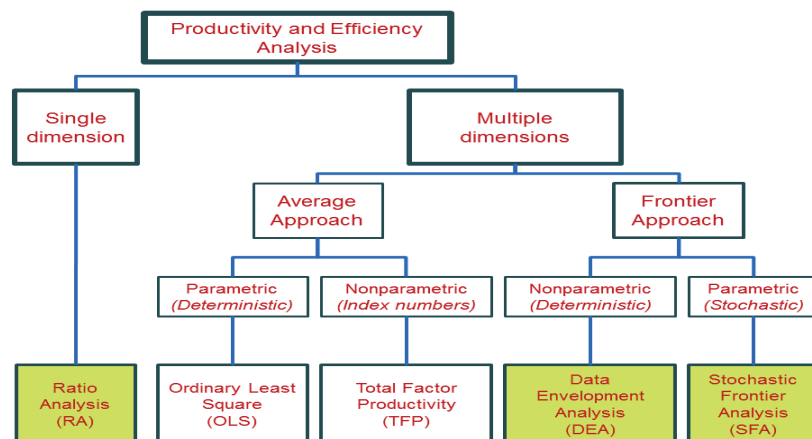
³¹ Details on CAMELS variables could be found in Sundararajan *et al.* (2002) or Grier (2007).

³² For example, Dzeawuni and Tanko (2008) and Hays *et al.* (2009) used different financial ratios for each aspect of the CAMELS system.

every dimension (generally rated 1 or 2) belong to composite 1, and banks that are extremely unsafe or unsound (generally rated as category 5) belong to composite 5 (FDIC, 1997). The discriminatory power of this composite rating scheme, however, is not strong as it is difficult to differentiate banks within a composite. Third, Thanassoulis, Boussofiane, & Dyson (1996) found that ratio analysis was unsuitable for setting targets in order to make inefficient firms become more efficient, although these performance indicators did provide information on a firm's absolute efficiency. The fourth weakness is that as each ratio analysis indicator reflects only one input and one output level, when multiple inputs or outputs are taken into account, it is difficult to gain an overall view of the performance of a firm via a ratio analysis approach (Paradi & Zhu, 2013).

To complement ratio analysis, which measures the efficiency under a single dimensional aspect, there are other approaches measuring the productivity and efficiency of an industry, in terms of multiple dimensions. They are summarized in Figure 10, in which frontier analysis has the advantage of being essentially a sophisticated way to measure the relative performance of production units (Berger & Humphrey, 1997).

Figure 10. Major approaches for efficiency measurement



Source: Modified from Liebert and Niemeier (2013)

2.2 Frontier analysis and X-efficiency measurement

As Ahmad *et al.* (2007) argued, financial ratios were most commonly used as indicators of performance or efficiency. However, these ratios are mainly focused on the financial but not the production aspect of firms. In addition, efficiency does not only mean the relationship between one output and one input (as in the ratio analysis approach) but also needs to be applied to the case of multiple outputs and/or multiple inputs. In economics, researchers refer to that as economic efficiency (Yotopoulos & Lau, 1973; Coelli, 1995; Siems & Barr, 1998) or X-(in)efficiency (Leibenstein, 1966; Berger *et al.*, 1993b; Peristiani, 1997; Sathye, 2001; Clark & Siems, 2002); however, they were all generated from the frontier analysis framework of Farrell (1957).

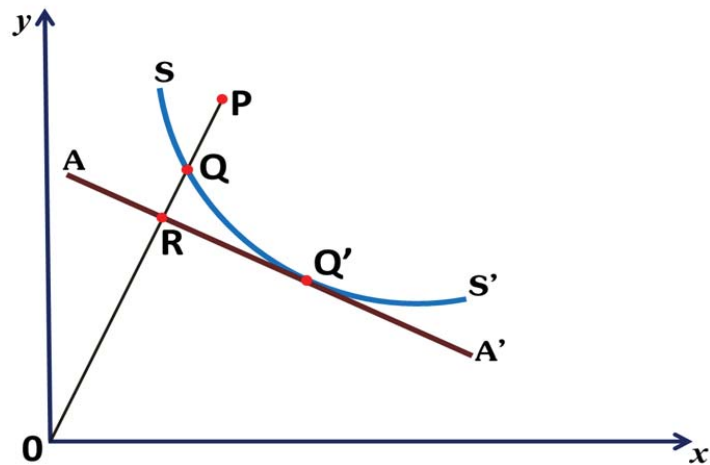
In frontier analysis, inefficiency is defined as the deviation from the efficient frontier,³³ or economic efficiency. Those deviations, later referred to as X-(in)efficiency,³⁴ include both technical and allocative (in)efficiency.³⁵ The former seeks for the maximization of outputs produced as input usage allows (or minimization of inputs used as output production allows); while the latter looks at optimizing the inputs combination concerning their relative prices. Following Farrell's diagram (1957, Diagram 1, p. 254), X-efficiency can be described as in Figure 11.

³³ The efficient frontier is defined following Pareto-efficient empirical production function where maximum observations of a production possibility set can form a production function (Charnes *et al.*, 1985).

³⁴ While reviewing the literatures of the welfare loss calculation, Leibenstein (1966, p. 393) found that the causes of that loss mainly came from monopoly or tariff restriction. However, when eliminating monopoly or tariff, one could only reduce the loss to a maximum of .07 or .18 percent of the gross national product (GNP), respectively. This conclusion led him to realize that the effect of resources allocation inefficiency is frequently small comparing to the real gap between the actual GNP and the optimal one, hence, an unknown inefficiency should exist, which he called "X-efficiency". Since allocative efficiency is small, in his later works, Leibenstein used X-efficiency as synonymous to technical efficiency (e.g. Leibenstein & Maital, 1992).

³⁵ Although Farrell (1957) first introduced it as price efficiency.

Figure 11. X-efficiency diagram



Source: Farrell's (1957)

Assume that we have the efficient frontier SS' representing the various (minimum) combination of two input x and y (thus AA' has the slope equal to the ratio of their prices) that an efficient firm might use to produce a unit output. If a certain firm is currently producing at point P , it is inefficient as it uses too much of inputs. Q will be an efficient position because it is on the frontier; therefore, coming from P to Q shows an increasing of efficiency as inputs are now minimized. The ratio of OQ/OP , which is smaller than one, represents the efficiency of the firm at point P due to over-utilization of inputs. It thus seems natural to refer to this ratio as the technical efficiency.

However, it is obvious that Q' is the optimal position as it lies on both SS' and AA' . Although Q has the same production level as Q' (they are on the same isoquant SS'), its position is above AA' , meaning there exists some cost inefficiency due to the non-optimization of the combination of inputs. Thus moving from Q to Q' also helps increase the efficiency of the firm, reflecting the improvement of inputs cost from Q to R , even though the point R seems technically infeasible. The distance QR expresses the amount of

inputs minimized, the efficiency of re-combining inputs is OR/OQ , and hence, it measures the allocative efficiency of point P. It is then important to notice that the movement from P to Q' in practice (or R in theory) shows an overall or economic efficiency improvement of the firm. Thus, the total economic efficiency or X-efficiency (OR/OP) is understood as a combination of technical efficiency (OQ/OP) and allocative efficiency (OR/OQ).

The technical efficiency and allocative efficiency above are referred to as radial measures,³⁶ indicating the ratio of two distance measures (Debreu, 1951; Malmquist, 1953; Shephard, 1953, 1970). Technical efficiency is the ratio between the distance from zero to Q (OQ) to the distance from zero to P (OP) while allocative efficiency is the ratio between the distance from zero to R (OR) to the distance from zero to Q (OQ). While these efficiency ratios are computed by distance measures of the observation firm (point P, Figure 11) with firms on the production frontier (point Q or Q'), they are regarded as relative, rather than absolute, efficiencies. The (relative) efficiency of a firm is considered within the production set and therefore it is not valid to compare with firms from different samples or production sets.

By moving from point P to point Q or Q', one can improve the economic efficiency of the firm. When time factors, particularly technological progress and innovation are included, there will be the case that the production frontier can shift inward or outward from its original position; hence, efficiency of a firm is subjected to change through time. The solution for this situation is applying distance functions to measure the TFP changes. The idea came from Malmquist (1953) and was developed by Caves *et al.* (1982a, b), with the Malmquist productivity index technique being further popularised, followed by Fare *et al.*

³⁶ The radial distance of a firm from a frontier, as efficient frontier can be an input minimization or output maximization, can be measured in either an input-conserving direction (Shephard, 1953) or an output-expanding direction (Debreu, 1951), respectively. Accordingly, the parametric and nonparametric approaches of measuring X-efficiency are also divided into input- and output-orientated models, which will be presented in section 2.2.4.1.

(1992), Berg *et al.* (1992), Fuentes *et al.* (2001), Casu *et al.* (2004), Tortosa-Ausina *et al.* (2008). Details on this approach are described in section 2.2.4.6 below.

Frontier analysis allows researchers to measure the X-efficiency in two ways: the parametric and nonparametric approaches (see Figure 10 above). Each approach has advantages and shortcomings compared to the other.

2.2.1 Parametric vs. Nonparametric approach

Although both parametric and nonparametric approaches are derived from frontier analysis and were originally introduced by Farrell (1957), there are essential differences between them, not only in the parametric technique but mathematical, efficiency measurement, data, and so forth.³⁷

Table 3 presents basic characteristics of the two approaches,³⁸ following Coelli *et al.* (2005). Accordingly, a researcher should choose the parametric approach for his research if he has a big enough data set (sample size) and would like to perform hypothesis test(s) regarding the efficiency measurements. As an *a priori* production function form is required, this approach is more suitable for the manufacturing sectors such as industry, agriculture, manufacture, construction, etc. Others, however, should use the nonparametric approach in case the sample size is small,³⁹ and for the non-manufacturing sectors.⁴⁰

³⁷ Note, however, that both parametric and nonparametric approaches may be impacted by outliers (Grosskopf, 1996).

³⁸ This table does not cover the extended and enhanced models of the two approaches. We later show that the DEA nonparametric model can analyze time series data as well (more details are provided in section 4.3.2.1).

³⁹ Although a certain ratio between the number of observations and the number of examined variables must be met (see section 2.2.4.4 below).

⁴⁰ Emrouznejad *et al.* (2008) showed that banking, education (including higher education), health care, and hospital are the most popular areas for DEA applications.

Table 3. The comparison of Parametric and Nonparametric approaches

No.	Characteristics	Parametric Approach	Nonparametric Approach
01	Parametric method	<i>Yes</i>	<i>No</i>
02	Accounts for noise	<i>Yes</i>	<i>No</i>
03	Hypothesis tests	<i>Yes</i>	<i>No</i>
04	Sample size	<i>Big</i>	<i>Any</i>
05	Measure for:		
5a	<i>Technical efficiency</i>	<i>Yes</i>	<i>Yes</i>
5b	<i>Allocative efficiency</i>	<i>Yes</i>	<i>Yes</i>
5c	<i>Technical change</i>	<i>Yes</i>	<i>Yes</i>
5d	<i>Scale efficiency</i>	<i>Yes</i>	<i>Yes</i>
5e	<i>TFP change</i>	<i>Yes</i>	<i>Yes</i>
06	Data used:		
6a	<i>Cross-sectional</i>	<i>Yes</i>	<i>Yes</i>
6b	<i>Time series</i>	<i>No</i>	<i>No</i>
6c	<i>Panel</i>	<i>Yes</i>	<i>Yes</i>

Source: Adapted from Table 12.1 in Coelli *et al.* (2005, p. 312)

2.2.2 Parametric X-efficiency and Stochastic Frontier Analysis (SFA)

In the parametric approach, the production frontier of an industry is usually estimated through the standard Cobb-Douglas function (Aigner & Chu, 1968); through the average production function, which is also referred to as the production function of an average firm (Marschak & Andrews, 1944; Winsten, 1957); or through the stochastic frontier (Aigner *et al.*, 1977; Banker & Maindiratta, 1988). Among them, the first and second methods use deterministic methodology, while the last one applies a stochastic one. Thus, efficiency of a certain firm in the industry can be easily calculated by comparing its production or cost level to the benchmark (frontier) level.

The deterministic method assumes that all deviations from the production frontier are attributable to inefficiency (Marschak & Andrews, 1944; Aigner & Chu, 1968; Afriat,

1972; among others). Greene (2008) reviewed several deterministic applications in X-efficiency measurement, including the Ordinary Least Square (OLS), Corrected Ordinary Least Square (COLS), and Modified Ordinary Least Square (MOLS), and concluded that these models embedded measurement errors and other stochastic variations in the one-side disturbance, which makes it difficult to distinguish between efficiencies and noises. Hence, he suggested that DEA and the stochastic frontier approach are more appealing than the parametric deterministic ones.⁴¹

When one allows stochastic variations to exist in the deviations, one is applying stochastic analysis. Berger and Humphrey (1997) divided it into three different methods whereas each method maintains a different set of assumptions about the functional form, the probability distribution, and the random error of the X-efficiency differences from the frontier. They are Stochastic Frontier Analysis (SFA), Distribution Free Analysis (DFA), and Thick Frontier Analysis (TFA). According to Kumbhakar and Lovell (2003), among those models, SFA is the basic and traditional one originated in 1977 by two independent teams on two continents (Aigner *et al.*; Meeusen & van den Broeck); while TFA and DFA were invented as additions for SFA in 1991 (Berger & Humphrey) and 1993 (Berger),⁴² respectively. Apparently, SFA remains the main model used within the parametric approach in measuring efficiency and productivity.⁴³

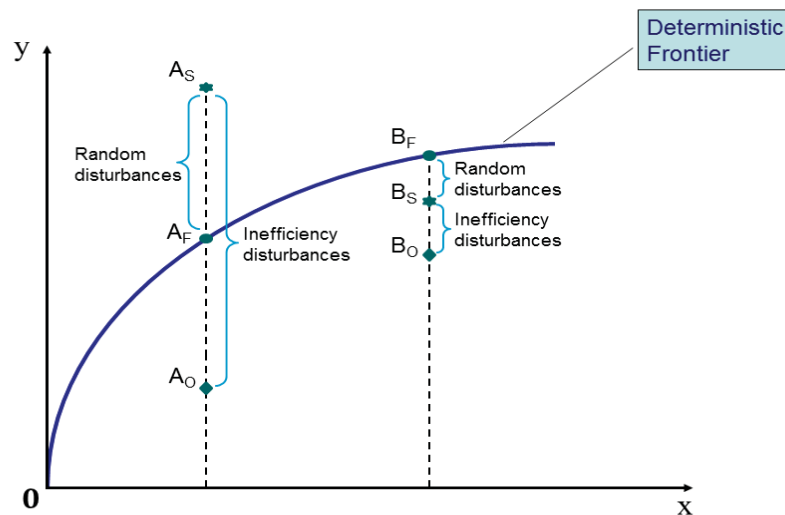
⁴¹ Ondrich and Ruggiero (2001), however, argued that in term of ranking the inefficiency units, COLS performs as well as SFA regardless of actual measurement error variance and sample size.

⁴² Berger's DFA model (1993) was triggered by the idea of Schmidt and Sickles (1984) that the assumption on the distributions of efficiency or random error can be modified, and that efficiencies are stable over time while random error tends to average out.

⁴³ Berger and Humphrey (1997) reported that, out of 60 parametric studies during 1992-1997 period, 24 were SFA, while DFA accounted for 20 and TFA for 16. Since then, numbers of applications using SFA have risen to 1095, when DFA are 124 and TFA are 14 only (search results with 'stochastic frontier analysis', 'distribution free analysis', and 'thick frontier analysis' as keywords, via www.sciencedirect.com on 28 July 2014).

The first published SFA articles were from Aigner *et al.* (1977), and Meeusen and van den Broeck (1977a), which later have been referred to as foundation papers of the SFA approach. In contrast with the deterministic parametric approach, Meeusen and van den Broeck (1977a, p. 436) argued that in the frontier production function, “next to a disturbance due to inefficiency, [there is] a statistical disturbance due to randomness in the real sense and to specification and measurement errors”. In parallel, Aigner *et al.* (1977), followed Schmidt (1976) and Aigner *et al.* (1976), presuming that the deviations between actual output of a firm and its frontier resulted from (1) utilizing the ‘best practice’ technology (i.e. inefficiency) and (2) facing random disturbances (e.g. luck, climate, topography, machine performance, measurement error, etc.). In this sense, the stochastic production frontier can be described as below, with A and B as two observations in the sample; the subscript S, F, and O respectively represents if the firm is on the stochastic frontier, the deterministic frontier, or it is the observation value.⁴⁴

Figure 12. The Stochastic Production Frontier



Source: Coelli *et al.* (2005)

⁴⁴ Aigner *et al.* (1977, p. 25) pointed out that, the farmer whose crop is decimated by drought or storm is considered unlucky in the stochastic frontier approach, but inefficient in the deterministic frontier approach.

This decomposition of the deterministic inefficiency into stochastic inefficiency and noise allows researchers to have a better view of efficiency measurement. However, the problem of estimating each component in the SFA approach remained unsolved until Jondrow, Lovell, Materov, and Schmidt (1982) – hereafter referred to as JLMS. Prior to their paper, one could only calculate the average technical inefficiency of the whole sample,⁴⁵ not the inefficiency of each observation, which is more important in terms of efficiency and productivity measurement. JLMS, however, suggested that the conditional distribution of technical inefficiency given overall disturbances (or, the ‘error term’, as defined by JLMS) is half-normal and truncated at zero; hence, it is possible to apply the likelihood function in calculating the mean (and mode) of the firms in the industry. The technique was then extended for use with panel data by Schmidt and Sickles (1984), Kumbhakar (1988), and Battese and Coelli (1988), among others. However, as Battese and Coelli (1988) pointed out, since the variability of the conditional distribution of technical inefficiency given the disturbances is not dependent on the level of the factor inputs for the given firm (or sample size), the estimates from the JLMS model are not consistent with the observation-specific inefficiencies (i.e. at the level of individual firm). Therefore, enhancements or modifications for the JLMS model were required, resulting in the introduction of cost and/or profit frontier function models (Kaparakis *et al.*, 1994; Vitaliano & Toren, 1994; Berger & DeYoung, 1997; Maudos *et al.*, 2002). However, these models also have weaknesses, as the half-normal assumption for the distribution of inefficiencies is relatively inflexible and thus, firms are presumed to be clustered near the frontier (Greene, 1990). Other types of distribution assumptions have been introduced, e.g., normal-gamma

⁴⁵ Average technical inefficiency can be estimated by the average of the composed error (Meeusen & van den Broeck, 1977a) or through the distribution function of the sum of a symmetric normal random variable and a truncated normal random variable (Aigner *et al.*, 1977; Lee & Tyler, 1978; Schmidt & Lovell, 1979).

(Stevenson, 1980; Greene, 1990; Yuengert, 1993), normal-truncated normal (Stevenson, 1980; Mester, 1996; Berger & DeYoung, 1997), or normal-exponential (Mester, 1996); however, in these cases it is difficult to separate inefficiency from random error in a composed-error framework (Berger & Humphrey, 1997).

The major advantage of SFA lies in its ability to account for noise and error, which later turns into the ability to test hypotheses through the test of significance. However, while imposing a functional form on the sample, SFA restricts the shape of the frontier, especially with the standard translog function.⁴⁶ Whenever the functional form is misspecified, it can lead to specification errors in efficiency measurement (Berger & Humphrey, 1997). Consequently, as SFA applies the regression-based econometric tools, it bears the difficulty of the lack of degrees of freedom (Evanoff & Israelvich, 1991) when the scale of measurement (sample size) is small. In contrast, the nonparametric approach works better with small sample size while the results are comparatively robust (Seiford & Thrall, 1990; Evanoff & Israelvich, 1991).

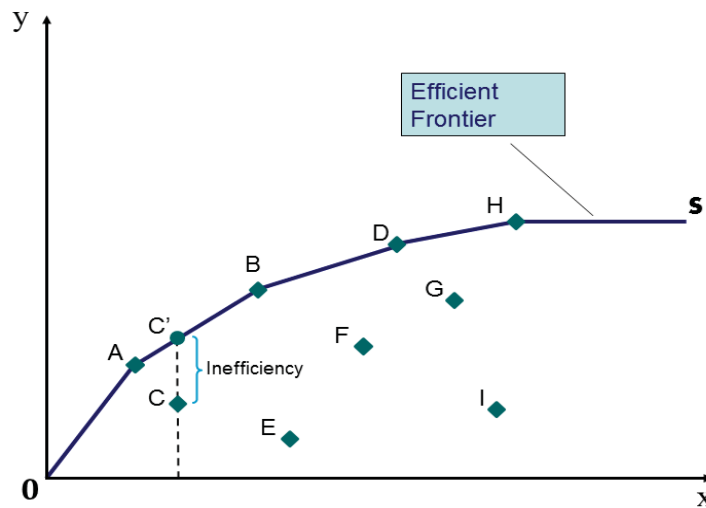
2.2.3 Nonparametric X-efficiency and Data Envelopment Analysis (DEA)

Distinct from parametric approaches, nonparametric approaches envelop the data collected from sampled financial institutions to estimate the optimal production or cost level for the whole sample, then score each institution by comparing its current level with the optimal one. In this sense, the efficient frontier is known as ‘best practice frontier’ which consists of the best performing firms (output, in terms of production frontier) within the industry, which is close to the efficient frontier defined by Farrell. According to Farrell (1957), the

⁴⁶ McAllister and McManus (1993), as well as Mitchell and Onvural (1996), realized that the translog function can provide poor approximations for banking data which are not near the mean scale and product mix. In addition, it also forces the frontier average cost curve to have a symmetric U-shape in logs (Berger & Humphrey, 1997).

efficient production function will be represented by an isoquant (SS', as in Figure 11) which satisfies the two conditions that (1) its slope is not positive and (2) no observed point can lie between it and the origin. As this definition applies for input-minimization approach, it should be converted into the output-maximization approach⁴⁷ as follows: the efficient frontier will be represented by the OS curve (as in Figure 12) which has (1) positive slope and (2) there is no observed point lies above it.⁴⁸

Figure 13. Nonparametric Efficient Frontier



Source: Adapted from Seiford and Thrall (1990)

There are two distinguishing differences between a stochastic and a nonparametric frontier, the first regarding how the frontier is formed, and the second concerning how inefficiency is measured/estimated. In SFA, the frontier is a stochastic variability of the deterministic (regression) production function and thus, inefficiency scores can be estimated through econometric techniques (details are in Section 3.2 of this thesis). In contrast, the nonparametric frontier is formed by wrapping a hull around the observed data and then the

⁴⁷ This is for consistency with the stochastic frontier mentioned in Section 2.2.2 above; however, Farrell's definition is most used in the nonparametric efficiency measurement.

⁴⁸ Although Seiford and Thrall (1990) originally described it as a piecewise linear surface which 'floats' on top of the observations.

individual inefficiency score is calculated, rather than estimated, between an observation and other ‘best practice’ observations that lie on the frontier (details are in Section 3.3). As a result, inefficiency scores will change if there is a change in choosing how to form the hull. In the nonparametric approach, one can use the Data Envelopment Analysis (DEA) or Free Disposal Hull (FDH)⁴⁹ to construct that best-practice frontier (Berger & Humphrey, 1997).

In contrast with the parametric approach, where there is only one dependent variable (output) to be analyzed, DEA can be easily applied for the case of multiple inputs and/or outputs. After the development of Charnes *et al.* (1978) and then Banker *et al.* (1984),⁵⁰ DEA was increasingly applied in efficiency evaluation, especially in social sciences. This is not only because of the flexibility and advantages of DEA itself but also its ability to be expanded and modified through such approaches as two-stage or multi-stage DEA models (Coelli, 1998; Fried *et al.*, 2002; Coelli *et al.*, 2005; Simar & Wilson, 2007; Chen *et al.*, 2010; Paradi *et al.*, 2011a) and the associated financial ratio - DEA model (Elyasiani *et al.*, 1994; Avkiran, 2011). Within these studies, the publication of Avkiran (2011) has potential in contributing to the DEA methodology as it combines the ratio analysis and X-efficiency approaches.

⁴⁹ The FDH, according to Berger and Humphrey (1997), is a special case of the DEA model where the frontier rests on the assumption of free disposability of inputs and outputs and hence, FDH frontier is either congruent with or interior to the DEA frontier. Thus, DEA remains dominance in the nonparametric frontier approach with more than 4,000 published articles or book chapters; or 7,000 entries if including unpublished works (Emrouznejad *et al.*, 2008).

⁵⁰ The two models were popularly referred to as CCR and BCC models after the name of their authors, in which CCR deals with constant returns to scale situation, and BCC deals with variable returns to scale. Details of the two models are in section 2.2.4.2 below.

2.2.4 Notes on measuring X-efficiency in practice

In the previous sections, we mentioned that the parametric and nonparametric approaches, as well as the models within each approach, have their own pros and cons. Hence, it is difficult to determine which approach/model is better than the other(s), especially when the true level of efficiency is unknown (Berger & Humphrey, 1997). Improvements, modifications, and enhancements of these models therefore will be needed in order to seek for the ‘true level of efficiency’. In measuring the X-efficiency, thus, it is important to take care of the following issues: model orientation, returns to scale, variable identification and selection, cross-sample comparison, and efficiency changes over time. Although focused on DEA, this section is important for other models/approaches as well.

2.2.4.1 Model orientation

As mentioned, X-efficiency measurement (and even ratio analysis) consists of a comparison between input(s) and/or output(s) of a production function. As a ratio in ratio analysis can be defined as output over input, or input over output; efficiency also can be estimated under either an output or input orientation. According to Cooper *et al.* (2006, p. 58), a model whose objective is to maximize outputs while using no more than the observed amount of any input is called output-oriented; and a model that attempts to minimize inputs while producing at least the given output levels is called input-oriented. The input-oriented model is chosen under the assumption that firms have particular orders to fill (e.g., as in electricity generation) and, hence, the input quantities appear to be the most important factor in decision-making. Otherwise, if firms are given a fixed quantity of resources and asked to produce as much as possible, the output-oriented model is preferable. Nevertheless, both models will estimate exactly the same frontier and therefore,

according to Coelli *et al.* (2005), identify the same set of firms as being efficient, although the efficiency measures associated with the inefficient firms may differ between the two models.

2.2.4.2 Returns to scale in efficiency measurement

In reality, firms are not operating at their optimal scale due to imperfect competition, government regulations, constraints of finance, etc. In this situation, efficiency of the firm can be improved just by changing the scale of operation, while other things stay unchanged. According to Frisch (1965), optimal scale of production refers to an input bundle where scale elasticity equals unity and, consequently, the firm operates under constant returns to scale. Førsund and Hjalmarsson (1979) defined ‘scale efficiency’ as a measure showing how close a firm is to the optimal scale of production, i.e. it describes the maximally attainable output for that input mix (Frisch, 1965).⁵¹ Thus, it is important to distinguish the scale efficiency from the (normal) efficiency, which is measured under the assumption of constant returns to scale (CRS).

In the nonparametric approach, the original DEA model founded by Charnes *et al.* (1978) is unable to deal with scale efficiency as it is based on the CRS assumption. Banker *et al.* (1984) proposed a variable returns to scale (VRS) model by introducing an unconstrained in sign μ_0 to define if a DMU is at increasing returns to scale (IRTS), constant returns to scale (CRS or MPSS), or decreasing returns to scale (DRTS).⁵² Thus, scale efficiency is calculated as the difference between the two technical efficiency measures under the two

⁵¹ Banker (1984) described it as the most productive scale size (MPSS) in the DEA context. A similar interpretation of MPSS as the maximum of ray average productivity, for instance, also developed in Ray (2004).

⁵² A DMU is at IRTS if μ_0^* is smaller than 0, CRS if μ_0^* equals to 0, and DRTS if μ_0^* higher than 0; with μ_0^* is the value of μ_0 that maximize the objective function of the DEA model. For more details, see Banker *et al.* (1984).

conditions, i.e. it is obtained as the CRS measure divided by the VRS one (Coelli *et al.*, 2005). Additionally, one can test whether this scale efficiency is significant by using the rank-sum-test for the efficiency scores from CCR and BCC models.⁵³

On the other hand, in the parametric approach, scale efficiency was not easy to measure because a closed form measure directly computable from the more flexible functional forms, such as translog specification, was not available. This was a shortcoming of the parametric approach where researchers can easily calculate scale elasticity but not scale efficiency. Ray (1998) proposed a parametric model in which scale efficiency can be calculated from estimated parameters of the production frontier function (under the VRS hypothesis) and from the estimated scale elasticity. Particularly, scale efficiency can be measured by the ratio of average productivity at the level of input used to maximize average productivity attained at the MPSS point; which can be directly computed from a fitted frontier translog function (Ray, 1998). This model has the advantage of being easily tractable from the econometric point of view and can be applied for a translog frontier function (Madau, 2011) and thus, helps overcome the disadvantage of the parametric approach in terms of scale efficiency measurement.

2.2.4.3 Variables identification and the production model

There are two main approaches to the choice of how to choose the (input and output) factors of a firm, the production and the intermediation approach.

Under the production approach, according to Frisch (1965), the [technical process of] production is known as a transformation process in which certain things, including goods and/or services, enter the process, and lose their identity in it, while other things are

⁵³ The comparisons between groups of efficiency scores are introduced in section 2.2.4.5 below.

generated. Frisch then referred to the first (certain) things as production factors (input elements) and the latter ones as products (the outputs or resultant elements). In this sense, “the grain put into the ground, nature, etc., are production factors, while the harvest is the product” (Frisch, 1965, p. 3). The production function, as consequence, will have the physical inputs such as capital and labour in its form and thus, is popularly applied in the parametric frontier analysis, and for the manufacturing sector.

For the non-manufacturing sector, which is more suitable for the nonparametric analysis, however, one can use the production as well as the intermediation approach, especially for financial institutions, in variable identification. The choice of variables of the production approach in the non-manufacturing sector is similar as in the manufacturing sector; however, intermediation approach’s selection for banks and financial institutions is different. Berger and Humphrey (1997) pointed out that this approach takes financial institutions as intermediaries standing between savers/lenders and borrowers/investors. Thus, they are collecting deposits and purchasing funds to be subsequently intermediated into loans and other assets. This approach therefore usually treats the financial institution’s assets as outputs and its liabilities as inputs (Sealey & Lindley, 1977; Clark, 1988; Berger & Mester, 1997; among others).⁵⁴

2.2.4.4 Variables selection

With a big enough sample, as in the parametric approach, one can include as many variables as needed, as long as there are sufficient degrees of freedom.⁵⁵ However, in the

⁵⁴ Berger and Humphrey (1997, p. 197) also pointed out that the intermediation approach is somewhat better for evaluating the efficiency of entire financial institutions while the production approach is more appropriate for evaluating at branch level.

⁵⁵ For more ‘mathematic’ details on the minimum requirement of sample size in relation to the number of predictors, in the case of the parametric approach, see Green (1991).

case of a small sample, and more important for the nonparametric approach, one should be cautious on which variables are to be included in the research model. Sexton *et al.* (1986) figured out that, as DEA applies the programming method in estimating the frontier from extremal points of observations, it is very sensitive to the variable selection procedure. They concluded that the efficiency estimates cannot be reduced when either input or output variables are added to the model; however, variable selection can affect the shape and position of the efficiency frontier in the neighborhood of specific DMUs which in turn alters the ranking of efficiency estimates (1986). Dyson *et al.* (2001) also argued that the omission of a highly correlated variable can occasionally lead to significant change in efficiencies,⁵⁶ as DEA generally is not translation invariant.⁵⁷ Hughes and Yaisawarng (2004) referred to the problem of adding or extracting a variable for a given sample as “a dimensionality issue” of DEA, where the dimensional differences may affect the DEA results. Simar and Wilson (2008), in particular, argued that when the number of examined variables is large, the DEA estimator will manifest in the form of large bias, large variance, and very wide confidence intervals, unless a very large quantity of observations is available. Therefore, in order to address the issue of variable selection in DEA, several methods were proposed, including principal component analysis, efficiency contribution measure, regression-based test, etc. An interesting summary and comparison of these methods was explained in Nataraja and Johnson (2011).

⁵⁶ However, Dyson *et al.* (2001) also mentioned that, the more variables are included in DEA model, the lower it gets for the discrimination power. They then suggested a ‘rule of thumb’ that the number of observations should be at least twice the product of the number of outputs and inputs (p. 248). Cooper *et al.* (2006, p. 284) proposed that sample size should be at least three times the sum of total outputs and inputs.

⁵⁷ Translation invariant DEA models were discussed in Pastor (1996).

2.2.4.5 *Cross-sample comparison of efficiency*

As discussed, efficiency measures estimated following the frontier approach, both parametric and nonparametric, are based on the comparison between observed data and the frontier. It leads to a caution that, different measures estimated from different frontiers should be compared carefully, regarding the robustness of the results. However, there are several ways to compare the efficiencies between different samples, as described in Berger and Humphrey (1997) and Cooper *et al.* (2006). Berger and Humphrey (1997) and Berger (2007) explained that, in order to compare efficiency levels across countries, one should calculate the efficiency scores first using individual domestic frontiers and then using a common frontier (Berg *et al.*, 1993; Pastor *et al.*, 1997; Lozano-Vivas *et al.*, 2002; Casu & Molyneux, 2003) or pooling the cross-country data into a common frontier directly (Fecher & Pestieau, 1993; Ruthenberg & Elias, 1996; Dietsch & Lozano-Vivas, 2000; Lozano-Vivas *et al.*, 2002). Meanwhile, Cooper *et al.* (2006) proposed using the rank-sum-test developed by Wilcoxon-Mann-Whitney to identify whether differences between two groups of efficiency scores (extracted from two samples) are significant.⁵⁸

2.2.4.6 *Efficiency changes through time*

Measuring efficiency changes through time is a special case of efficiency comparison, in this case the comparison of efficiencies in a certain year and in a base year. As we will not only examine if there is any difference between these efficiencies but also want to measure them, thus, the rank-sum-test is not suitable. A popular tool that satisfies the two purposes

⁵⁸ Berg *et al.* (1993, p. 381), Pastor *et al.* (1997, p. 403) and Chaffai *et al.* (2001), among others, proposed another way to compare the differences between two groups of efficiency scores by adapting the Malmquist index idea, in which one group will be used as the technology of reference or technology base.

above is the Malmquist productivity index, sometimes referred to as the Malmquist TFP index.

Malmquist (1953) first introduced the notion of a proportional scaling of goods and services needed in year t_2 that could maintain the same utility level for a consumer as in year t_1 , which is later referred to as a (consumption) quantity index. However, as it did not allow for any differences over time in the structure of consumer tastes, this deflation idea of Malmquist only had limited meaning in term of (utilities) comparison over time. Caves, Christensen, and Diewert (1982a, b) applied the distance function (Shephard, 1970), which allows the structures of production to be differed, into the Malmquist consumer index, to provide the theoretical framework for the measurement of productivity and changes in it. Thus, the Malmquist deflation idea was extended to be the Malmquist productivity index (Caves *et al.*, 1982a, p. 1394).

Meanwhile, based on the theory of growth (Solow, 1957) and the parametric translog production frontier (Aigner & Chu, 1968), Nishimizu and Page (1982) showed that productivity growth could also be estimated under the frontier approach framework. Using the parametric approach, productivity growth could be estimated and decomposed into technical change and efficiency change; where the first term corresponds to shifts of the frontier and the latter corresponds to individual improvement toward the frontier. Later, Fuentes *et al.* (2001) combined the work of Nishimizu and Page (1982) with the Malmquist index of Caves *et al.* (1982a, b) into a stochastic Malmquist productivity index model. Thus, this model has the power of decomposing productivity change into efficiency change and technical change, similar to the Fare *et al.* (1992) method.

Under the DEA approach, Fare *et al.* (1992) combined the frontier efficiency measurement from Farrell (1957) and the Malmquist productivity index from Caves *et al.* (1982a, b) into a single framework to measure the productivity growth, allowing for inefficiencies and model technology as piecewise linear. Thus, the DEA-Malmquist productivity index also can distinguish between efficiency change and technical change (Färe *et al.*, 1992).⁵⁹

In order to calculate the Malmquist productivity index, one should have a panel data set (panel data). In addition, a panel data helps researchers overcome the problem of small sample size and strong distributional assumption if using the parametric approach (Schmidt & Sickles, 1984) or mitigating the statistical noise on the efficiency measures if using DEA (Gong & Sickles, 1992). Tulkens and Eeckaut (1995b) proposed that one can break down the panel data into several windows, a special case of what they called ‘intertemporal production sets’, to get the same advantage on a small sample.

2.3 X-efficiency measurement in the banking sector

Prior to the frontier analysis and X-efficiency approach, banking and financial institutions were evaluated mainly through ratio analysis indicators. However, as Farrell (1957) pointed out, attempts to combine those indicators into a satisfactory measure of the overall efficiency had failed. This failure includes using the average productivity of labour, which ignores all other inputs; or constructing the “indices of efficiency”, which facing the usual index number problem when comparing a weighted average of inputs with output. Research on the banking and financial sector applying the frontier analysis had increased, however,

⁵⁹ Tulkens and vanden Eeckaut (1995b) respectively referred to them as efficiency gain or loss and frontier shifts. In which, the term ‘frontier progress’ was used to define an outward shift (i.e., the enlargement of the constructed production possibility set); while ‘frontier regress’ referred to an inward shift (p. 483).

the field was not attractive until the review of Berger and Humphrey (1991) and Berger *et al.* (1993b).

In a review of past research on the efficiency of financial institutions, Berger *et al.* (1993b) found that X-inefficiencies normally account for about 20% or more of the cost in banking, whereas scale and product mix inefficiencies, if accurately estimated, are usually found to account for less than 5% of cost.^{60,61} This conclusion helped researchers realize the significant role of X-efficiency, and according to Molyneux *et al.* (1996, p. 273), “a great deal more work is needed on X-efficiency research in banking”. Following this conclusion, studies on banking efficiency have significantly increased, which made frontier analysis become superior in performance measurement, both theoretically and practically. Recent data from the Journal of Banking and Finance, one of the most popular journals for banking study, shows that there were only 74 articles applying frontier analysis on measuring banking efficiency prior to 1993, but the number rose to 472 articles recently,⁶² since

“Frontier efficiency is superior... to the standard financial ratios from accounting statements - such as return on assets (ROA) or the cost/revenue ratio... because frontier efficiency measures use programming or statistical techniques to try to remove the effects of differences in prices and other exogenous market factors affecting the standard performance ratios in order to obtain better estimates of the underlying performance of the managers” (Bauer *et al.*, 1998, p. 86).

⁶⁰ In an earlier study, Berger and Humphrey (1991) argued that X-inefficiency may reach 25% or more of average costs.

⁶¹ Berger *et al.* (1993b) pointed out that studies applying the parametric approach usually find average inefficiency to be about 20-25% of costs, while it ranges from less than 10 to over 50% under DEA.

⁶² Search result with keyword ‘frontier analysis’ on www.sciencedirect.com (24/06/2014).

In another review article, Berger & Humphrey (1997) found that X-efficiency and frontier analysis for financial institutions were popularly applied in 130 studies during 1992-1997. They found that, overall, the depository financial institutions (banks, S&Ls, credit unions) included in those studies experienced an average efficiency of around 77%; or in other words, average inefficiency of financial institutions was around 23%, consistent with the previous literature.⁶³

2.3.1 Parametric studies on X-efficiency of banking institutions

Because the parametric approach is more appropriate for production sectors, as mentioned in section 2.2.1 above, the number of studies applying this approach in the banking and financial sector is limited. Prior to 1997, Berger and Humphrey reported that there were 60 parametric out of 130 frontier studies on the X-efficiency of financial institutions, of which 24 were SFA, 20 were DFA, and 16 TFA. Overall, there were 110 observations on U.S. banks using the parametric techniques,⁶⁴ resulting in average efficiency of 0.84⁶⁵ and a range from 0.61⁶⁶ to 0.95.⁶⁷ They also reported that a DFA-based fixed effects application for 11 OECD countries also ended with similar results when the mean average efficiency was 0.82 and range from 0.67 (Denmark) to 0.98 (Japan).

Since there is no 'best' frontier method among the parametric and nonparametric approaches, and because results from these two approaches were inconsistent in ranking inefficient institutions, one should add more flexibility to the parametric approach (Berger

⁶³ These 130 studies covered 21 countries; however, they were mainly focusing on U.S. (57%) and Europe (34%), except some studies on Canada, India, Japan, Mexico, Saudi Arabia, Tunisia, and Turkey (9%).

⁶⁴ The authors treated reported values for multiple years, techniques, and/or type of banks of those 130 studies as a single observation; hence, there were 188 annual estimates.

⁶⁵ Excluding profit efficiency and branch efficiency studies.

⁶⁶ This figure came from a working paper of Adams, Berger, and Sickles; while their published ones (1999) showed a lower value of 0.565.

⁶⁷ For 14 non-U.S. countries, the average efficiency was 0.76.

& Humphrey, 1997). As more enhancements were incorporated into the stochastic model, more research has been conducted recently.⁶⁸

One of the enhancements of the stochastic model regards using the Fourier flexible cost function (hereafter the FF function) instead of a standard (Cobb-Douglas) translog form. Basically, the FF function consists of two main components: the first is a modified translog function, and the latter is a trigonometric Fourier series (Gallant, 1981, 1982). Hence, the FF function is more general and flexible which helps estimating the true function with better fits than the ordinary translog form (Berger & Humphrey, 1997; Berger & Mester, 1997). Berger *et al.* (1997) used both a standard translog and FF terms in order to reduce the number of terms needed for a close approximation.⁶⁹ They found that U.S. bank branches were at about 5% to 10% inefficient in terms of branching costs and 20% to 25% inefficient in term of operating costs. Huang and Wang (2004) argued that X-efficiency measures of Taiwanese banks estimated from the FF function may be more reliable and reasonable than the translog function. Kraft *et al.* (2006), using data from Croatia banks during 1994-2000, showed that the FF form would be preferred over the translog one. Tsionas (2012) used the maximum likelihood to estimate the output-oriented stochastic frontier model regarding the fast Fourier transform to a sample of 500 U.S. commercial banks in 2000. Consistently, Tsionas also found that this modification was quite feasible and provided reliable results, even with complicated models like the normal-gamma and normal-beta, suggesting U.S. banks were, on average, operating at 91.2% of optimal capacity. This finding was consistent with Berger and Humphrey (1997).

⁶⁸ A quick search on Scopus for stochastic frontier studies in the banking sector resulted with 213 studies for the period after 1997.

⁶⁹ Berger *et al.* (1997) later statistically rejected the hypothesis that the translog is a superior specification, and hence, favour the FF specification.

Another way to improve the estimated results is using semi-parametric models. In contrast with the parametric models which assume the same functional form over a certain examination period, which could lead to specification error, the original semi-parametric models allow the functional form of some components to be unknown (Newey, 1990). In this sense, researchers are flexible to impose the necessary restriction and monitor the correlation between a subset of regressors and efficiencies (Adams *et al.*, 1999). However, one can also apply the semi-parametric approach by using a two-stage efficiency model, in which efficiencies were calculated in the first stage using nonparametric methods, and then were correlated with the (environmental) regressors in the second stage using parametric techniques.⁷⁰ Kumbhakar and Tsionas (2008), in estimating the stochastic cost frontier for a sample of 3,691 U.S. commercial banks, found that the local maximum likelihood (LML) method can relax several deficiencies of the parametric approach. In addition, the LML model gave more precise results on both scale economies and efficiency, particular higher mean and smaller spread, compared to the global translog frontier (Kumbhakar & Tsionas, 2008). Meanwhile, Delis and Papanikolaou (2009) also found that the semi-parametric two-stage model could be a solution to the many problematic features of the standard censored regression, the most important being the serial correlation of efficiencies. Using the bootstrapping method in the second stage, the authors could unmask some of the explanatory power of some variables on efficiency of banks, including bank size (positive), bank concentration (negative), and investment environment (positive effect) (Delis & Papanikolaou, 2009).

⁷⁰ Simar and Wilson (2007) proposed using the bootstrapping method to improve the sensitivity and robustness of these two-stage models.

The use of Bayesian techniques within the context of efficiency measurement provides an alternative way to improve the stochastic frontier models, as it does not impose *a priori* sampling distributions on the efficiency term of the composed error component. In addition, Bayesian techniques also have the ability to deal with multiple inputs and undesirable outputs (Murillo-Zamorano, 2004). Kumbhakar and Tsionas (2005) applied this approach to a data set of 500 U.S. banks for the years 1996-2000 and found that they were at least 70% efficient. Another application using 61 bank branches in the Republic of South Africa showed that on average, these banks were 82.3% efficient (Okeahalam, 2006).

2.3.2 Nonparametric studies on X-efficiency of banking institutions⁷¹

The first significant paper that applied DEA into the banking sector, according to Paradi *et al.* (2011b), was a study on 14 branches of a saving bank by Sherman and Gold (1985). This study allowed Sherman and Gold to argue that DEA can provide meaningful insights not available from other performance measures, specifically in terms of the mix of outputs and inputs and identify inefficient units (1985). This was the start of a long list of DEA application to banking from several different angles, including countrywide analysis, cross-country analysis, bank merger efficiencies, and so on (Paradi *et al.*, 2011b). The review of Berger and Humphrey showed that there were about 41 DEA studies on the banking sector for the period 1992-1997. This number increased to 192 in 2009 (Fethi & Pasiouras, 2010) and 266 in 2010 (Paradi *et al.*, 2011b).⁷² Another study by Liu *et al.* (2013) reported 323

⁷¹ Regarding the dominance of DEA over FDH, as mentioned in footnote 49, this section will focus on DEA applications only.

⁷² Fethi and Pasiouras (2010) found 151 DEA-like studies over the period 1998-early 2009 while Paradi *et al.* (2011b) identified 225 DEA application in banking industry from 1997 to 2010.

DEA papers in banking applications, accounted for 10.31% of total DEA applications⁷³ from the foundation of DEA (Charnes *et al.*, 1978) to August 2010.⁷⁴

Using over 78 (within country) observations using DEA and FDH, Berger and Humphrey (1997, p. 185) concluded that the average efficiency of U.S. banks was 0.72 and ran from 0.31 to 0.97. The higher dispersion of the nonparametric approach compared to the parametric one, i.e., lower efficiency score and higher range, was due to the inability to differentiate efficiency from random error (Bauer *et al.*, 1998).⁷⁵ Berger and Humphrey also reported DEA applications in thrift institutions (S&L, life insurance,, etc.) and cross-country banks. They found that (i) deregulation could typically improve the performance of the banking and financial sector; (ii) most bank failures were directly related to having large problem loans, a low cash position, a weak or negative cash flow, and/or a poor management quality; and (iii) there was a positive statistical relationship between market concentration and profitability and hence, mergers of large banks could improve (profit) efficiency. Accordingly, to overcome the weakness of DEA, they suggested the use of a ‘composite frontier’ instead of a normal frontier; and the use of cone-ratio or assurance region DEA models (Berger & Humphrey, 1997).

Fethi and Pasiouras (2010), by discussing 196 studies between 1998 and early 2009, of which 151 were DEA-like, had three important conclusions. The first conclusion stated that DEA applications in banking had limited attention to profit efficiency and capacity

⁷³ Other major applications of DEA are Health care (8.65%), Agriculture and farm (8.23%), Transportation (7.95%), and Education (5.87%).

⁷⁴ Liu *et al.* (2013) applied the citation network to analyse important studies regarding DEA in the banking application, however, it is not a ‘real’ survey of DEA for the banking industry (i.e., it does not mention on efficiency-related issues). Hence, their work will not be included in this section.

⁷⁵ Although the finding of Berger and Humphrey was based on different studies with different samples, time periods, variables, etc.; this conclusion still applies for studies using both SFA and DEA on the same data set (Bauer *et al.*, 1998; Fiorentino *et al.*, 2006; Delis *et al.*, 2009; among others).

efficiency. The second referred to the fact that bootstrapping technique was not applied in most of the two-stage DEA studies, which in turn, implies that their results may be biased. The last one pointed out that variable selections of DEA models vary widely, especially for banks' deposits – as discussed in section 2.3.4.4 above, and that made results from these studies differ.

Fethi and Pasiouras also reviewed a number of studies on regulatory reform or liberalization. The authors argued that these studies indicated a positive relationship between liberalization and efficiency of the banking sector in most countries, except for Germany and Austria (Fethi & Pasiouras, 2010).

While Fethi and Pasiouras gave much attention to the methodological issues and topics of interest of DEA applications, Paradi *et al.* (2011b) focused more on bank's efficiency regarding bank mergers, progress over time, and model orientation. They were also concerned about the sample sizes, service qualitative variable, outliers, environmental factors, and results validation, among others. They concluded that the banking sector is an almost ideal study subject for DEA and hence, many papers using this approach have been written and more will be done in the future, as this is an interesting and challenging field to explore. To overcome any possible data error, consideration must be given to both the technical and management aspects in building the model, and it is better to use DEA in conjunction with other approaches and validate the results against accepted ones in the financial industry (Paradi *et al.*, 2011b).

Similar to the parametric approach, improvements and enhancements also have been made for DEA since the advent of it in 1978, both in theoretical developments and applications (Cook & Seiford, 2009). According to Cooper *et al.* (2006) and Cook and Seiford (2009),

beside the traditional CCR and BCC models, researchers could also use the additive models (Cook & Hababou, 2001; Bala & Cook, 2003); the slack-based measure models (Chiu & Chen, 2009; Drake *et al.*, 2009; Paradi *et al.*, 2011a); the super-efficiency models (Hartman *et al.*, 2001; Chiu *et al.*, 2008); the multistage/level models (Färe & Grosskopf, 2000; Färe *et al.*, 2007); the weight/multiplier restriction models (Thompson *et al.*, 1990; Allen *et al.*, 1997; Pedraja-Chaparro *et al.*, 1997); and so forth.⁷⁶ These models mainly evaluate the efficiency of DMUs based on their (different) optimal multipliers or weights (Frei & Harker, 1999) and thus, make it difficult for ranking comparison between DMUs. Resolutions for this matter use cross-efficiency (Sexton *et al.*, 1986; Mukherjee *et al.*, 2002; Ji *et al.*, 2012) or common set of weights (Jahanshahloo *et al.*, 2005; Kao & Hung, 2005; Zohrehbandian *et al.*, 2010; Ngo, 2011; Davoodi & Rezai, 2012) DEA models. Other fruitful modifications include combine DEA with the traditional financial ratio (Yeh, 1996; Siems & Barr, 1998; Halkos & Salamouris, 2004; Kao & Liu, 2004; Avkiran, 2011; etc.) or with the parametric technique (Tsionas, 2003; Casu *et al.*, 2004; Avkiran & Thoraneenitiyan, 2010; among others).

Although DEA is superior to ratio analysis in terms of multi-dimensional analysis, i.e., to deal with multiple inputs and/or outputs, many regulators and market analysts continue to use ratio analysis and its financial ratios to monitor the performance of banks (Avkiran, 2011). Elyasiani *et al.* (1994) and Yeh (1996), among others, reported a significant relationship between financial ratios from ratio analysis and efficiency scores from DEA. Thus, they argued that DEA should be considered to be a supplement to ratio analysis

⁷⁶ Cook and Seiford (2009) provided a detailed review on the models for efficiency measurement, approaches for incorporating multiplier restrictions, considerations for variables status, and modelling for data variation in DEA.

because it helps aggregate the puzzling ratios into meaningful dimensions that somehow link with the financial operating strategy of a bank.

The conjunction of ratio analysis and DEA is usually derived by a two-stage DEA model, in which the first stage applies DEA and the second associates DEA results with ratio analysis financial ratios via a regression technique. The Tobit regression has been popularly used in this stage, because the DEA efficiencies are censored/bounded between 0 and 1 (Fethi & Pasiouras, 2010). Although it was popularly used previously, Hoff (2007) was the first to conclude that the Tobit approach will in most cases be sufficient in representing the second stage DEA models;⁷⁷ however, it was also suggested that OLS could be the ‘second best’ alternative to Tobit regression. Despite the type of the regression model, Simar and Wilson (2007) suggested that bootstrapping technique also should be used in this stage in parallel.⁷⁸

The major problem of the DEA-RA approach is that it regards these ratios as exogenous whereas they may be endogenous, driven by factors reflected in the efficiency score itself. Halkos and Salamouris (2004) and Avkiran (2011) are among the few exceptions to this, using financial ratios directly in the DEA model, with the former considering these ratios as output variables⁷⁹ and the latter treating some as outputs, and the rest as input variables.⁸⁰

In their study on Greek commercial banks, Halkos and Salamouris (2004) used the financial

⁷⁷ Other regression models reported in Hoff (2007) were the quasi-maximum likelihood estimation, the unit-inflated beta model, and the OLS.

⁷⁸ Simar and Wilson (2007) pointed out that independent variables of the second stage are normally correlated with input/output variables used in the DEA model of the first stage, hence, DEA efficiency scores are likely to be (highly) not independent from those regressors. Thus, they proposed a ‘double bootstrap’ procedure, applying to the U.S. banks. Brissimis *et al.* (2008) and Delis and Papanikolaou (2009) extended this approach for examining EU banks.

⁷⁹ They assumed that inputs are similar and equal for all banks because they operate in the same markets, thus, a dummy-variable with value equal to one was employed as input (Halkos & Salamouris, 2004).

⁸⁰ The selection was based on the degree of direct managerial control and the ratio’s position in the production process (Avkiran, 2011).

ratios as outputs of the DEA model⁸¹ and concluded that the DEA-ratio analysis model seemed to be more reliable and can provide the highest discrimination power, compared to ratio analysis or DEA model alone. Meanwhile, Avkiran used financial ratios as both inputs and outputs in constructing the super-efficiency DEA model, and after examining the Chinese banking sector in 2007-2008, he found that DEA has the potential to predict certain key financial ratios' future value (2011). These studies, however, ended up with relative efficiency scores rather than absolute ones and are thus meaningful only within the research sample and cannot be used for performance comparison between samples.⁸² An extended application using this approach on Vietnamese banks will be examined in section 4.3 below.

2.4 Previous research on the efficiency of Vietnamese banks

Research undertaken so far has been quite limited. This is due to the data limitations, the sensitivity of the financial and banking sector, and the research purposes of institutional and individual researchers.

Firstly, there are reviews and reports of international financial institutions such as the World Bank (WB), International Monetary Fund (IMF), Asian Development Bank (ADB), but also reports from specialized organizations such as Business Monitor International (BMI), Moody's Investor Service (MIS) or Fitch Ratings (FR). These publications are based on ratio analysis and thus, could not provide the multi-dimensional views on the performance and efficiency of the Vietnamese banking system.

⁸¹ To avoid the problem of mixing indices and volume measures (Dyson *et al.*, 2001), they assumed that inputs are similar and equal for all Greek banks as they operated in the same markets and thus, the input variables can be omitted from the DEA model (Halkos & Salamouris, 2004).

⁸² DEA measures the efficiency of a certain decision-making-unit (DMU) relatively to other DMUs in the sample assuming that a common frontier exists in the sample (Charnes *et al.*, 1978). Comparison between different samples employing different frontiers is therefore impossible.

In their report 'Vietnam Commercial Banking Report Q4 2009' (published in September, 2009), BMI used SWOT analysis to review the developing potential of the Vietnamese economy in general and the banking system in particular. Combining the outlooks for the business environment, global commercial banking and the Asian banking sector, they offer a forecast for the Vietnamese commercial banking sector in the 2009-2013 period, suggesting that the Vietnamese banking system will continue its 'strong expansion' if it can deal with the 'troubled short-term horizon' of 'distressed loan portfolios, low capital bases, fierce competition and expected monetary tightening' (Business Monitor International, 2009, p. 24). The updated release 'Vietnam Commercial Banking Report Q2 2010' (May 2010) supported these arguments by maintaining their 'bullish view for the Vietnamese banking sector over the medium-to-long term', however, 'only a few of the larger and more efficient JSCBs⁸³ will be able to compete with foreign players' (Business Monitor International, 2010, p. 27). Those reports did not analyze any individual bank but only provided general information on them (balance sheet, key statistics, etc.), thus, can only provide a general view on the Vietnamese banking sector.

Alongside its rating system (based on operating environment, quality of supervision, management quality, franchise value, etc.),⁸⁴ MIS released a report on the banking systems of various countries, including Vietnam, in August 2009. The MIS report focused on four banks in the system (ACB, BIDV, TCB and VIB), contradicting the BMI report, arguing that 'the outlook for the Vietnamese banking system is negative' (Moody's Investors Service, 2009, p. 1). However, as these four banks only account for 26 percent of market share in the banking sector (Moody's Investors Service, 2009, p. 6), this argument may be a

⁸³ JSCB stands for Joint Stock Commercial Bank.

⁸⁴ For more detail, see MIS (1997).

bit strong. Once again, this report did not discuss the efficiency of the Vietnamese banking system.

In contrast, the FR report, with a bigger sample of six commercial banks,⁸⁵ was consistent with the BMI report, suggesting that 2010 would be ‘another year of high growth’ for the Vietnamese banking system (FitchRatings, 2010, p. 1). However, because the FR report also uses the traditional approach (based on measures such as the loan to deposit ratio, non-performing loan ratio, net interest margin, etc. – similar to the MIS report) in analyzing these bank’s activities, it did not show banks’ efficiency in using multiple inputs to produce multiple outputs, which are the basis of efficiency measurement.⁸⁶

Secondly, individual researchers and non-profit institutions usually dig deeper into the liberalization process of the Vietnamese financial system. These include studies of the banking sector; attempts to measure the efficiency of the Vietnamese commercial banks; or to use bootstrapping technique to improve the Malmquist productivity index for these banks.

Le (2006) noted that banking regulations had been issued since 2005 in order to improve the soundness of the banking system and equitize⁸⁷ (privatize) the big SOCBs in Vietnam. However, due to the poor sequencing of banking reforms, “Vietnam’s banking system is quantitatively and qualitatively inadequate” (Le, 2006, p. 42). Hence, as of 2006, the

⁸⁵ Except for ACB and BIDV, the other four banks are different from the MIS’ report.

⁸⁶ According to Thanassoulis, Boussofiene, and Dyson (1996), in traditional approach, under the situation of multiple inputs and multiple outputs, a multitude of ratios will be necessary. However, it is difficult to gain a general overview on the performance of a unit through these multitude ratios, meanwhile, using only some of the ratios can bias the assessment.

⁸⁷ Equitization is a process to convert State Owned Enterprises (include SOCBs) into shareholding companies (Vietnamese Government, 1998).

efficiency of Vietnamese banking system in Le's view was not high. This view was supported by Nguyen (2007).

Nguyen (2007) examined the cost efficiency of 13 commercial banks in Vietnam during the 2001-2003 period. This research applied the Malmquist DEA approach to measure the efficiency change, productivity growth, and technical change. The results showed that these banks were inefficient in both allocative (regulatory) and technical (managerial capacity) aspects, with technical inefficiency the major problem.⁸⁸ However, as this study covered a short period, the productivity change therefore is limited and it is hard for any conclusion to be realized.

Nguyen *et al.* (2008; 2012a) enlarged the sample size into 32 commercial banks to examine their super-efficiency during 2001-2005 through the slacks-based model, and argued that there would be room to improve the efficiency of those banks. This is consistent with Ngo and Tripe (2010) and Nguyen (2012) although the former paper only examined the efficiency of the top-22 banks in Vietnam in 2008 while the latter analyzed 20 banks in 2007-2010.⁸⁹

Analyzing technical and cost efficiency, as well as the Malmquist productivity index, of 20 Vietnamese banks during 2007-2010, Nguyen (2012) concluded that inefficiency across those banks was over 30 percent for the whole period. The author suggested that this result might be attributed to pure technical inefficiency instead of scale inefficiency, although no hypothesis test, such as Mann-Whitney, was conducted.

⁸⁸ Berger and Humphrey (1991) and Berger, Humphrey, and Hancock (1993a) also concluded that normally a bank's inefficiency was technical rather than allocative.

⁸⁹ Nguyen *et al.* (2012b) ranked the branches within the Vietnamese Agriculture Bank during 2007-2010 using a modification of the super-efficiency DEA model and found similar results: the efficiency scores of those branches was low (0.61 and 0.69 on average under CRS and VRS assumptions, respectively) and even decreased during the period examined.

A recent study of Nguyen, Roca, and Sharma (2014) on the cost and profit efficiency of Vietnamese banks showed that the banks were good at monitoring their cost (with average cost efficiency score of 0.9) but not in terms of profit making (only 0.75 on average). In addition, they found that these measures increased during the examined period (1995-2011) with insignificant effect from the AFC and GFC.⁹⁰ Interestingly, the authors also found that the SOCBs performed better than the JSCBs (at 5% level of significance), which is consistent with Gardener *et al.* (2011) and Nahm and Vu (2013).

In terms of SFA, Vu and Turnel (2010) employed a Bayesian SFA approach to investigate the cost efficiency of 56 Vietnamese banks in the 2000-2006 period. They reported that in general the cost efficiency of the state-owned banks increased while the measures of private-owned and foreign-owned banks decreased,⁹¹ which resulted in a slight decrease in cost efficiency of the Vietnamese banking sector in the whole period. Nahm and Vu (2013) examined profit efficiency using the same data set and found that the average bank operated well below the frontier mainly due to allocative rather than technical inefficiency, contrary to Nguyen (2007). Reasons for this situation were analyzed in Vu and Nahm (2013) where a low quality of assets and a too high level of capitalization were the major burdens.⁹²

While the research scope of these studies is limited, e.g., they all focused on the Vietnamese banks after 2000, which is due to the data limitation problem, Ngo (2012) may be the first paper trying to analyze the X-efficiency of Vietnamese banks before 2000. The

⁹⁰ Thangavelu et al. (2010) also noticed that banking efficiency in Vietnam was increasing even after the AFC, although the efficiency scores were the lowest among Southeast Asian banks.

⁹¹ Although the *t* test for the differences in the mean cost efficiency between those banks was statistically insignificant (Vu & Turnel, 2010).

⁹² The research model of these SFA studies, i.e. Vu and Turnel (2010), Nahm and Vu (2013), and Vu and Nahm (2013), however, might be biased. It is because (i) they had to use the estimated wages (price of labour) for some observations where actual figures were missing; and (ii) they defined the price of fixed assets by dividing other non-interest expenses by the total value of fixed assets.

paper applied a DEA time trend model in which the Vietnamese banking system (as a whole) in each year was treated as a single DMU and thus, macro level data on the whole banking system can be used as inputs and outputs of the DEA model. This approach helps overcome the data problem at bank or bank branch level, which propose a new application for DEA in banking and financial performance measurement.⁹³

These results show that efficiency of Vietnamese banks generally increases over time, which might be resulted from the financial liberalization of the country. Hence, examining the liberalization effect is justified, and there is a need for further research on the Vietnamese banking system, especially relating to efficiency/performance and financial liberalization. Only by improving efficiency can the banking sector of Vietnam compete strongly and fairly with foreign banks in the integrated global financial system.

2.5 Summary

This section provides a brief review on the previous efforts in measuring the efficiency and productivity of banking institutions. The efficiency of Vietnamese banks is also reviewed, which leads to the research question of how efficient the Vietnamese banking system has been under the financial liberalization process since the 1990s.

Traditionally, since 1890s, researchers have been using Ratio Analysis to define important financial ratio measures for assessing the efficiency and performance of a bank. These ratios are then compared between banks to get a broader view of the whole banking system as well as ranking banks via their performance, in which the CAMELS rating system has been popularly used as an assessment tool. CAMELS is a way of categorizing financial

⁹³ The association of macro level data was found in country's performance (Lovell, 1995; Lovell *et al.*, 1995; Ramanathan, 2006) and economic development and growth (Poveda, 2011); however, not in the banking sector.

ratios in order to cover six important aspects of efficiency and performance management, including Capital, Assets, Management, Earnings, Liquidity, and Sensitivity (to market risks) management. Other ways to categorize financial ratios, includes using factor analysis or principal component analysis, also conclude that a set of four to seven (essential) categories is enough for monitoring the performance of a bank. In banking evaluation, these ratios are used individually (i.e., banks cannot be compared in both profitability and liquidity at the same time), and efforts to combine them into a single measure of the overall efficiency has failed. The measure that can handle multi-dimensions, including financial and production aspects as well as multiple input and output variables, is X-efficiency.

Although the term X-efficiency was first used in 1966, multi-dimensional (and overall) efficiency had been measured as far back as 1957 using frontier analysis.⁹⁴ X-efficiency is measured as deviations between the examined institution and the efficient frontier, traditionally referred to as production frontier. There are two ways to estimate that frontier, thus resulting in two approaches in measuring X-efficiency, which are parametric and nonparametric frontier analysis. In the parametric approach, where Stochastic Frontier Analysis (SFA) is most used, the frontier is estimated through a (stochastic) regression function of the observations. In contrast, the nonparametric approach and its popular model Data Envelopment Analysis (DEA), envelopes the frontier as a piecewise surface which ‘floats’ on top of the observations. Each approach has its own strengths and weaknesses; however, there should be a consistency between DEA, SFA, and ratio analysis. There are also some other cautions when using X-efficiency measures, including model orientation,

⁹⁴ Although this idea, as Farrell (1957) pointed out, was inspired by the concept of “coefficient of resource utilization” (Debreu, 1951).

scale efficiency, variables identification and selection, cross-sample comparison, and efficiency changes through time.

The section also reviews major studies on X-efficiency of the banking industry, using parametric or nonparametric approaches, of international banking institutions as well as the Vietnamese banks. The results propose that there is room for research on the X-efficiency of the Vietnamese banking system under financial liberalization, regarding larger data and time span, a combination of ratio analysis and DEA model, and a new time-trend DEA model using macro-level data. This could be a contribution to the literature of banking efficiency measurement, especially in Vietnam. Data and methodologies for the above models are explained in the following sections.

3 Research methodologies

The purpose of this study is to assess the performance, efficiency and productivity of the Vietnamese banking system under financial liberalization, employing different approaches and methods. In this chapter, we describe the methodologies used to achieve that purpose. First, in section 3.1, we explain how ratio analysis could be used to evaluate the single- and multi-dimensional performance of Vietnamese banks. We then employ frontier analysis, a more modern technique, for efficiency and productivity evaluation. Section 3.2 discusses the parametric method of Stochastic Frontier Analysis (SFA) while section 3.3 provides the methodology of Data Envelopment Analysis (DEA). These methods, all together, could complement each other in providing an overall assessment of the Vietnamese banking system. Section 3.4 describes the data used in this study, in accordance with each method. The last section summarizes.

3.1 Ratios Analysis on banking and financial institutions

As discussed in the previous chapter, ratio analysis is traditionally and popularly used in efficiency and performance evaluations of banks and financial institutions (Avkiran, 2011; Paradi & Zhu, 2013). The basic use of financial ratios is to compare the observed ratio with some standards (Whittington, 1980) or key figures (Edmonds *et al.*, 2011) to evaluate how efficient a bank is. Thus, via ratio analysis, one could understand how the bank is financed (whether through debt, equity, or earnings); analyze past earnings performance and dividend policy for estimating the future value of his/her investments; and examine past operations in order to plan future policies (Edmonds *et al.*, 2011).

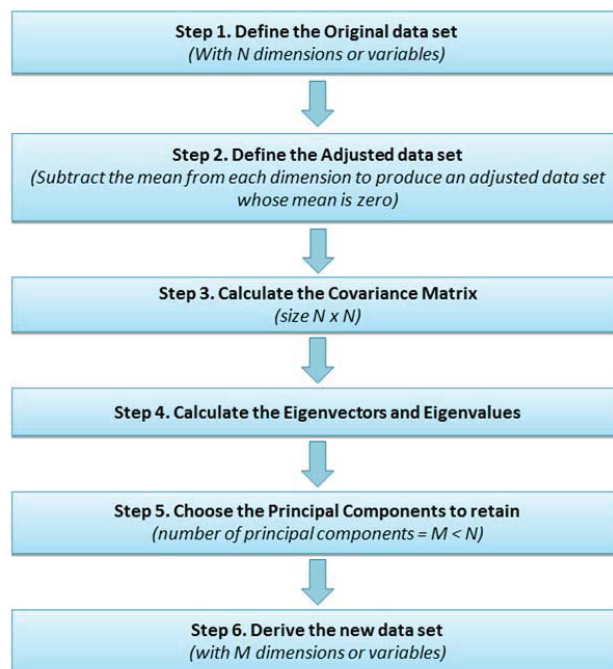
3.1.1 Single-dimensional evaluation using Ratio Analysis

According to Horrigan (1968), financial analysis using ratio analysis and financial ratios could be traced back to the 1870s. Nowadays, many ratios are used in financial analysis, especially for performance and efficiency measurement. Salmi and Martikainen (1994) argued that a number of 4 to 7 essential ratios was justified. One could find these essential ratios using the six categories of the CAMELS system (Cole & Gunther, 1998; DeYoung *et al.*, 2001; Männasoo & Mayes, 2009) or using the (ratios) reduction method of principal component analysis (Laurent, 1979; Canbas *et al.*, 2005).

3.1.1.1 PCA principal components

PCA consists of a transformation technique in which the original data set is transformed into a new one with fewer characteristics or dimensions - the “compression” technique - while the information is kept at minimum loss.

Figure 14. Data compressing procedures in PCA



Source: Based on Smith (2002)

In order to compress the data, similarities and differences in the data patterns need to be found and by putting these data spreads in a covariance matrix, one can extract the dominant patterns from this matrix to form a new data set through six major steps (Figure 13). In the fifth step, several rules are introduced in determining the number of principal components to retain (see, for example, Zwick & Velicer, 1986); however, the most popular is from Guttman (1954) and Kaiser (1960) - the K1 rule - where components with eigenvalues greater than one should be included in the new data set. To increase the robustness of our PCA model, we combine the K1 rule with the scree test and the cumulative variance rule.⁹⁵

3.1.1.2 *CAMELS ratios*

The CAMELS system is easier than PCA in terms of choosing the essential ratios to retain in our analysis, as we do not need to use the “compression” technique as in Figure 14. Six financial ratios are chosen representing six categories of the CAMELS system due to their popularity in the literature (see Table 4).

⁹⁵ The scree test (Cattell, 1966) checks for any “break” between the eigenvalues where components appear before the break are assumed to be meaningful and should be retained. Meanwhile, the cumulative variance rule concerns of minimum information loss and suggests that the new components should carry at least 70 percent of the original data’s variance (Costello, 2009).

Table 4. CAMELS ratios in the banking sector

Ratio	Category	Meaning	Previously used by
Equity capital to total assets (EQ)	Capital adequacy	High level of capital reflects a sound capital base, meaning that the bank has more time to consider problems and to deal with them effectively	Canbas <i>et al.</i> (2005); Brewer and Jackson (2006); Männasoo and Mayes (2009)
Nonperforming loans to total loans (NPLL)	Asset quality	A bank aiming for a good loan portfolio quality should reduce its problem loans in order to minimize default risk	Laurent (1979); Gonzalez-Hermosillo (1999)
Return on assets (ROA)	Management quality	Profitability is equated to management performance and vice versa; better management quality should lead to higher profitability	Laurent (1979); DeYoung <i>et al.</i> (2001); Canbas <i>et al.</i> (2005); Männasoo and Mayes (2009)
Net interest margin (NIM)	Earnings ability	Higher interest spread indicates good yields on loans, lower costs, effective use of earning assets, and sensible mix of interest-bearing liabilities	Laurent (1979); Gonzalez-Hermosillo (1999); Canbas <i>et al.</i> (2005)
Liquid assets over total assets (LIQUID)	Liquidity	High level of liquid assets would allow a bank to meet unexpected withdrawals and should be positively correlated with bank performance	Laurent (1979); Canbas <i>et al.</i> (2005)
Cumulative 1-year repricing gap over total assets (CGAPA)	Sensitivity to market risk	The sign of CGAPA indicates the direction of the interest rate exposure, while the value measures its scale relative to bank asset size	DeYoung <i>et al.</i> (2001); Brewer and Jackson (2006)

Our study is different from the CAMELS approach, however, in terms of classifying the ratios used. After financial ratios are chosen following the six CAMELS categories, they are defined as either maximization or the minimization ratios.⁹⁶ The maximization (MAX) ratios are ones that have a positive relationship with efficiency and performance of a bank, i.e. the higher the ratio is, the better the bank is operating. Hence, they will have a positive

⁹⁶ This new approach in financial ratios categorization also helps with the empirical studies using the RA-DEA model in section 4.3 below.

relationship with outputs of the bank and therefore, cover ratios regarding incomes, profits, revenues, earnings, salaries, etc. In contrast, the minimization (MIN) ratios have a negative relationship with the bank's performance, and thus, they are the ratios that relate to costs, expenses, losses, etc.

3.1.2 *Multiple-dimensional evaluation using the Performance Index*

The major shortcoming of ratio analysis is it cannot deal with the multiple-dimensions issue, i.e., each financial ratio can reveal a certain aspect of a bank, not the overall performance of that bank (Thanassoulis *et al.*, 1996). In order to assess the overall performance, an aggregated or composite performance index should be constructed. However, as Farrell (1957) pointed out, attempts to combine those ratios into a satisfactory measure of the overall efficiency using a (fixed) weighted average approach had failed. Therefore, we should apply the unequal and unfixed weighting scheme, a DEA-like approach, in order to construct the performance index (PI)⁹⁷ as below.

Firstly, financial ratios⁹⁸ will be normalized to avoid the problem of “adding up apples and oranges” (OECD, 2008, p. 27). It includes the transformation of undesirable values, i.e. minimization ratios, into desirable ones; and at the same time, the conversion of original data into a normalized data using the min-max method⁹⁹ as follow:

$$X_i = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad \text{if } X_i \text{ is a maximization ratio} \quad (1)$$

⁹⁷ The Handbook on constructing composite indicators from OECD (2008) provided useful information on several ways to create a composite index. Although the handbook focused on nations' performance, the methods could be applied to any object as well, including banks.

⁹⁸ Since the (principal) component derived from the PCA technique also has the form of a ratio, hence, the term “financial ratio” and “principal component” are interchangeable in this section.

⁹⁹ For more details, see Moesen and Cherchye (1998); OECD (2008); among others.

Or
$$X_i = \frac{X_{max}-X_i}{X_{max}-X_{min}} \quad \text{if } X_i \text{ is a minimization ratio} \quad (2)$$

where X_{max} and X_{min} are respectively the maximum and minimum value of the variable X_i in year t .

After that, the PI is calculated from this normalized data set following the “benefit of (weighting) doubt” approach. This approach was firstly introduced by Melyn and Moesen (1991) and then used in Moesen and Cherchye (1998) and Cherchye (2001), in the context of macroeconomic performance evaluation. It was also applied in the technology achievement index (Cherchye *et al.*, 2007; Cherchye *et al.*, 2008); the labour market performance index (Storrie & Bjurek, 2000); the human development index (Mahlberg & Obersteiner, 2001; Depotis, 2005); the road safety index (Hermans *et al.*, 2008); the global banking competitiveness index (Ngo, 2011); and so on. Recent studies such as Depotis (2005), Hermans *et al.* (2008), and Ngo (2011) applied DEA directly into the process of calculating the performance index, where indicators or variables were treated as outputs of the DEA models while input was assumed to be equal to one, following the approach of Lovell and Pastor (1999). The DEA-like model for calculating the performance index used in this paper, however, follows the road of Melyn and Moesen (1991).¹⁰⁰ Here, we use a set of maximization problems in determining the highest available scores that could be achieved by combining the six CAMELS ratios of each bank in each year.¹⁰¹ The idea behind this is based on the argument that the overall performance index should be calculated without any *a priori* weighting assumptions and thus, it is better to let the weights be assigned by the variables themselves.

¹⁰⁰ Although Lovell and Pastor (1999) showed that the two approaches are equivalent.

¹⁰¹ Our alternative performance index, for the purpose of robustness testing, is a set of maximization problems combining the principal components derived from the PCA technique in section 3.1.1.1 above.

$$PI_t^m = \max \left[\sum_i k_{it} X_{it}^m \right] \quad (3)$$

subject to

$$\sum k_{it} = 1 \text{ (all weights add up to 1 or 100\% for each it combination),}$$

$$k_{it} \geq 0.01 \text{ (non-zero weights restriction).}^{102}$$

where PI_t^m represents the performance index of bank m in year t ; X_{it}^m is the (normalized) CAMELS ratio i of bank m in year t ; and k_{it} is the weight of ratio X_i in year t .

3.2 Stochastic Frontier Analysis (SFA)

3.2.1 SFA using production function

In the frontier analysis approach, efficiency is measured by “comparing the observed performance of a firm with some postulated standard of perfect efficiency” which lies on the efficient production function (Farrell, 1957, p. 255). In this sense, the problem of estimating an efficient production function from observations of the inputs and outputs of a number of firms becomes trivial for the whole analysis. In trying to use regression analysis to estimate a parametric frontier production function, Aigner and Chu (1968), Afriat (1972), and Richmond (1974) assumed that the frontier should be a function giving maximum possible outputs using certain inputs. For a given firm i in the industry of n firms, the maximum output y_i^* obtainable from input x_i will have the form of

$$y_i^* = f(x_i) \quad (4)$$

¹⁰² This is to assure that each variable at least plays some role in the composite index, whereas zero weights may not be consistent with accepted view (Allen *et al.*, 1997). This kind of restriction is commonly found in the “benefit of doubt” approach (e.g., Cooper *et al.*, 2009).

In reality, as actual observations on outputs lie on or below the frontier (Aigner & Chu, 1968), one should notice that the observed output y_i are always equal to or smaller than the maximum output y_i^* and thus,

$$y_i \leq y_i^* \quad \text{or} \quad y_i \leq f(x_i) \quad (5)$$

The differences between y_i and y_i^* are the inefficiency, or in another words, the technical efficiency (TE) of the firm i could be calculated as follow:

$$TE_i = \frac{y_i}{f(x_i)} \leq 1 \quad \text{or} \quad y_i = f(x_i) \times TE_i \quad (6)$$

In order to estimate the production function (from the observed output y_i using linear regression technique), a vector of parameters β is introduced into the equation (6) above:

$$y_i = f(x_i; \beta) \times TE_i \quad (7)$$

The log-log version of (7) will have the form of

$$\ln y_i = \ln[f(x_i; \beta)TE_i] = \ln[f(x_i; \beta)] + \ln TE_i \quad (8)$$

Let ε_i be a measure of technical inefficiency, hence, $\varepsilon_i = -\ln(TE_i)$ or $TE_i = \exp(-\varepsilon_i)$, then the estimated production function of the firm i will be:

$$\ln y_i = \ln[f(x_i; \beta)] - \varepsilon_i \quad (9)$$

or

$$\varepsilon_i = \ln[f(x_i; \beta)] - \ln y_i \quad (10)$$

In this equation, the deviations between the logarithmic estimated outputs, i.e. $\ln[f(x_i; \beta)]$, and the logarithmic observed output, i.e. $\ln(y_i)$, are the inefficiency and could be calculated as the disturbance term or residuals. There are several ways to estimate these disturbances, including the linear programming technique (Aigner & Chu, 1968), the maximum likelihood technique (Afriat, 1972), the (modified) ordinary least squares technique (Richmond, 1974), and the stochastic technique (Aigner *et al.*, 1977; Meeusen & van den

Broeck, 1977a). Since the production frontier (8) is deterministic, the stochastic technique is obviously a solution for this problem (Coelli *et al.*, 2005) and thus, this study will focus on the SFA approach.

3.2.2 SFA using (Cobb-Douglas) translog production frontier

There are several functional forms of the production frontier, including the linear form, the Cobb-Douglas and its translog form, the quadratic and normalized quadratic form, the generalized Leontief form, and the constant elasticity of substitution form, and so on.¹⁰³

The choice between these forms depends on their characteristics, in which preference is given to those that are flexible, linear in the parameters, regular, and parsimonious (Coelli *et al.*, 2005). Because of that, researchers often use the (logarithmic) Cobb-Douglas and the translog Cobb-Douglas functional forms in their SFA models (Aigner *et al.*, 1977; Meeusen & van den Broeck, 1977b; Thiry & Tulkens, 1992; Battese & Broca, 1997; Ray, 1998; Battese *et al.*, 2000; among others).

Cobb and Douglas (1928) assumed every firm in an industry of n firms has the same technology, environment, etc. and therefore has the same production function of using two inputs (capital K and labour L). Therefore, the i -th firm will have its output(s) defined by its inputs as follows:

$$y_i = AK_i^{\beta_1}L_i^{\beta_2} \quad (11)$$

where A represents technology and environmental factors; K is capital; L is labour; i is the index number of the firm in the industry; and β_1 and β_2 are the output elasticity of capital and labour, respectively.

¹⁰³ An interesting review on more functional forms could be found in Griffin, Montgomery, and Rister (1987) where they covered twenty forms in their research. Earlier studies include Applebaum (1979), Berndt and Khaled (1979), Guilkey, Lovell, and Sickles (1983), among others.

In order to transform the non-linear formula in (11) into a linear one, we can take the logarithm for both sides of it and yield

$$\ln y_i = \ln A + \beta_1 \ln K_i + \beta_2 \ln L_i \quad (12)$$

Or
$$\ln y_i = \beta_0 + \beta_1 \ln K_i + \beta_2 \ln L_i \quad (13)$$

The estimated production frontier function derived from (13) in case of multiple variables X_i , according to equation (9) above, will be generalized as below:

$$\ln y_i = \beta_0 + \beta_i \ln X_i - \varepsilon_i \quad (14)$$

Since the Cobb-Douglas function is first-order flexible, i.e. it only has enough parameters to provide a first-order differential approximation to an arbitrary function at a single point,¹⁰⁴ it is less flexible than the transcendental logarithmic or translog function, which is a second-order flexible (Coelli *et al.*, 2005). The translog function was introduced by Christensen, Jorgenson, and Lau (1973) and was found to be more reliable than the generalized and extended generalized Cobb-Douglas forms (Guilkey *et al.*, 1983). Since the Cobb-Douglas form is subsumed by the translog (Griffin *et al.*, 1987), it would be justified to apply the translog functional form instead of the original Cobb-Douglas one. The translog production frontier will have the form as follow

$$\ln y = \beta_0 + \sum_n \beta_n \ln X_n + \frac{1}{2} \sum_n \sum_m \beta_{nm} \ln X_n \ln X_m \quad (15)$$

And the translog frontier with inefficiency component is

$$\ln y = \beta_0 + \sum_{n=1}^N \beta_n \ln X_n + \frac{1}{2} \sum_{n=1}^N \sum_{m=1}^N \beta_{nm} \ln X_n \ln X_m - \varepsilon_i \quad (16)$$

Nevertheless, the two forms in (14) and (16) differ in the deterministic component but not the inefficiency one. Since our purpose is the technical inefficiency measure ε_i , and since it

¹⁰⁴ The value of the approximating function and all its derivatives up to order one are equal to those of the arbitrary function at that point.

is treated similarly in both equations, we only examine the translog case. Our results, however, could be applied to the original Cobb-Douglas case as well.

In order to differentiate the inefficiency from statistical noise or errors or even environmental factors (such as weather, strikes, luck, etc.), Aigner *et al.* (1977) and Meeusen and van den Broeck (1977a) divided the deterministic inefficiency component ε_i into the error component v_i and the inefficiency component u_i :

$$\ln y_i = \beta_0 + \beta_i \ln X_i + v_i - u_i \quad (17)$$

Vice versa, the estimated output values are calculated as

$$y_i = \exp[\beta_0 + \beta_i \ln X_i + v_i - u_i] \quad (18)$$

Or
$$y_i = \exp[\beta_0 + \beta_i \ln X_i] \exp(v_i) \exp(-u_i) \quad (19)$$

Equation (19) shows that the output values are bounded from above by the stochastic (i.e. random) variable of $\exp[\beta_0 + \beta_i \times \ln X_i] \exp(v_i)$ and thus is called the stochastic frontier production function.¹⁰⁵

As mentioned in the previous section, the (deterministic) inefficiency component ε_i could be calculated following the equation (8). However, in terms of the stochastic frontier, it is more complicated as we have two different components u_i and v_i . The error component v_i accounts for all random factors which can (positively and negatively) affect the production and thus, having the usual Gaussian characteristics. The inefficiency component u_i , in contrast, is assumed to be distributed independently of v_i and is truncated at zero ($u_i \geq 0$). The distribution assumptions on u_i , therefore, will result in different predictions of the

¹⁰⁵ Although Meeusen and van den Broeck (1977a) referred to it as the “composed error” model due to the fact that it can differentiate the errors from inefficiency within the overall composed error component.

inefficiency measures.¹⁰⁶ However, since those inefficiencies are relative measures in SFA, i.e. they are estimated in comparison to the frontier, firms' rankings will be more important than the values of inefficiency themselves. Coelli *et al.* (2005) argued that the rankings are often quite robust to distributional choice and thus, according to the principal of parsimony, the simple models of half-normal and exponential are favoured.

In the half-normal case, one can (only) calculate the average inefficiency via the average of the composed error ε (Meeusen & van den Broeck, 1977a) or through the variance σ_u^2 (Aigner *et al.*, 1977; Lee & Tyler, 1978; Schmidt & Lovell, 1979) before JLMS (1982). According to JLMS, under the half-normal distribution,¹⁰⁷ the conditional distribution of u given ε is that of a $N(u^*, \sigma_*)$ variable truncated at zero and thus, one can predict the mean of the point estimators for u as follow:

$$\hat{u}_i \equiv E\{u_i|\varepsilon_i\} = u_i^* + \sigma_* \times \left[\frac{\phi(u_i^*/\sigma_*)}{\Phi(u_i^*/\sigma_*)} \right] \quad (20)$$

where:

$\Phi(\cdot)$ is the distribution function of the standard normal random variable

$\phi(x)$ is the probability density function (pdf) of the standard normal random variable evaluated at x

$$u_i^* = -\varepsilon_i \times \frac{\sigma_u^2}{\sigma^2}$$

$$\sigma_*^2 = \frac{\sigma_u^2 \times \sigma_v^2}{\sigma^2}$$

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

¹⁰⁶ Other distributional assumptions include the gamma model (Stevenson, 1980; Greene, 1990; Yuengert, 1993), truncated normal model (Stevenson, 1980; Mester, 1996; Berger & DeYoung, 1997), etc.

¹⁰⁷ According to JLMS, the exponential case is identical to the half-normal one and the results are similar to those from the half-normal case. Hence, we do not include the mathematical contents of the exponential case in our study.

The $(1 - \alpha) \times 100\%$ prediction interval of the estimated value \hat{u}_i could be calculated as below, following Horrace and Schmidt (1996; 2000) and Bera and Sharma (1999)

$$L_i = u_i^* + \sigma_* \times \Phi^{-1}\{(1 - \alpha/2)\Phi(u_i^*/\sigma_*)\} \quad (21)$$

$$U_i = u_i^* + \sigma_* \times \Phi^{-1}\{(\alpha/2)\Phi(u_i^*/\sigma_*)\} \quad (22)$$

By using the estimated values of \hat{u}_i and its interval L_i and U_i , one can predict the efficiency of the i -th firm, using $TE_i = \exp(-u_i)$.¹⁰⁸ However, Battese and Coelli (1988) propose an alternative predictor

$$\begin{aligned} \widehat{TE}_i &\equiv E\{\exp(-u_i)|\varepsilon_i\} \\ &= \left\{ \frac{1 - \Phi[\sigma_* - (u_i^*/\sigma_*)]}{1 - \Phi[-u_i^*/\sigma_*]} \right\} \exp\left(-u_i^* + \frac{1}{2}\sigma_*^2\right) \end{aligned} \quad (23)$$

Battese and Coelli (1995) extended this formula to work with time series values and panel data in which

$$\widehat{TE}_{it} = \exp(-u_{it}) = \exp(-z_{it} \times \delta - W_{it}) \quad (24)$$

where:

W_{it} is a random variable defined by the truncation of a normal distribution with zero mean and variance σ^2

z_{it} is a vector of explanatory variables associated with technical efficiency of production of firms over time

δ is a vector of unknown coefficient parameters

¹⁰⁸ Note that TE_i is a monotonic transformation of u_i , hence, the lower and upper bounds on TE_i could also be translated from ones of u_i . In this sense, we have $\exp(-U_i) < TE_i < \exp(-L_i)$.

3.2.3 SFA using (Cobb-Douglas) translog cost frontier

As previously discussed, SFA originated using a production frontier where one can estimate the technical efficiency and productivity change over time (as well as technological and scale change effects). The production SFA, however, could not measure the allocative efficiency, which was a component of Farrell's (1957) efficiency definition, because it uses data on input quantities but not input prices. One way to incorporate the input prices into efficiency and productivity measurement is using the cost function. The cost function can "uniquely define the technology" (compared to the production function) but "yields information on the extra cost of technical and allocative efficiency" (Førsund *et al.*, 1980, p. 15) and thus, could provide a detailed view on the Vietnamese banking system. According to Berger and Mester (1997), a simple bank's total cost C is a function of quantities of variable outputs y and prices of variable inputs w as well as the inefficiency components u and the error components v following

$$C = C(y, w, u, v) \quad (25)$$

After taking natural logs on both sides of equation (25), we have

$$\ln C = f(y, w) + \ln u + \ln v \quad (26)$$

The time-variant¹⁰⁹ translog form¹¹⁰ of the cost function in (26) is presented in equation (27). In addition, the standard homogeneity and symmetry restrictions (Kumbhakar & Lovell, 2003) are imposed in order to ensure that the cost function is well behaved. Note

¹⁰⁹ The time-decay model of Battese and Coelli (1992) allows for the examination of productivity change over time.

¹¹⁰ The translog function was introduced by Christensen, Jorgenson, and Lau (1973) and was found to be more reliable (Guilkey *et al.*, 1983) and flexible (Coelli *et al.*, 2005) than the generalized and extended generalized Cobb-Douglas forms. Since the Cobb-Douglas form is subsumed by the translog (Griffin *et al.*, 1987), it would be justified to apply the translog functional form instead of the original Cobb-Douglas one.

that in common with previous studies, the bank and time subscripts are suppressed for ease of exposition.

$$\begin{aligned}
\ln C = & \alpha_0 + \sum_{i=1}^3 \alpha_i \ln w_i + \frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 \alpha_{ij} \ln w_i \ln w_j + \sum_{k=1}^2 \beta_k \ln y_k \\
& + \frac{1}{2} \sum_{k=1}^2 \sum_{l=1}^2 \beta_{kl} \ln y_k \ln y_l + \sum_{m=1}^3 \sum_{n=1}^2 \gamma_{mn} \ln w_m \ln y_n \\
& + \omega_t t + \frac{1}{2} \omega_{tt} t^2 + \sum_{p=1}^3 \omega_p t \ln w_p + \sum_{q=1}^2 \varphi_q t \ln y_q \\
& + v + u
\end{aligned} \tag{27}$$

This equation summarizes a cost function which employs three input prices ($w_i, i=1, \dots, 3$) of the three (hidden) inputs ($x_i, i=1, \dots, 3$) in order to produce two outputs ($y_k, k=1, 2$).¹¹¹ After the parameters and the inefficiency component u were estimated, we could calculate the cost efficiency (of each bank) as well as its change, the technical change, and the scale economies (and their change) over time. These figures will help us in defining the total factor productivity of the Vietnamese banking system and its change in the 2003-2010 period.

Berger and Mester (1997) defined the cost efficiency (CE) of a certain bank i as the proportion of costs that have been used efficiently (addressed by the minimum costs that would be used if that bank was efficient) over the actual costs of bank i , adjusted for the random error v_i , i.e.,

¹¹¹ Details on these variables are presented in section 3.5.2 below.

$$CE_i = \frac{\hat{C}^{min}}{\hat{C}^i} = \frac{\hat{u}_{min}}{\hat{u}_i} \quad (28)$$

where: CE_i is the cost efficiency of the bank i ;

\hat{C}^{min} is the minimum costs used by the best-practice bank;

\hat{C}^i is the actual costs of the bank i ;

\hat{u}_{min} is the minimum inefficiency component across all banks in the sample;

\hat{u}_i is the actual cost inefficiency of bank i .

Maudos *et al.* (2002) proposed that:

$$CE_i = \frac{\exp[\hat{f}(y_i, w_i)] \times \exp[\hat{v}_i]}{\exp[\hat{f}(y_i, w_i)] \times \exp[\hat{u}_i] \times \exp[\hat{v}_i]} = \exp(-\hat{u}_i) \quad (29)$$

The economies of scale (*EOS*) is defined as a reciprocal of cost elasticity (*CES*), which in turn is measured by differentiating the cost function of (27) with respect to outputs. This gives us:

$$EOS = \frac{1}{\sum_{i=1}^2 CES_i} \quad (30)$$

where: $CES_i = \frac{\partial \ln C}{\partial \ln y_i}$ is the cost elasticity with respect to output i .

If $EOS > 1$ then increasing returns to scale exists, implying economies of scale exists.

If $EOS = 1$ then constant returns to scale exists.

If $EOS < 1$ then decreasing returns to scale exists, implying diseconomies of scale exists.

Meanwhile, the technical progress is measured by the estimated parameter of variable t as follows:

$$TECH = \frac{\partial \ln C}{\partial t} = \omega_t + \omega_{tt}t + \sum_{p=1}^3 \omega_p \ln w_p + \sum_{q=1}^2 \varphi_q \ln y_q \quad (31)$$

where:

$TECH < 0$ indicating a cost reduction due to technological progress;

$TECH = 0$ if the costs are unchanged regardless of technology;

$TECH > 0$ indicates an increasing in actual costs due to a development in technology.

The total factor productivity growth is measured using the derivative-based technique (Bauer, 1990; Kumbhakar & Lovell, 2003)¹¹² where TFP growth ($T\dot{F}P$) is decomposed into change in cost efficiency ($\dot{C}E$), technical change ($\dot{T}E\dot{C}H$), change in scale efficiency ($\dot{S}E$), and a residual price effect ($R\dot{P}E$) term:¹¹³

$$T\dot{F}P = \dot{C}E - \dot{T}E\dot{C}H + \dot{S}E + R\dot{P}E \quad (32)$$

Where:

$$\dot{S}E = (1 - \sum_{i=1}^2 CES_i) \dot{y} ;$$

$$\dot{y} = \sum_{i=1}^2 \left(\frac{CES_i}{\sum_i CES_i} \right) \dot{y}_i ;$$

$$R\dot{P}E = \sum_{i=1}^3 (s_i - s_i^*) \ln w_i ;$$

$$s_i = \frac{\partial \ln C}{\partial \ln w_i} ;$$

$$s_i^* = \min(s_i) .$$

¹¹² One could also use the explicit distance measures (e.g. see Fuentes *et al.*, 2001; Orea, 2002).

¹¹³ The $R\dot{P}E$ occurs because when the firm is (allocatively) inefficient, the aggregate measure of input usage is biased. In addition, when input prices change at the same rate, $R\dot{P}E$ also equals to zero (Bauer, 1990).

3.3 Data Envelopment Analysis (DEA)

3.3.1 *DEA in Constant returns to scale condition – The CCR model*

As discussed before, in ratio analysis, each ratio could only provide information on (the efficiency of) a single-dimension aspect of a firm or bank. In terms of production efficiency, it could be defined as a ratio between output y and the corresponding input x :

$$EF = \frac{\text{Output}}{\text{Input}} = \frac{y}{x} \quad (33)$$

However, in order to examine the technical efficiency, i.e. the overall efficiency of using multiple inputs to produce multiple outputs, equation (33) should be rewritten as

$$EF = \frac{\text{All Outputs}}{\text{All Inputs}} = \frac{\sum y}{\sum x} \quad (34)$$

Since each input (output) has a different role in the total inputs (outputs), they should be accompanied with weights or multipliers. Traditional economists tended to give them a fixed (and equal) weight, however, it was proven to be incorrect (Farrell, 1957). The original idea of DEA is to find out the optimal multipliers (weights) for input and output variables which can maximize the efficiency score (EF) of the selected firm. By doing this, each firm can achieve its optimal (or highest) efficiency score, and the most efficient firms (classified as 100% efficient or with an efficiency score equals 1.00) will envelop a frontier for the sample, remaining firms relatively are inefficient (with an efficiency score of less than 1.00).

Charnes, Cooper and Rhodes (1978) developed this idea by using the fractional programming approach on a set of data from firms, or as they referred to, the Decision Making Units (DMUs). Consider a set of n DMUs, with each DMU j ($j=1, \dots, n$) using k

inputs x_{ij} ($i=1, \dots, k$) to produce m outputs y_{rj} ($r=1, \dots, m$). In this case, under the constant returns to scale (CRS) assumption (hereafter is referred as the CCR model), a certain j_0 -th DMU can maximize its efficiency by solving the following mathematical problem:

$$EF_{j_0} = \max_{u,v} \frac{\sum_r^m u_r y_{rj_0}}{\sum_i^k v_i x_{ij_0}} \quad (35)$$

Subject to

$$\frac{\sum_r^m u_r y_{rj}}{\sum_i^k v_i x_{ij}} \leq 1, \forall j$$

$$u_r, v_i \geq \varepsilon, \forall i, r$$

where ε is a non-Archimedean value designed to enforce positivity on the multipliers.

As this equation is in ratio form, in order to avoid the infinite results problem,¹¹⁴ the denominator should be equal to unity. Thus, we have the (multiplier form) CCR model as

$$EF_{j_0} = \max_{u,v} \sum_r^m u_r y_{rj_0} \quad (36)$$

Subject to

$$\sum_i^k v_i x_{ij_0} = 1$$

$$\sum_r^m u_r y_{rj} - \sum_i^k v_i x_{ij} \leq 0, \forall j$$

$$u_r, v_i \geq \varepsilon, \forall i, r$$

By duality, equation (36) is equivalent to the (envelopment form) CCR model of

$$EF_{j_0} = \min_{\theta, \lambda} \theta_{j_0} \quad (37)$$

¹¹⁴ For a result which is calculated by a ratio of A over B, then if (A*,B*) is a solution, then ($\alpha A^*, \alpha B^*$) also is a solution, etc.

Subject to

$$\sum_i^k \lambda_j x_{ij} \leq \theta_{j_0} x_{ij_0}, \forall i, j$$

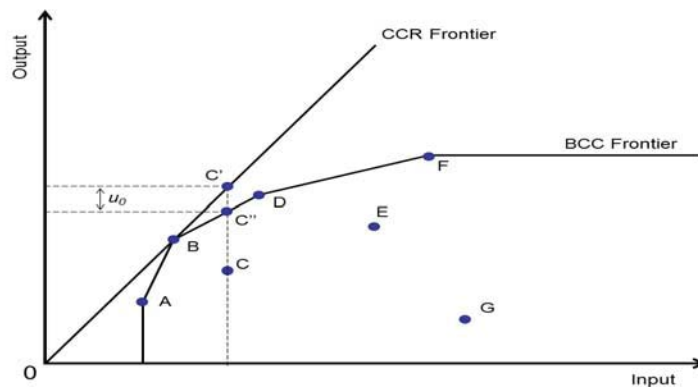
$$\sum_r^m \lambda_j y_{rj} \geq y_{rj_0}, \forall r, j$$

$$\lambda_j \geq 0, \forall j$$

3.3.2 DEA in Variable returns to scale condition – The BCC model

Banker *et al.* (1984) improved the CCR model by adding a variable returns to scale (VRS) condition (hereafter is referred to as the BCC model) in order to split the total technical efficiency (under CRS) into pure technical efficiency (under VRS) and scale efficiency (SE). This technique allows analyzers to determine whether a DMU is working at increasing, decreasing or constant returns to scale.¹¹⁵ A simple example with one input and one output case as in Figure 15 shows that the point A is (increasing returns to scale) efficient, point B is (constant returns to scale) efficient, while D and F are (decreasing returns to scale) efficient.

Figure 15. CCR and BCC frontiers in DEA



The inefficient point C, however, could be measured differently under CCR and BCC, as its optimal positions or benchmarks are C' and C'', respectively. This led to a conclusion that

¹¹⁵ Banker (1984) also referred to the constant returns to scale condition as ‘most productive scale size’ (MPSS) condition.

CCR-efficiency does not exceed BCC-efficiency (Cooper *et al.*, 2006) since the difference between them, i.e. u_0 , is always greater or equal to zero. Hence, in order to account for the scale effect, the fractional programming problem in (35) should be modified into

$$EF_{j_0} = \max_{u,v,u_0} \frac{\sum_r^m u_r y_{rj_0} - u_0}{\sum_i^k v_i x_{ij_0}} \quad (38)$$

Subject to

$$\frac{\sum_r^m u_r y_{rj} - u_0}{\sum_i^k v_i x_{ij}} \leq 1, \forall j$$

$$u_r, v_i \geq \varepsilon, \forall i, r$$

u_0 is unconstrained in sign

Consequently, we also have the BCC envelopment form as

$$EF_{j_0} = \min_{\theta, \lambda} \theta_{j_0} \quad (39)$$

Subject to

$$\sum_i^k \lambda_j x_{ij} \leq \theta_{j_0} x_{ij_0}, \forall i, j$$

$$\sum_r^m \lambda_j y_{rj} \geq y_{rj_0}, \forall r, j$$

$$\sum_j^n \lambda_j = 1, \forall j$$

$$\lambda_j \geq 0, \forall j$$

And the BCC multipliers form as

$$EF_{j_0} = \max_{u,v,u_0} \sum_r^m u_r y_{rj_0} - u_0 \quad (40)$$

Subject to

$$\sum_i^k v_i x_{ij_0} = 1, \forall i, j$$

$$\sum_r^m u_r y_{rj} - u_0 - \sum_i^k v_i x_{ij} \leq 0, \forall i, r, j$$

$$u_r, v_i \geq \varepsilon, \forall i, r$$

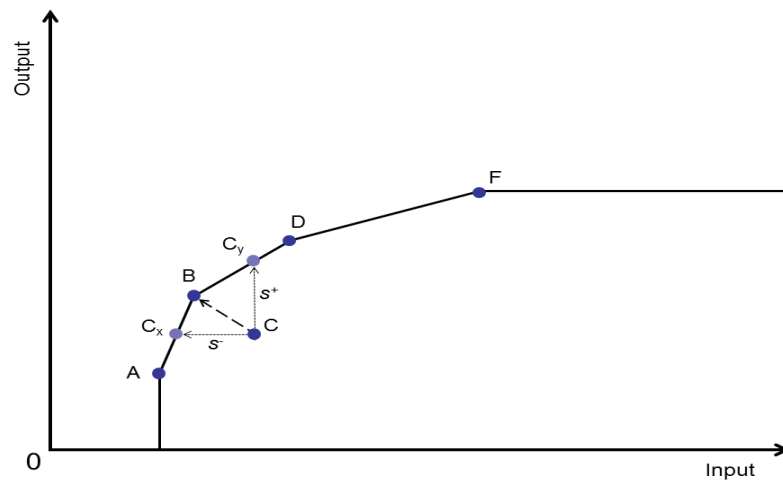
u_0 is unconstrained in sign

3.3.3 The Slacks-Based Measure of efficiency (SBM) models

3.3.3.1 The additive model

Normally, the maximization in multiplier form (and minimization in envelopment form) of CCR and BCC models could be achieved by maximizing the weighted outputs while the inputs are constrained (input-oriented); or minimizing the weighted inputs while outputs are constrained (output-oriented). Practically, however, one should reach for both maximizing the outputs and minimizing the inputs used and thus, should use a combination of both output- and input-oriented models.

Figure 16. Additive DEA model



In this combination model, namely the additive model, a DMU is efficient if it has no slack,¹¹⁶ whether it is on input or output side.¹¹⁷ In our illustration, the benchmark point of

¹¹⁶ Slacks are defined as inequalities between the observed values and the frontier (Charnes *et al.*, 1978). It can be input inequalities (or input excesses) or output inequalities (output shortfalls).

our inefficient unit C is neither C_y (in term of output-oriented) nor C_x (in term of input-oriented) but the point B, which is at the largest distance from C. Hence, with the input excesses denoted by s^- and the output shortfalls is denoted by s^+ , our (BCC)¹¹⁸ linear programming problem at point j_0 will be

$$EF_{j_0} = \max_{\lambda, s^-, s^+} \sum_i^k s_i^- + \sum_r^m s_r^+ \quad (41)$$

Subject to

$$\sum_i^k \lambda_j x_{ij} + s_i^- = x_{ij_0}, \forall j, i$$

$$\sum_r^m \lambda_j y_{rj} - s_r^+ = y_{rj_0}, \forall j, r$$

$$\sum_j^n \lambda_j = 1, \forall j$$

$$\lambda_j, s_i^-, s_r^+ \geq 0, \forall j, i, r$$

3.3.3.2 The SBM models

The objective of the additive model in (41) seeks to maximize the sum of slacks and thus, it faces the units variant problem in a multi-dimensional context of DEA, where different inputs and outputs may be measured in non-commensurate units (Russell, 1985). Tone (2001) introduced a single scalar called “SBM” which is invariant with respect to the units of data (units invariant); monotone decreasing in each input and output slack (monotone); should be invariant under parallel translation of the coordinate system applied (translation invariant); and should be determined only by consulting the reference-set of the DMU concerned (reference-set dependent). Thus, the VRS fractional form of SBM model will be

¹¹⁷ When all slacks equal to zero, one cannot improve the situation further without affecting the (original) inputs/outputs and thus, this is equivalent to the Pareto-Koopmans’ efficient or optimal situation.

¹¹⁸ Note that the CCR model could be achieved by taking the unity constrain of lambdas, i.e. $\sum_j^n \lambda_j = 1$, out of the BCC model.

$$EF_{j_0} = \min_{\lambda, s^-, s^+} \frac{1 - \frac{1}{k} \sum_i^k s_i^- / x_{ij_0}}{1 + \frac{1}{m} \sum_r^m s_r^+ / y_{rj_0}} \quad (42)$$

Subject to

$$\sum_i^k \lambda_j x_{ij} + s_i^- = x_{ij_0}, \forall j, i$$

$$\sum_r^m \lambda_j y_{rj} - s_r^+ = y_{rj_0}, \forall j, r$$

$$\sum_j^n \lambda_j = 1, \forall j$$

$$\lambda_j, s_i^-, s_r^+ \geq 0, \forall j, i, r$$

Tone (2001) also transformed (42) into a linear programming problem of

$$EF_{j_0} = \min_{t, s^-, s^+, \Lambda} t - \frac{1}{k} \sum_i^k S_i^- / x_{ij_0} \quad (43)$$

Subject to

$$\sum_i^k \Lambda_j x_{ij} + S_i^- = tx_{ij_0}, \forall j, i$$

$$\sum_r^m \Lambda_j y_{rj} - S_r^+ = ty_{rj_0}, \forall j, r$$

$$1 = t + \frac{1}{m} \sum_r^m S_r^+ / y_{rj_0}$$

$$S_i^- = ts_i^-, S_r^+ = ts_r^+, \Lambda_j = t\lambda_j, \forall i, r, t$$

$$\sum_j^n \lambda_j = 1, \forall j$$

$$\Lambda_j, S_i^-, S_r^+ \geq 0, t > 0, \forall j, i, r, t$$

3.3.4 TFP change over time: MI-DEA vs. FI-DEA

3.3.4.1 The MI-DEA approach

In this approach, a DMU is studied at two different periods with respect to a common reference technology from a base period. According to Fare *et al.* (1994), the output-based

TFP changes between point A^t in year t and A^{t+1} in year $t+1$ (of the same DMU) could be calculated as the geometric means of two Malmquist productivity indexes using the constant returns to scale (CRS) distance functions (Caves *et al.*, 1982a, b) in equation (44) below. Thus, if m_o is greater than one then there is an improvement in TFP, otherwise TFP has been decreasing.

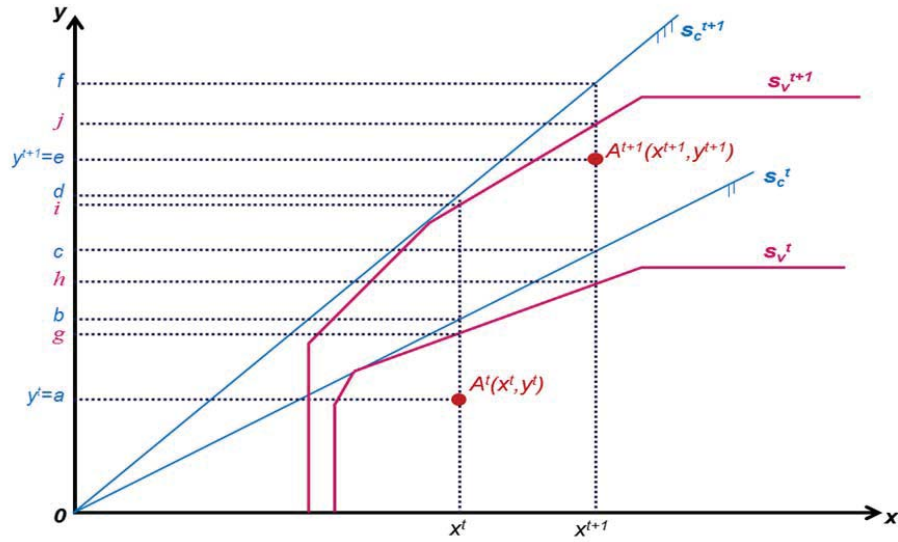
$$\begin{aligned}
m_o(x^{t+1}, y^{t+1}, x^t, y^t) &= \left[\frac{d_c^t(x^{t+1}, y^{t+1})}{d_c^t(x^t, y^t)} \times \frac{d_c^{t+1}(x^{t+1}, y^{t+1})}{d_c^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \\
&= \frac{d_c^{t+1}(x^{t+1}, y^{t+1})}{d_c^t(x^t, y^t)} \times \left[\frac{d_c^t(x^{t+1}, y^{t+1})}{d_c^{t+1}(x^{t+1}, y^{t+1})} \times \frac{d_c^t(x^t, y^t)}{d_c^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \\
&= \left(\frac{0e}{0f} \frac{0b}{0a} \right) \times \left[\frac{0f}{0c} \frac{0d}{0b} \right]^{\frac{1}{2}}
\end{aligned} \tag{44}$$

$$\text{TFPCH} = (\text{EFCH}) \times [\text{TECHCH}]$$

where $A^t(x^t, y^t)$ and $A^{t+1}(x^{t+1}, y^{t+1})$ are production points at time t and $t+1$, respectively (see Figure 17). The notations $d_c^t(x^t, y^t)$ represents the distance of the point (x^t, y^t) to the CRS frontier S_c^t .

The MI-DEA model of Fare, Grosskopf, Norris, and Zhang (1994) could be understood as follow.

Figure 17. Malmquist output-based index of TFP change



Source: Adapted from Fare *et al.* (1994)

While m_o (TFPCH) can be decomposed into efficiency changes (EFCH) and technological changes (TECHCH), one can also apply the variable return to scale (VRS) condition (Banker *et al.*, 1984) to analyse the pure efficiency (PECH) and scale efficiency changes (SECH)¹¹⁹ following:

$$\begin{aligned}
 EFCH &= PECH \times SECH \\
 &= \frac{d_v^{t+1}(x^{t+1}, y^{t+1})}{d_v^t(x^t, y^t)} \times \frac{s^{t+1}(x^{t+1}, y^{t+1})}{s^t(x^t, y^t)} \quad (45) \\
 &= \frac{0e \ 0g}{0j \ 0a} \times \frac{0j \ 0b}{0f \ 0g}
 \end{aligned}$$

In overall,

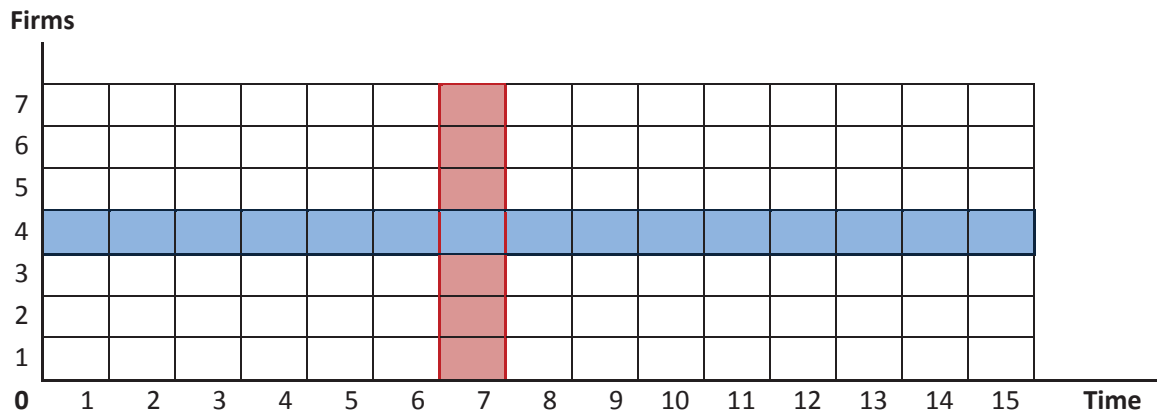
$$TFPCH = PECH \times SECH \times TECHCH \quad (46)$$

¹¹⁹ Although there are some problems regarding SECH in Malmquist index such as the local scale efficiency issue or the VRS technology. Grifell-Tatjé and Lovell (1999) proposed the use of a generalized Malmquist index instead.

3.3.4.2 The FI-DEA approach

There is a problem for the MI-DEA model when dealing with a small number of DMUs in a certain period, regarding the number of input and output variables used (Dyson *et al.*, 2001),¹²⁰ i.e. the dimensional curse (Donoho, 2000). The problem arises because MI-DEA measures the “contemporaneous subset”¹²¹ (the red shape in Figure 18) in order to get the yearly efficiency scores and then use the Malmquist index approach to compare them through the years to get to the productivity change measures. Some studies (Färe *et al.*, 1985; Thiry & Tulkens, 1992; Tulkens & vanden Eeckaut, 1995a) pointed out that DEA could be used to calculate the “time-series subset” (the blue shape in Figure 18) of the same DMU in each year (hereafter called the time-series DEA model). Contrary to these studies, we will not use the Malmquist index but employ the Fisher index (FI) approach to measure TFP change in this case.

Figure 18. Time-series DEA efficiency



¹²⁰ For example, with a panel data of 100 observations constructed from 5 DMUs in 20 years, in which each DMU uses 3 inputs in order to produce 2 outputs, the contemporaneous MI-DEA may be biased in calculating the yearly efficiency of each DMU (see also our discussion in section 2.2.4.4 above). Researchers can use the window-Malmquist DEA technique, however, at the cost of not being able to decompose the MI TFP accurately since a single change in technology may affect several efficiency scores as one DMU may appear in several windows (Asmild *et al.*, 2004).

¹²¹ For more details on various subsets of a panel data, see Tulkens and Eeckaut (1995b).

It is important to recognise, however, that the MI is not a productivity measure but a technological one (Grosskopf, 2003). Only under some stringent conditions (e.g., constant returns to scale and inverse homotheticity), MI could approximate other superlative indices such as the Fisher index (Balk, 1993), Tornqvist index (Caves *et al.*, 1982b), or Hicks-Moorsteen index (Kerstens & Woestyne, 2014). Diewert (1992) listed 20 properties that an index should have, and concluded that the Fisher ideal TFP index (FI) is the unique function that satisfies all these requirements. Thus, it strengthens our argument that the Fisher index should be preferred in measuring productivity change over time.

We further notice that TFP measures calculated from the basic DEA models (CCR or BCC) are either output or input oriented, and inconsistency may occur between the two orientations (Kuosmanen & Sipiläinen, 2009). To cooperate with both input and output sides, we employ the SBM DEA model in our calculation. It also helps determine the shadow prices for both input and output variables to use later in our FI-TFP calculation and decomposition.

Another issue is the uniqueness of the shadow prices. In SBM DEA, for the extreme points of the frontier (where DMUs are efficient), however, the input and output slacks are non-unique and thus, we end up with non-unique shadow prices. This problem, however, does not occur under a super-efficiency assumption as there is no extreme point in its mathematical formulation (Andersen & Petersen, 1993).

Consider t period-observations of a certain DMU that forms a time-series production frontier.¹²² Assuming that this DMU uses k inputs x_i ($i=1,\dots,k$) to produce m outputs y_r

¹²² If we examine more than one unit, i.e., panel data situation, then we will have to analyse more than one time series frontier.

$(r=1, \dots, m)$.¹²³ According to Tone (2002), under the CRS assumption, in a certain period j_0 ($1 \leq j_0 \leq t$), a certain DMU can maximize its super-efficiency SBM (SE-SBM) by solving the following mathematical problem:¹²⁴

$$SE-SBM_{j_0}^{CRS} \equiv \min \delta_{j_0} = \frac{\frac{1}{m} \sum_{i=1}^k \bar{x}_i / x_{j_0}}{\frac{1}{s} \sum_{r=1}^m \bar{y}_r / y_{j_0}} \quad (47)$$

subject to:

$$\sum_{j=1, \neq j_0}^t \lambda_j x_{ij} \leq \bar{x}_i, \quad i = 1, \dots, k,$$

$$\sum_{j=1, \neq j_0}^t \lambda_j y_{rj} \geq \bar{y}_r, \quad r = 1, \dots, m,$$

$$\bar{x}_i \geq x_{ij_0}, \quad i = 1, \dots, k,$$

$$0 \leq \bar{y}_r \leq y_{rj_0}, \quad r = 1, \dots, m,$$

$$\lambda_j \geq 0, \quad j = 1, \dots, t$$

where δ_{j_0} is a weighted L_1 distance from (x_{j_0}, y_{j_0}) to the time series frontier spanned by $(x_{j_0}, y_{j_0}), j = 1, \dots, t, j \neq j_0$.

Basically, the FI (of a certain DMU) measures the ratio between Fisher's output quantity index F_y and Fisher's input quantity index F_x (of that DMU) between two periods θ and I , given the output price p for output y and input price w for input x (Diewert, 1992, p. 213, equation 6):

¹²³ For our DEA models to get enough discrimination power, it is required that $t \geq 3(m + s)$. See footnote 56 for more details.

¹²⁴ The constraint for the VRS condition is $\sum_{j=1, \neq j_0}^t \lambda_j = 1$.

$$FI_{0,1} = \frac{F_y(p^{0,1}, y^{0,1})}{F_x(w^{0,1}, x^{0,1})} \quad (48)$$

where: $F_y(p^{0,1}, y^{0,1}) = \left(\frac{p^0 y^1 p^1 y^1}{p^0 y^0 p^1 y^0} \right)^{1/2}$ is the Fisher output quantity index (49)

$$F_x(w^{0,1}, x^{0,1}) = \left(\frac{w^0 x^1 w^1 x^1}{w^0 x^0 w^1 x^0} \right)^{1/2} \text{ is the Fisher input quantity index} \quad (50)$$

Following Balk (2004), we also have:

$$F_y^P(p^{0,1}, y^{0,1}) = \left(\frac{p^1 y^0 p^1 y^1}{p^0 y^0 p^0 y^1} \right)^{1/2} \text{ is the Fisher output price index} \quad (51)$$

$$F_x^P(w^{0,1}, x^{0,1}) = \left(\frac{w^1 x^0 w^1 x^1}{w^0 x^0 w^0 x^1} \right)^{1/2} \text{ is the Fisher input price index} \quad (52)$$

Despite MI-DEA not requiring price data, its distance functions are calculated based on the observed position of the examined DMUs and their projections on the frontier, and thus still depend on shadow prices. The MI-DEA, therefore, becomes an indirect measure (of the shadow prices). However, if the shadow prices are known, which are estimated from the dual problem of equation (47), they could be applied directly¹²⁵ into the our FI measurement:

$$FI_{0,1} = \frac{\left(\frac{u^0 y^1 u^1 y^1}{u^0 y^0 u^1 y^0} \right)^{1/2}}{\left(\frac{v^0 x^1 v^1 x^1}{v^0 x^0 v^1 x^0} \right)^{1/2}} \quad (53)$$

With some adjustments, (53) could be rewritten as

¹²⁵ Kuosmanen, Post, and Sipiläinen (2004) used DEA shadow prices to calculate FI; however, they used distance functions and thus, came up with indirect FI measures. In addition, they were not able to decompose the FI.

$$\begin{aligned}
FI_{0,1} &= \left(\frac{\frac{u^0 y^1}{u^0 y^0} \frac{u^1 y^1}{u^1 y^0}}{\frac{v^0 x^1}{v^0 x^0} \frac{v^1 x^1}{v^1 x^0}} \right)^{\frac{1}{2}} \\
&= \left(\frac{u^0 y^1}{u^0 y^0} \frac{u^1 y^1}{u^1 y^0} \frac{v^0 x^0}{v^0 x^1} \frac{v^1 x^0}{v^1 x^1} \right)^{\frac{1}{2}} \\
&= \left(\frac{v^0 x^0}{u^0 y^0} \frac{u^1 y^1}{v^1 x^1} \frac{u^0 y^1}{v^0 x^1} \frac{v^1 x^0}{u^1 y^0} \right)^{\frac{1}{2}} \tag{54} \\
&= \frac{v^0 x^0}{u^0 y^0} \frac{u^1 y^1}{v^1 x^1} \left(\frac{u^0 y^0}{v^0 x^0} \frac{v^1 x^1}{u^1 y^1} \frac{u^0 y^1}{v^0 x^1} \frac{v^1 x^0}{u^1 y^0} \right)^{\frac{1}{2}} \\
&= \frac{v^0 x^0}{u^0 y^0} \frac{u^1 y^1}{v^1 x^1} \left(\frac{u^0 y^0}{v^0 x^0} \frac{v^1 x^0}{u^1 y^0} \frac{v^1 x^1}{u^1 y^1} \frac{u^0 y^1}{v^0 x^1} \right)^{\frac{1}{2}}
\end{aligned}$$

By definition, the first component $\frac{v^0 x^0}{u^0 y^0}$ is the reciprocal of the CRS efficiency score at period 0 (EF_0^{CRS})¹²⁶ while the second component $\frac{u^1 y^1}{v^1 x^1}$ measures the efficiency at period 1 (EF_1^{CRS}). These two measure the change in CRS efficiency scores between period 1 and 0 and thus, representing technical efficiency change under CRS condition ($\Delta TE_{0,1}^{CRS}$). On the other hand, by making use of (49)-(52), we obtain the result that the component inside the brackets is the ratio of the Fisher input price index to the Fisher output price index $\frac{F_y^P(p^{0,1}, y^{0,1})}{F_x^P(w^{0,1}, x^{0,1})}$. Kuosmanen and Sipiläinen (2009) suggested that this is a price deflator (*PD*) component as it measures the change of output prices relative to the change of input prices. Thus, the CRS decomposition of the FI is

$$FI_{0,1}^{CRS} = \Delta TE_{0,1}^{CRS} \times PD \tag{55}$$

¹²⁶ Notice that this is different from the *SE-SBM*^{CRS} measure calculated from equation (47).

If the scale effect is also taken into account, following Fare et al. (1994), we further have

$$\Delta TE_{0,1}^{VRS} = \frac{EF_1^{CRS}}{EF_0^{CRS}} = \frac{EF_1^{VRS} \times SE_1}{EF_0^{CRS} \times SE_0} \quad (56)$$

And therefore, our decomposition of FI in VRS condition become

$$FI_{0,1}^{VRS} = \Delta TE_{0,1}^{VRS} \times \Delta SE \times PD \quad (57)$$

where

$$\Delta SE = \frac{SE_1}{SE_0} \text{ is the change in scale efficiency} \quad (58)$$

Note that (57) is similar to the MI decomposition of Fare *et al.* (1994) where their technical change component (*TECHCH*) is replaced by the price deflator (*PD*) due to the nature of the Fisher (price) index.¹²⁷

3.4 Determinants of Vietnamese banks' performance

It is noted that our studies on the performance of Vietnamese banks are based on the assumption that all banks are undertaking similar activities and producing comparable products or services under common technologies. According to Dyson *et al.* (2001, p. 247), “there is an unwritten assumption that the units are operating in similar environments... however, this assumption can rarely be safely made, and, as a consequence, environmental variables are often brought into the analysis” as supplements.

In SFA, Battese and Coelli (1995) modeled the cost inefficiency component as

$$u = \delta z + w \quad (59)$$

¹²⁷ Remember that the time series frontier as well as the index number approach (of which SPFI belongs to) could not measure technological change.

where u is the cost inefficiencies derived from equation (27), z is the vector of environmental factors, w is a random variable distributed as a truncated-normal distribution with zero mean and variance σ_u^2 , and δ is the vector of coefficients to be estimated.

Meanwhile, efforts were made in order to account for these environmental factors directly within the DEA model in a single-stage (Banker & Morey, 1986a, b), however, since it has some limits,¹²⁸ the multi-stage DEA models are preferred (Charnes *et al.*, 1981; Ray, 1988; Fried *et al.*, 1999; Muñiz, 2002; Hoff, 2007; and so on). An advantage of this approach is that it allows for the examination of environmental variables (on the dependent variable) in both sign and significance (Fried *et al.*, 1999). Therefore, for the RA and DEA approaches, we check for the effects of bank's ownerships and sizes (expected finding E2, section 1.2.3) using a second-stage regression model:

$$Y = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (60)$$

where Y is the dependent variable that vary depending on the model used in the first stage (CE in SFA and PI or CAMELS ratios in RA); $TYPE$ is a dummy variable represents the ownership of the bank ($TYPE = 1$ if the bank is SOCB, otherwise $TYPE = 0$); $SIZE$ is the logarithmic value of the bank's total assets; and ε is the error component. We also control for the interaction between $TYPE$ and $SIZE$, as one may argue that the SOCBs tend to have bigger size compared to the JSCBs, by using an addition variable $TYPE*SIZE$.

The above environmental factors or bank' specific characters (i.e. $TYPE$ and $SIZE$) help explain the differences between efficiency measures (CE or PI) as well as key ratios of

¹²⁸ For example, the incorporation of environmental variables directly into the linear problem of DEA will increase the number of variables and thus, may bias the efficiency measures as DEA is sensitive to the "dimensional issue" (Sexton *et al.*, 1986; Dyson *et al.*, 2001; Hughes & Yaisawarng, 2004). More detailed commentary on the single-stage DEA is provided by Fried, Schmidt, and Yaisawarng (1999) and Fried, Lovell, Schmidt, and Yaisawarng (2002), among others.

different banks (CAMELS ratios) in the examined duration. Due to data limitation (more discussion are in the following section), these studies only cover the 2003-2010 period and thus could not reflect the whole financial liberalization process in Vietnam. Our FI-DEA model helps overcome that limitation utilizing the time-series data of macro-level information of the whole Vietnamese banking system instead of the individual bank-level data. Consequently, to examine the effect of liberalization on the performance of the Vietnamese banking system, we employ a set of macroeconomic variables X_j in the second-stage regression of the FI-DEA study.

$$Y_i = \beta_0 + \beta_1 X_j + \varepsilon \quad (61)$$

This macroeconomic set is chosen following the literature (e.g. McKinnon, 1973; Shaw, 1973; Bandiera *et al.*, 2000; Laeven, 2003; Lane & Milesi-Ferretti, 2007; Chinn & Ito, 2008). We notice that these variables also proxy for the financial liberalization progress proposed by McKinnon as in Figure 1 of section 1.2.1 above. In addition, to analyse the effect of important turning points in the financial liberalization process, we divide our regression model into two sub-models. In each model, we introduce a crisis dummy variable with zero-year lag (C0) or one-year lag (C1), assuming that the effect of the crisis may happen at the time the crisis occurred or one year later, respectively. Descriptive information on these environmental variables is presented in the following section (Table 11). The dependent variable Y_i , however, will differ in each model (see Table 6).

Table 5. Independent variables of the second-stage FI-DEA study

X_i	Explanations and Sources	Associations with FI measures
<i>KA</i>	Kaopen index, measuring the financial openness of the country (extracted from Chinn & Ito, 2008)	+
<i>BD</i>	Budget deficit (extract from ADB statistical online database)	-
<i>TB</i>	Trade balance (extract from ADB statistical online database)	+
<i>CB</i>	Capital account balance (extract from ADB statistical online database)	+
<i>NB</i>	Number of banking institutions in the system (from SBV reports)	+
<i>NS</i>	Number of equitized SOCBs in the system (from SBV reports)	+
<i>BC</i>	Bank concentration ratios (extracted from Beck <i>et al.</i> , 2000)	-
<i>RR</i>	Reserve requirement ratios, announced by the SBV (from SBV reports)	-
<i>LI</i>	Nominal interest rates on working capital loans (extracted from the Vietnam Annual Statistical reports from the IMF)	-
<i>RD</i>	Real interest rates on deposits (calculated from IMF data on nominal interest rates on 3-month household loans and quartile average inflation rates, using the exact Fisher equation)	+
<i>C0</i>	Zero-year crisis effect, dummy variable (equals 1 if the year is 1997 and 2007; else equals 0)	-
<i>CI</i>	One-year crisis lag effect, dummy variable (equals 1 if the year is 1998 and 2008; else equals 0)	-

There are several regression methods to estimate the correlation between the efficiency/performance/productivity scores in the first-stage with the independent variables of the second-stage, including the OLS, Tobit, and logit. Regarding that performance and efficiency scores (e.g. CE or PI) are censored/bounded between 0 and 1, the Tobit regression is preferred (Fethi & Pasiouras, 2010).¹²⁹ For CAMELS ratios or other TFP (and its components) change the basic regression model OLS is justified. Additionally, for the regression part of our FI-DEA study, since the sample size is small (we have only 21 observations by looking at the Vietnamese banking system in each year of the 1990-2010

¹²⁹ Although Simar and Wilson (2007) suggested the use of truncated regression.

period as an individual DMU), we also employ the backward step-wise regression technique (Mark, 1988; Harrell, 2001). This technique begins with all variables included in the Tobit regression, and then it eliminates one variable at a time that has the highest p-value (or the most insignificant variable) until the eliminating could not improve the significance of the model. Hence, it reduces the environmental variables into an acceptable number that allows for valid conclusions could be made, regarding our small sample size.

Table 6. Second-stage regression: Dependent variables and techniques

	Dependent variable (Y)	Obs.	Regression technique
Ratio Analysis	<i>PI</i>	96	Tobit
	<i>EQ, NPLL, ROA, NIM, LIQUID, CGAPA</i>	96	OLS
SFA	<i>CE</i>	96	Tobit
	<i>CE, TECH, SE, RPE, TFPCH</i>	96	OLS
MI-DEA	<i>EF</i>	96	Tobit
	<i>EFCH, TECHCH, TFPCH</i>	96	OLS
FI-DEA	<i>EF</i>	21	Step-wise Tobit
	$\Delta TE^{VRS}, \Delta SE, \Delta AE, FI$	21	Step-wise OLS

Note: *Obs.:* Observations,

EF in MI-DEA is the efficiency scores calculated using a pooled data for 12 banks in 8 years; while the *EF* in FI-DEA is calculated using the time-series DEA model.

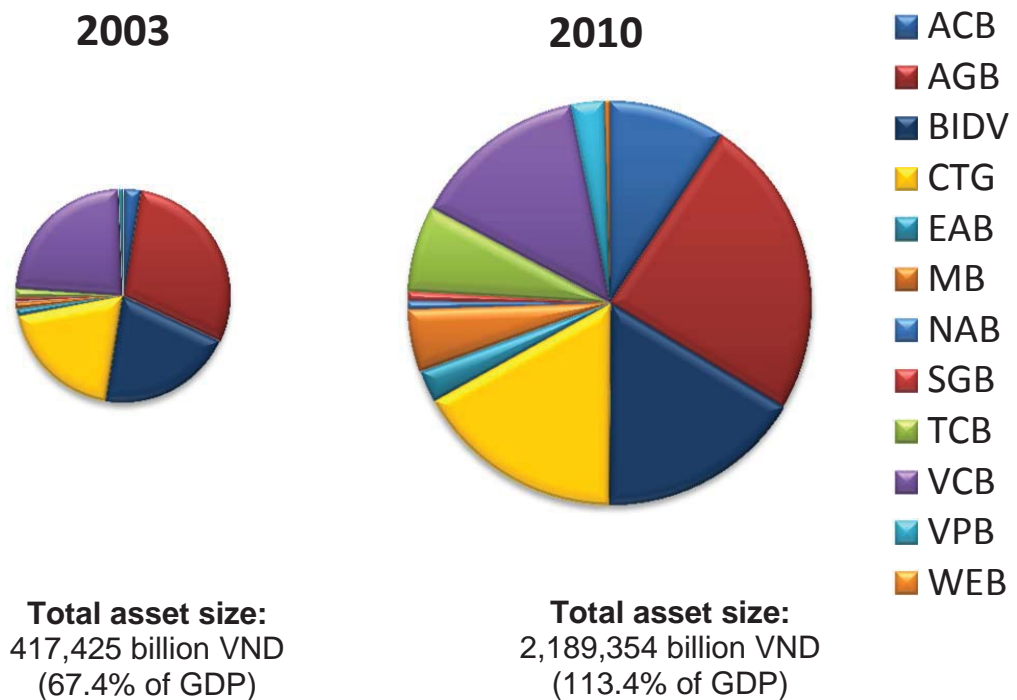
3.5 Data availability on the Vietnamese banking system (2003-2010)¹³⁰

The availability of data on more than 100 banks currently in Vietnam varies significantly, with data of new or minor banks limited and uncompleted. This dissertation therefore focuses on banks that exist throughout the 2003-2010 period and can represent the whole banking sector in Vietnam. Although there were 75 banking institutions in the system in

¹³⁰ Data on individual banks is limited prior to 2000 due to the limitation of the information technology system in the Vietnamese banking sector. Hence, except for the FI-DEA model (more details are provided in section 4.3.2 below) which uses macro-level data of the 1990-2010 period, all other sections use bank-level data from 2003 to 2010.

2003, only 12 of them have had their reports published since that date.¹³¹ However, the total assets of those 12 banks accounted for 67% (in 2003) to 113% (in 2010) of GDP (see Figure 19). The average deposits and credit share that they provided accounted for 96.3% and 65.1% of total domestic deposits and credit of the whole banking system in the period 2003-2010 (author's estimates). This makes those banks become a suitable sample for the research.

Figure 19. Share of assets of banks in the research sample



Source: Author's calculation

Table 7 presents the list of sample banks included in the research as well as their codes (defined by the author), type of bank, and their assets (in billion Vietnam Dong, where 1 USD \approx 18,932 VND, as of 31/12/2010). Note that in the Vietnamese banking system, two

¹³¹ It was not a requirement for Vietnamese banks to publish their reports until July 2009 (Vietnamese Government, 2009).

accounting standards exist in parallel, the International Financial Reporting Standards (IFRS) and the Vietnamese Accounting Standards (VAS). Hence, the data is built from a mix of reports in both IFRS and VAS, in which IFRS are preferred if both IFRS and VAS reports are available. However, as the VAS had started to adopt IFRS since 2001, differences in value between the two approaches are minor and not considered important.

Table 7. Sample banks for the study

No.	Bank	Code	Type	Assets
1	Asia Commercial Bank	ACB	JSCB	205,103
2	Vietnam Bank for Agriculture and Rural Development	AGB	SOCB	530,713
3	Bank for Investment and Development of Vietnam	BIDV	SOCB	361,954
4	Vietnam Bank for Industry and Trade	CTG	SOCB	367,712
5	DongA Bank	EAB	JSCB	55,873
6	Military Bank	MB	JSCB	109,623
7	Nam A Bank	NAB	JSCB	14,509
8	Saigon Bank for Industry and Trade	SGB	JSCB	16,812
9	Vietnam Technological and Commercial Bank	TCB	JSCB	150,291
10	Bank for Foreign Trade of Vietnam	VCB	SOCB	307,621
11	Vietnam Prosperity Bank	VPB	JSCB	59,807
12	Western Bank	WEB	JSCB	9,335

Source: SBV

Other data on the macro-economic environment such as GDP, credit, total liquidity, etc. have been obtained from the State Bank of Vietnam, the Asian Development Bank, the World Bank, IMF, APEC, ILO, and the United Nations.

3.5.1 Data for Ratio Analysis

Within the scope of the research, from 2003 to 2010, financial and annual reports from 12 Vietnamese commercial banks were collected. Hence, the data set will include financial ratios, both maximization and minimization ones, of 12 banks over 8 years, equivalent to

96 bank-year observations. Descriptive statistics for the six variables of our ratio analysis (see also Table 4 in section 3.1.1.2) are presented as below.

Table 8. Descriptive statistics of variables in the Ratio Analysis (2003-2010)

	EQ	NPLL	ROA	NIM	LIQUID	CGAPA
Mean	9.25	2.80	1.35	3.16	10.41	34.64
Standard Deviation	6.93	5.24	1.02	1.11	6.36	23.19
Maximum	43.82	33.13	5.54	8.26	29.09	79.16
Minimum	0.10	0.08	-1.04	1.27	0.96	-34.95
Number of observations	96 bank-years					
Examined period	2003-2010					

Source: Author's calculation from individual bank's financial reports

3.5.2 Data for SFA models

Since SFA is based on the production or cost frontiers, hence, it tends to select variables following the production approach. Traditional studies used labour and capital as inputs while the value added is output (Aigner & Chu, 1968; Meeusen & van den Broeck, 1977a). Later, more variables, mostly on the input side, were added into the model, depending on the circumstance of the research.¹³²

In terms of the banking sector, however, the intermediation approach (Sealey & Lindley, 1977) seems to be preferred as it helps explain the role of banking in providing financial services (Berger & Mester, 1997; Altunbas *et al.*, 2000; Maudos *et al.*, 2002; Kumbhakar & Tsionas, 2008). As pointed out by Sealey and Lindley (1977), the cost of a bank normally is composed from the implicit resource costs (of capital, labour, etc.) and explicit deposits cost (interest payments). Therefore, our study will have three input variables (deposits, physical capital, and labour), following previous studies such as Ferrier and Lovell (1990),

¹³² This included the (logarithmic) total cost of fodder, seed and fertilizer (Battese & Coelli, 1988) or land area and labour bullock hours (Battese & Coelli, 1995) in the agriculture sector; the actual consumption of fuel in the steam-electric generating plants (Schmidt & Lovell, 1979); and so forth.

Kaparakis *et al.* (1994), Sturm and Williams (2004), among others. The associated input prices are usually approximated by relating individual banks' factor expenses (*i.e.* interest expenses, occupancy expenses, and labour expenses) to the input amount. However, these expenses only cover parts of the total costs of a bank, where the non-interest non-occupancy expenses are left aside. Some studies tried to cover this part, which are becoming more and more important in modern banking, by relating all other non-interest expenses to total fixed assets (Bonin *et al.*, 2005a; Vu & Turnel, 2010) or to total number of employees (Hasan & Marton, 2003). Therefore, we will examine both cases of using occupancy expenses as well as other non-interest expenses in defining the input price of capital.

On the output side, two outputs were specified following Delis *et al.* (2009), namely customer loans and other earning assets. Notice that the nonperforming loans were subtracted from customer loans in order to measure the net loan portfolio (Vu & Turnel, 2010). Meanwhile, the latter variable represents the bank's assets except fixed assets and customer loans.

Table 9. SFA variables

Variables	Definitions	Mean	Standard Deviation	Minimum	Maximum
<i>Dependent variables</i>					
<i>C</i>	Actual costs, equal to interest expenses plus operating expenses ($C=x_1*w_1+x_2*w_{2a}+x_3*w_3$)	3,526,201	4,874,120	6,726	23,071,028
<i>TC</i>	Total costs, equal to interest expenses plus non-interest expenses ($TC=x_1*w_1+x_2*w_{2b}+x_3*w_3$)	3,583,470	4,919,989	6,742	23,071,028
<i>Output variables</i>					
<i>y₁</i>	Customer loans (excluding NPLs)	32,101,616	43,231,597	84,585	182,699,530
<i>y₂</i>	Other earning assets ($y_2=Total\ assets - y_1 - x_2$)	15,296,760	17,413,003	3,279	65,516,151
<i>Input variables</i>					
<i>x₁</i>	Total deposits	59,995,055	80,076,875	30,949	389,890,718
<i>x₂</i>	Physical capital, <i>i.e.</i> fixed assets	862,144	1,040,274	769	5,275,762
<i>x₃</i>	Number of employees	6,520	8,907	54	37,500
<i>Input prices</i>					
<i>w₁</i>	Price of deposits, equal to interest expenses divided by total deposits	0.052	0.021	0.021	0.168
<i>w_{2a}</i>	Price of physical capital, equal to occupancy expenses divided by total fixed assets	0.516	0.404	0.068	2.334
<i>w_{2b}</i>	Price of physical capital, equal to non-interest expenses (except occupancy and labour expenses) divided by total fixed assets	0.593	0.431	0.079	2.469
<i>w₃</i>	Price of labour, equal to labour expenses divided by number of employees	47.508	22.392	12.613	120.256
Number of observations		96 bank-years			
Examined period		2003-2010			

Source: Author's calculation from individual bank's financial reports

Table 9 presents the descriptive statistics of SFA variables (see also sections 3.2.2 and 3.2.3) where data are collected from 12 Vietnamese banks (see Table 7 above) and have been converted into constant prices uses 1994 as base year (in million VND, except for x_3 in persons) using the GDP deflator index.¹³³

3.5.3 Data for DEA models

Our DEA research consists of two models. The first is the MI-DEA model for the examination of productivity changes of the Vietnamese banking sector in the 2003-2010 period, represented by 12 banks that were previously examined using Ratio Analysis and SFA, using bank-level data. The second is the FI-DEA model for the examination of productivity changes of the whole banking system in Vietnam using macro-level data.^{134,135}

As a result, the data set used in these models differs from each other. The MI-DEA model will check the consistency of the Ratio Analysis and SFA model and thus, will use the same variables as in Table 8. The FI-DEA will use macro-level data of the Vietnamese banking sector including the broad money (M2) as output¹³⁶ while number of employees (NE)¹³⁷

¹³³ Data on GDP deflators were extracted from the ADB (2011) where 1994 is chosen as the base year.

¹³⁴ DEA applications using macro-level data has been employed by Moesen and Cherchye (1998), Storrie and Bjurek (2000), Cherchye (2001), Depotis (2005), Cherchye *et al.* (2008), among others.

¹³⁵ In this sense, the Vietnamese banking system is defined as a single DMU which uses financial investments to create banking services for the whole economy. Hence, at the national level, its performance could be measured by comparing the banking services (outputs) with the finance consumed by the banking sector (inputs).

¹³⁶ One could use the demand deposit as output (Hancock, 1985; Berger & Humphrey, 1991; Bauer *et al.*, 1998; Gilbert & Wilson, 1998; among others). However, as demand deposit and broad money are highly correlated, and broad money could indicate the (money) multiplier function of the banking system, it is more appropriate to use M2 as output of our DEA model.

¹³⁷ This figure was collected from several Vietnam Statistical Yearbooks under the term of employed population working in financial, banking, and insurance activities. A survey from the General Statistic of Vietnam (GSO, 2010) showed that during 2000-2008, the banking institutions acquired nearly 90% of the total labour force in the financial sector. Since data for the banking sector alone is unavailable prior to 2000, it is acceptable to use the above figure in the whole 1990-2010 periods.

and time and saving deposits (TD) are treated as inputs (Table 10). The values of M2 and TD are also deflated.

Table 10. Descriptive statistics of variables for FI-DEA model

	NE <i>(thousand people)</i>	TD <i>(billion VND)</i>	M2 <i>(billion VND)</i>
Mean	114.800	243,759.739	562,801.133
Standard Deviation	62.464	398,474.434	775,275.538
Minimum	66.9	2,315	11,358
Maximum	257.110	1,466,950	2,789,184
Number of observations	21 years		
Examined period	1990-2010		

Source: ADB, GSO

3.5.4 Data for the second-stage regressions

As discussed above, except for the FI-DEA study where macroeconomic factors are considered, other studies will test for the conjunction between TYPE and SIZE of the bank with its performance. Table 11 will first present the descriptive information on the two independent variables (TYPE and SIZE) that will be used in all other regression models, followed by eleven independent variables of the FI-DEA study.

Table 11. Descriptive statistics of explanatory variables for second-stage regression

Variable	Mean	Standard Deviation	Minimum	Maximum
<i>Second-stage regression for RA and SFA</i>				
<i>TYPE</i>	0.33	0.47	0.00	1.00
<i>SIZE</i>	17.12	1.92	11.55	20.09
<i>Second-stage regression for DEA</i>				
<i>KA</i>	-1.11	0.49	-1.86	-0.11
<i>BD</i>	-2.19	2.02	-7.23	1.33
<i>TB</i>	-4.92	4.92	-14.70	3.39
<i>CB</i>	-6.51	1.35	-8.55	-2.78
<i>NB</i>	70.24	25.93	9.00	100.00
<i>NS</i>	0.29	0.72	0.00	2.00
<i>BC</i>	76.64	18.16	39.43	95.45
<i>RR</i>	6.81	3.61	1.00	13.00
<i>LI</i>	16.88	8.62	8.80	36.00
<i>RD</i>	1.08	8.80	-15.27	25.87
<i>C0</i>	0.19	0.40	0.00	1.00
<i>CI</i>	0.19	0.40	0.00	1.00

Source: WB, IMF, ADB, SBV, and individual bank's financial reports

3.6 Summary

This chapter explained the methodologies used in this study in order to evaluate the efficiency and performance of the Vietnamese banking system. Ratio analysis was first used to examine the single-dimensional performance of a bank regarding its capital adequacy, asset quality, management ability, earnings ability, liquidity, and sensitivity to market risks. These ratios were later used to construct a performance index measuring the multi-dimensional and overall performance of the bank. This method suggests that ratio analysis could be used to analyze the efficiency and performance at both single- and multi-dimensional perspectives.

Other methods to examine the multi-dimensional efficiency of Vietnamese banks include SFA and DEA which belong to the frontier analysis approach. While SFA is a parametric

method, DEA is a nonparametric one. These methods, in combination with the ratio analysis, will help provide a better image about the efficiency and performance of the banking system in Vietnam under financial liberalization.

This chapter also provides information on the data sets used in the different models and methods in this study. It would be better if more data could be assessed, as the data limitation constrained most of our analysis on the performance of twelve Vietnamese banks in the 2003-2010 period, except for the FI-DEA model.¹³⁸ Results as well as discussions are presented in the next chapter.

¹³⁸ This model used the macro-level data and thus, could be applied for a longer period, from 1990 to 2010.

4 Efficiency and performance of the Vietnamese banking system under financial liberalization

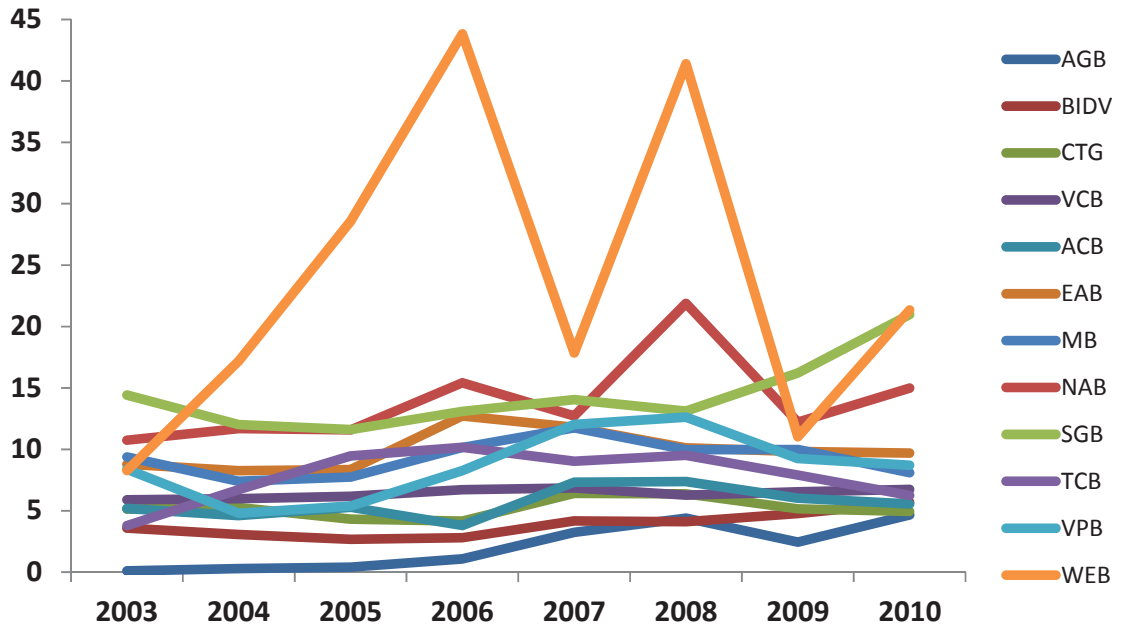
This chapter examines the efficiency and performance of the Vietnamese banking system, as well as its changes, during the financial liberalization process in Vietnam, from 1990 to 2010. It explores the findings relative to what was expected, as discussed in section 1.3 above, using three different approaches of ratio analysis (section 4.1), stochastic frontier analysis (section 4.2), and data envelopment analysis (section 4.3). These findings and discussions are summarized in section 4.4.

4.1 Evaluate the performance of Vietnamese banks using Ratio Analysis

This section provides a multi-stage analysis assessing the performance of Vietnamese banks based on their CAMELS ratios. As discussed in previous chapters, the CAMELS ratios could provide a basic idea on how the Vietnamese banks are performing, regarding their capital adequacy, asset quality, management ability, earnings ability, liquidity, and sensitivity to market risks. We first evaluate their single-dimensional performance in six aspects of the CAMELS system (section 4.1.1) and then combine them into a performance index for evaluating the banks' overall performance (section 4.1.2). The performance index, in this sense, is a multi-dimensional measure. It will then be compared to the Principal Component Analysis' results to check for robustness (section 4.1.3). Determinants of those performances, both single- and multi-dimensional, are detected in section 4.1.4. Section 4.1.5 summarizes.

4.1.1 Single-dimension analysis using CAMELS ratios

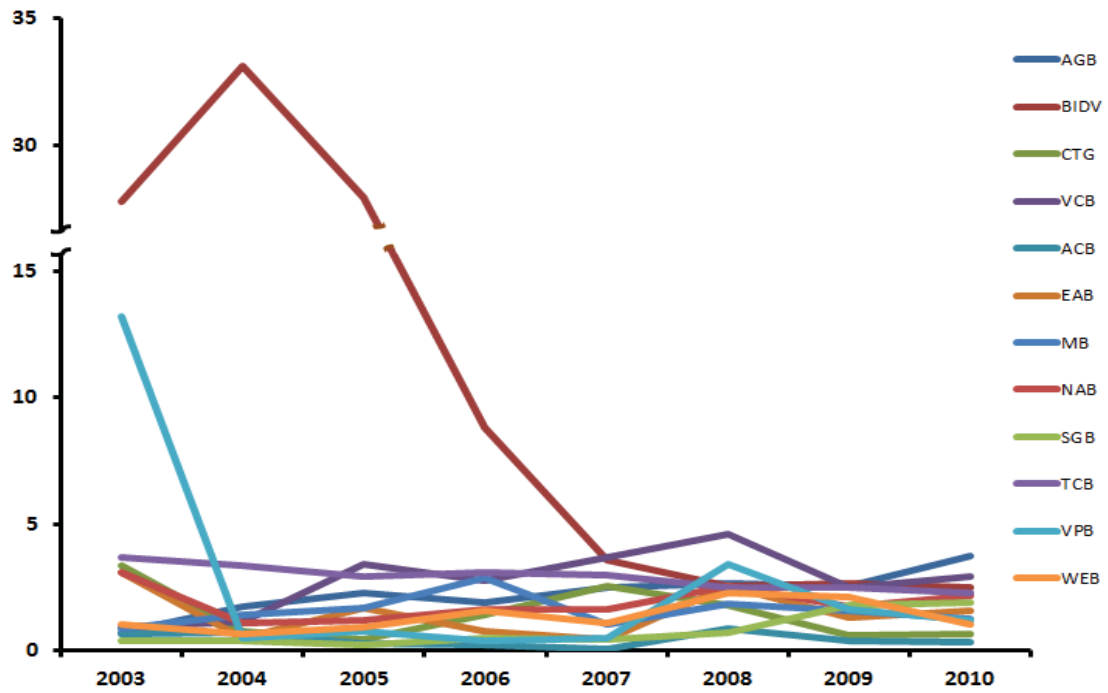
Figure 20. Capital adequacy: EQ ratios



We begin by looking at capital adequacy, and find that the capital bases of Vietnamese banks mainly increased in the latter part of phase II (2003-2006) and then decreased in phase III (2007-2010).¹³⁹ There was an increase in the yearly average value of EQ (from 6.97% in 2003 to 9.80% in 2010), which suggests that the Vietnamese banking system was benefiting from the boom period rather than being affected by the Global Financial Crisis 2007-2008. The SOCBs seemed to have inadequate capital as their average EQ ratios are 2.08%, 3.86%, 5.22%, and 6.40%, respectively for AGB, BIDV, CTG, and VCB. However, they may have back up from the government and thus their performance and health may not be affected. It is confirmed in section 4.1.4 below that big banks tend to have less capital base than small banks; however, the effect of ownership is not significant.

¹³⁹ Small banks such as NAB, VPB, and WEB (with the average assets sizes under 5 trillion VND in the period) are the ones with significant changes in the EQ ratio.

Figure 21. Assets quality: NPLL ratios



In terms of Asset quality, bad loans or nonperforming loans are situated at around 2.80% of total loans for the whole period. BIDV had extremely high NPLL ratios in 2003-2005 (around 27-33%)¹⁴⁰ due to the non-differentiation of policy and commercial loans.¹⁴¹ This ratio sharply decreased after Government-directed loans were left out of nonperforming loans calculation after 2006, but they still accounted for about 2.5% in 2010.¹⁴² For most of the banks examined, their NPLL ratios decreased in recent years, with the JSCBs showing better asset portfolio management than the SOCBs. On average for the period, the SOCBs had NPLL of about 2.5 times higher than the JSCBs (4.08% and 1.64% respectively). A

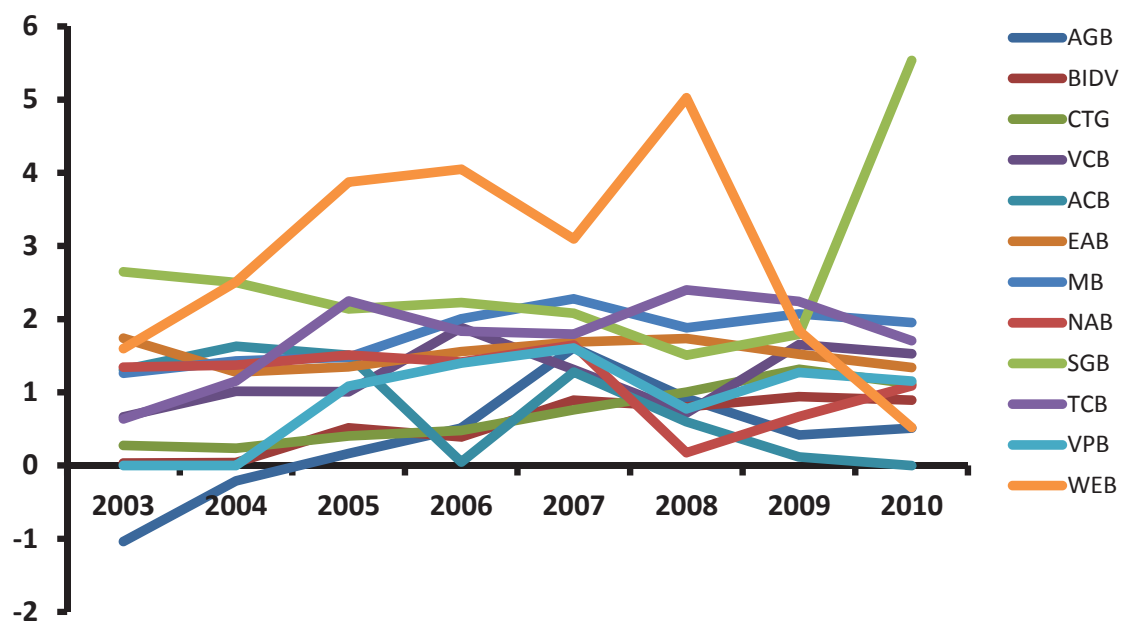
¹⁴⁰ If the NPLL ratios of BIDV in 2003-2005 were excluded, the average NPLL ratio of the remaining eleven banks was at 1.93% only.

¹⁴¹ Results from our regression models suggest that the SOCBs have significantly more nonperforming loans than the JSCBs (see section 4.1.4 below).

¹⁴² BIDV is the SOCB in charge of financing investment and development, mostly in the infrastructure area. Hence, the Government could intervene in its lending policy by appointing some designated borrowers at favourable low interest rates but high risk of default and thus, when policy loans were not separated from commercial loans, the amount of nonperforming loans would be far higher than what they really were.

previous study on the Mexican banking system (1991-1995) also found that NPLL of banks that were government controlled was about three times higher than the non-government controlled ones (González-Hermosillo *et al.*, 1997). Such ownership was also suggested as politicizing the resource allocation process and reducing the efficiency of the banks (La Porta *et al.*, 2002).

Figure 22. Management quality: ROA ratios



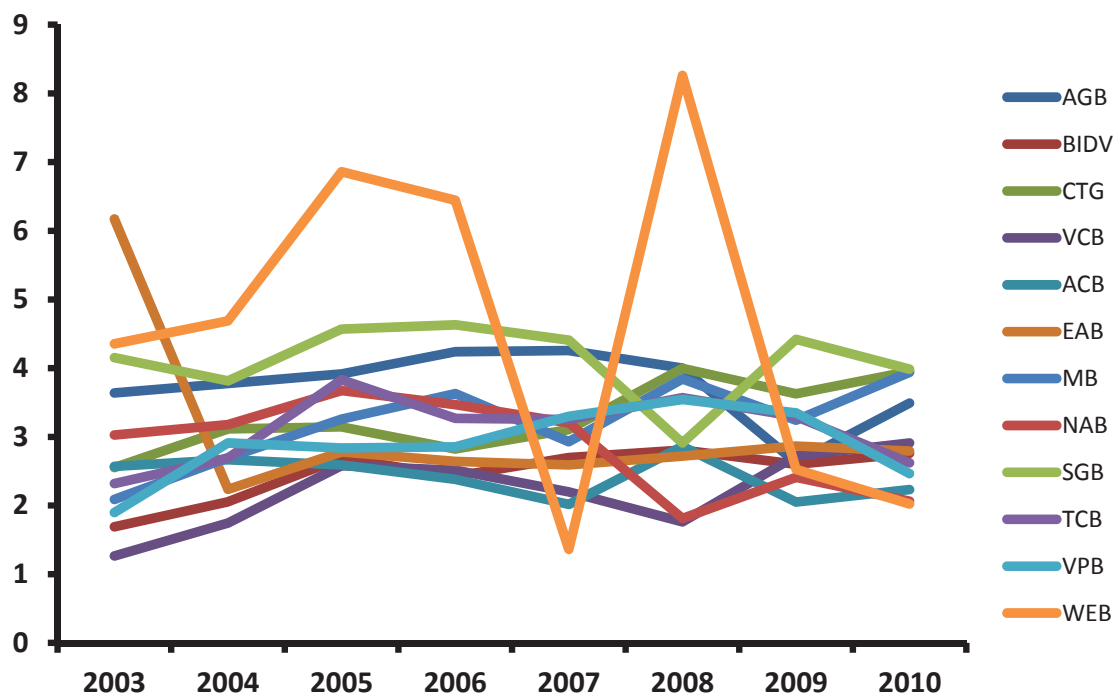
Profits a bank earns also helps reveal the quality of the bank’s management and hence, ROA could be a good proxy for the Management quality evaluation. Except for AGB in 2003-2004, all banks earned positive profits and hence, positive ROA over the period.¹⁴³ SGB and WEB showed the best figures with average ROA of 2.55% and 2.81%;¹⁴⁴

¹⁴³ While the standard requirement for ROA is 1%, the examined Vietnamese banks achieved 1.35% on average for the 2003-2010 periods and around 1.3-1.4% in the last three years. It suggests that banking is still a profitable sector, however, the intensive competition in the market as well as the financial crisis is making it less attractive, compared to other sectors.

¹⁴⁴ A high value of ROA for SGB in 2010 was from an increase in other operating income (more than 33 times that of 2009); while in WEB, a high ROA in 2008 came from interest income (nearly 4 times that of 2007).

however, while SGB showed an impressive improvement in management quality in 2008-2010, the managers from WEB seemed to have difficulties in recent years. Once again, profitability of the SOCBs is much lower than that of the JSCBs (0.71% compare to 1.66% for the whole period), consistent with the argument that in transition economies, government-owned banks are normally less efficient than private-owned banks (Bonin *et al.*, 2005b), especially under the effect of the recent financial crisis (Cornett *et al.*, 2010). Our regression model in section 4.1.4 helps strengthen the argument: it is significant that the SOCBs (which had state ownership and are bigger in size) are associated with lower ROA, consistent with Bonin *et al.* (2005a).

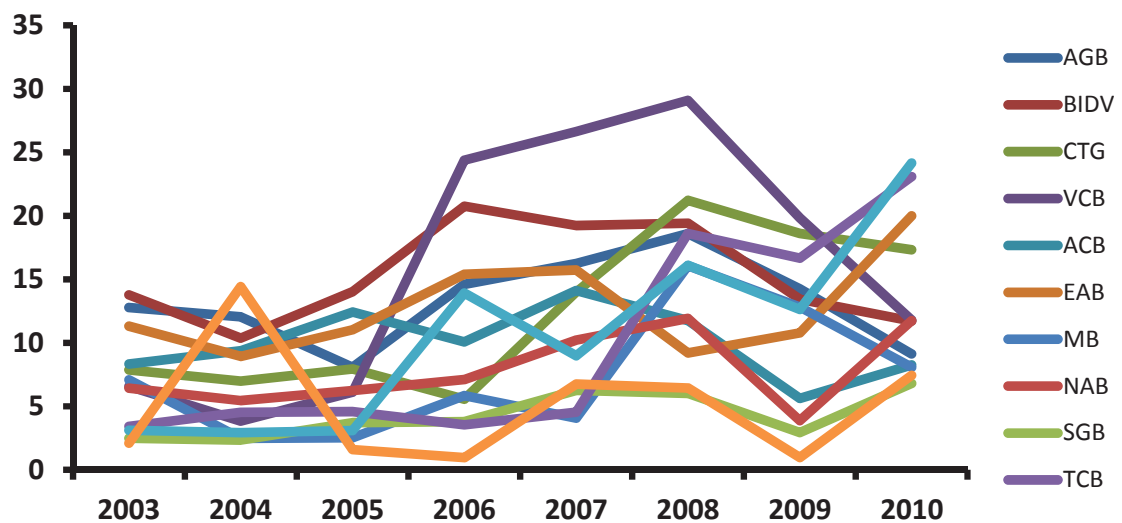
Figure 23. Earnings ability: NIM ratios



The Earnings ability of those Vietnamese banks was represented by NIM ratios. Although the average value of NIM for all banks in the whole period was 3.16%, a decrease in

interest margin was found after 2008,¹⁴⁵ leading to a NIM of 2.94% in 2010. The NIM ranged from the minimum of 1.27 to the maximum of 8.26 suggesting that high risk lending existed in the system (e.g. in 2003, EAB had a high value of net interest income (twice that of 2004) but its (average) total asset was still small; for the case of WEB in 2008, see footnote 144 above). In the last two years (2009-2010), the SOCBs seemed to perform better than the JSCBs in term of interest earnings (their NIM ratios were increasing recently while NIM ratios for the JSCBs were decreasing). However, our regression results in section 4.1.4 find that SOCBs are associated with lower NIM, and bigger banks will earn less than smaller banks, suggesting the situation of decreasing returns to scale in the Vietnamese banking system, consistent with Vu and Turnel (2010).

Figure 24. Liquidity assessment: LIQUID ratios



The Liquidity ratios show whether the liquidity assets of a bank can withstand withdrawals from customers (as a reserve). It is believed that Vietnamese banks increased their liquid asset stocks (as a proportion of total assets) to deal with the liquidity risk, especially in the

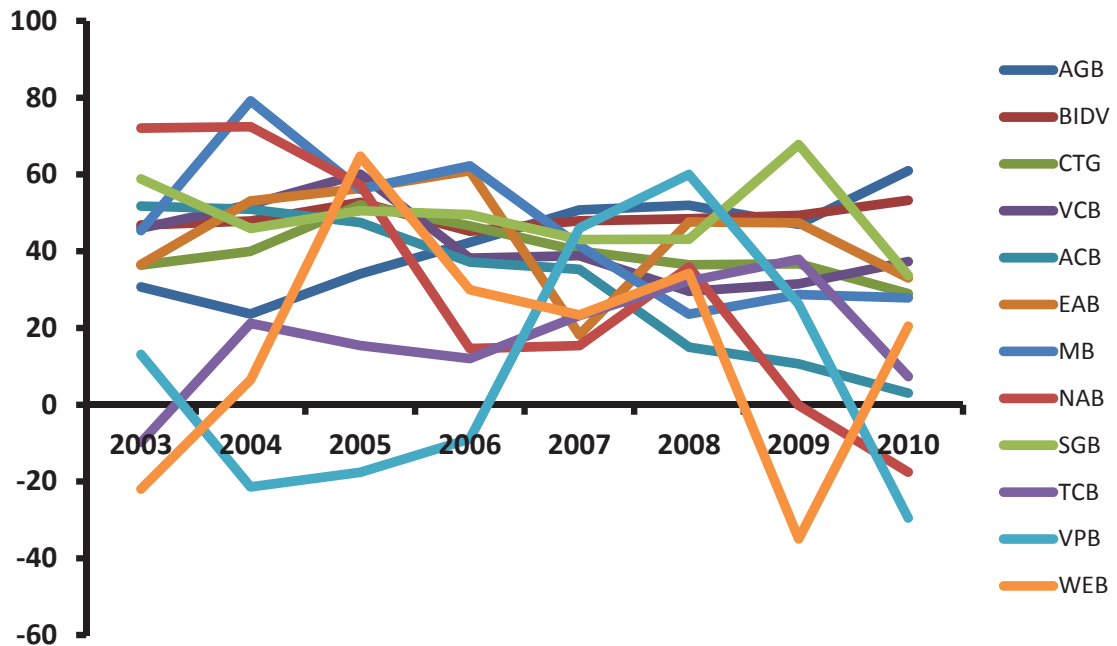
¹⁴⁵ That decrease, however, is not significant as the Mann-Whitney test for the two groups (2003-2008 and 2009-2010) resulted in a z value of 0.795.

face of competition from foreign banks and the effects of the global financial crisis 2007-2008. In fact, the average LIQUID ratio of examined banks increased from 7.11% in 2003 to 13.29% in 2010. Because government bonds account for a large proportion of the SOCBs' assets, it is expected that the SOCBs would have a higher LIQUID ratio than the JSCBs. In fact, the period's average value of LIQUID ratio for the SOCBs was 14.26%, nearly double of the JSCBs, which was 8.49%.¹⁴⁶ The ownership of banks, however, is found to be insignificantly correlated with LIQUID ratios, while bank size is positively associated with LIQUID at 1% level of significance (see Table 16, section 4.1.4 below). Despite that fact, banks with bigger size (including four SOCBs and some JSCBs such as ACB and MB) may have the advantage of "too big to fail" and their LIQUID ratios thus started to decrease towards the end of the period.¹⁴⁷ Hence, it could be a sign of fragility in the banking system that needs to be assessed carefully in the future.

¹⁴⁶ This is consistent with the case of Mexican banks in 1991-1995 (González-Hermosillo *et al.*, 1997).

¹⁴⁷ This bias allowed these banks to acquire more (general) assets, especially in the situation of high competition and restructuring, at a faster speed than the increasing of their liquidity assets.

Figure 25. Sensitivity to market risk: CGAPA ratios



The Sensitivity to market risks is assessed via the CGAPA ratios. The CGAPA is defined as the percentage of the one-year cumulative gap (which is equal to the one-year rate-sensitive assets minus the one-year rate-sensitive liabilities) over the total assets of a bank. Thus, it not only reveals the relationship between rate-sensitive assets and liabilities but also the scale of that exposure.¹⁴⁸ In terms of soundness, a bank is expected to have a small, tactical gap compared to its assets.¹⁴⁹ It was not the case of Vietnamese banks, however, when the average value of CGAPA in the 2003-2010 periods was 34.64%. The CGAPA decreased rapidly in recent years (from its peak of 38.18% in 2008 to 29.01% in 2009 and

¹⁴⁸ Banks with higher exposure proportions to interest-rate fluctuations (higher CGAPA ratios) are expected to have higher probability to participate in the market for interest-rate derivatives (Carter & Sinkey, 1998).

¹⁴⁹ Although a small CGAPA ratio may be related to a lower earning possibility; however, it represents a lower sensitivity to fluctuations of the interest rates and thus, reveals a lower possibility of failure. In order to get an overall assessment on both earning and sensitivity, hence, one should combine CGAPA and NIM, as well as with other ratios used in the literature.

21.58% in 2010), thanks to decreasing interest rates¹⁵⁰ rather than banks' asset and liability management. In fact, all of the examined banks had their Assets/Liabilities Committee or Asset Management Company established since early 2000s to monitor and supervise the bank's assets and liabilities portfolio; however, the available instruments are limited by on-balance sheet adjustments while the off-balance ones are not assessed. According to Nguyen and Nguyen (2013), Vietnamese banks did not have complete internal rating systems (in terms of human resource, technology, knowledge, etc.) to evaluate the risks of off-balance sheet items and thus, off-balance sheet activities were not seriously considered, especially when the derivatives market did not exist. Small and privately owned banks were trying to reduce their sensitivity,¹⁵¹ while the SOCBs continued to have a high level of CGAPA at the end of 2010.

In summary, the Vietnamese banking system developed soundly during the 2003-2010 periods. Overall, the maximization ratios (EQ, ROA and LIQUID), which positively related with performance of Vietnamese banks, were increasing; while the minimization ratios (NPLL and CGAPA) were decreasing. However, the reduction in NIM, especially after 2008, indicated that banking sector earnings were under pressure and thus, this sector may not be as attractive as it was. Additional information on the latter part of the period, i.e. after the global financial crisis 2007-2008, reveals some weaknesses and fragility in the banking system where NPLL started to rise, LIQUID of SOCBs fell but their CGAPA remained high. Thus, evaluation using the performance index may help provide a different view on the Vietnamese banking system.

¹⁵⁰ The SBV started tightening the interest base rates from mid-2008 to deal with effects from the Global Financial Crisis. Later, the interest rates were further reduced incorporating the implementation of the first stimulus package in December 2008 (ADB, 2009a).

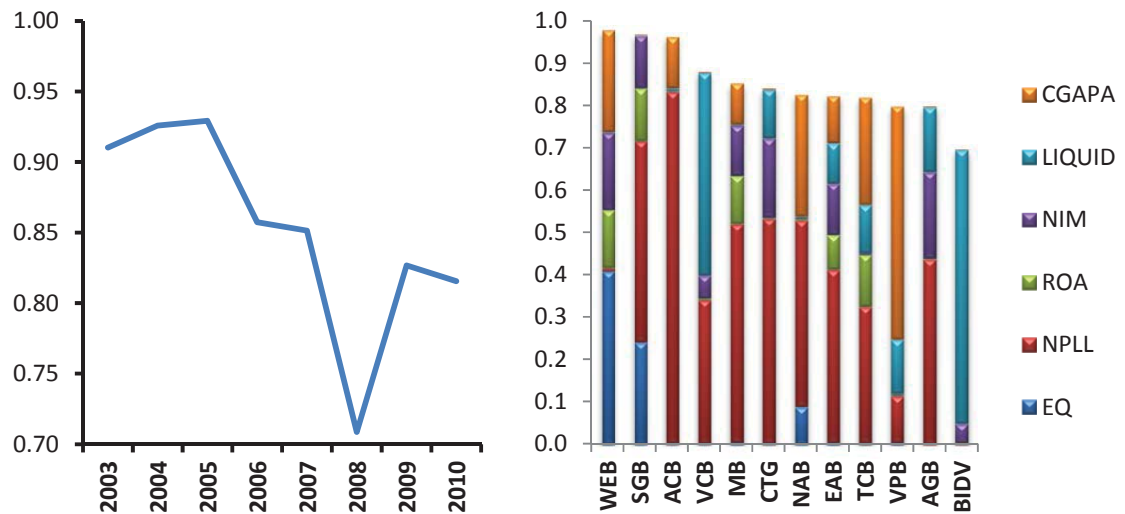
¹⁵¹ Some banks even had negative CGAPA ratios in some years, such as NAB, VPB, and WEB, suggesting that they would have been exposed to interest income losses.

4.1.2 Multi-dimensional analysis: A (overall) performance index

After normalization using the min-max method, the normalized ratios became similar (all run from 0 to 1) and hence, can be used to construct the performance index (PI) using the Solver function in MS Excel, following equation (3) on page 80.

Consistent with previous research (which used DEA or SFA approaches), our result showed that the average performance index of the examined banks was decreasing during the 2003-2010 period (Figure 26, left). For example, Le (2006) found that in 2006, the Vietnamese banking system was quantitatively and qualitatively inadequate; while Nguyen (2012) showed a decreasing in technical efficiency of 20 Vietnamese banks in the 2007-2010 period.

Figure 26. (Average) performance indexes: All banks (left) vs. Individual banks (right)



On average, the PI of Vietnamese banks in the 2003-2010 period is 0.853 points. It was lowest in 2008 at 0.709 points, which supports the expected finding E1 in arguing that performance of the Vietnamese banks was affected by the regional and global financial crises. PI rose back in 2009 but continued to drop in 2010, bringing the overall performance

of the whole banking system to 0.816 points. As 1.000 points refers to the optimal level or the maximum available score, the PI results suggest that the Vietnamese banks performed at about 20% and 15% below their optimal capacity in 2010 and in the 2003-2010 periods, respectively. These figures are very close to that found by Vu and Turnel (2010) or Nguyen (2014) in which they also suggested that Vietnamese banks were about 10% to 25% away from their (cost or profit, respectively) efficient. Among the banks examined, ACB, SGB, and WEB outperformed the others while AGB and BIDV were the worst performers (Figure 26, right). Reasons behind the best performers relate to the fact that ACB and SGB had an advantage in managing their assets (in term of low NPLL ratios) while WEB had the advantage of having a good capital adequacy and management quality (high EQ and ROA ratios). In contrast, the low PI score of AGB came from a high NPLL; while for BIDV, it came from the not-so-high LIQUID ratio.

Since PI is calculated from a dynamic weight system, i.e. the most important variable will be appointed with the highest weight, it also tells the role of each ratio in the overall performance of each bank as well as for the banking system. The ratio with highest frequency of being identified as important in PI calculation, hence, will be assessed as the (comparative) advantage of the Vietnamese banking system. Table 12 shows that during the 2003-2010 periods, quality of the assets (NPLL) played an important role in the overall performance index of the Vietnamese banks¹⁵² while capital adequacy (EQ) and management (ROA) were less important.¹⁵³ Liquidity (LIQUID) and sensitivity to market

¹⁵² It means that banks with better asset quality (or lower NPLL) should be considered as better performers. There is evidence that asset quality, particularly the NPLL ratio, is positively correlated with bank failures (see, for example, Wheelock & Wilson, 2000).

¹⁵³ This is consistent with previous studies where they argued that Vietnam's banking system overall, particularly the SOCBs, were weakly capitalized (FitchRatings, 2010) and their capital adequacy was far below the level that their peers in other Asian countries maintain (OECD, 2013). Another study on

risk (CGAPA) were the second and third important factors with 18 and 16 times of having highest weight respectively. It suggests that, alongside the improvement of asset quality management, those banks should also take care of their asset portfolio (by converting other assets, especially real estates and fixed assets, into liquid assets) as well as the mismatching between assets and liabilities.

Table 12. Frequency of being the important factor

Frequency	EQ	NPLL	ROA	NIM	LIQUID	CGAPA
ACB	0	7	0	0	0	1
AGB	0	4	0	2	2	0
BIDV	0	0	0	1	7	0
CTG	0	5	0	2	1	0
EAB	0	4	1	1	1	1
MB	0	5	1	1	0	1
NAB	1	4	0	0	0	3
SGB	2	4	1	1	0	0
TCB	0	3	1	0	1	3
VCB	0	3	0	1	4	0
VPB	0	1	0	0	2	5
WEB	4	0	1	1	0	2
Total	7	40	5	10	18	16

4.1.3 Robustness check: Principal Component Analysis vs. CAMELS ratios

In order to double-check the results of PI analysis, we also conduct a principal component analysis (PCA) based on 24 financial ratios on our 12 sample banks. They includes the six CAMELS ratios (EQ, NPLL, ROA, NIM, LIQUID, and CGAPA) as well as others such as the capital-asset ratio, equity multiplier, non-performing loans over assets, salaries and benefits over assets, returns over equity, cost-income ratio. The eigenvalues and variances of the computed principal components (PCs) are reported in Table 13.

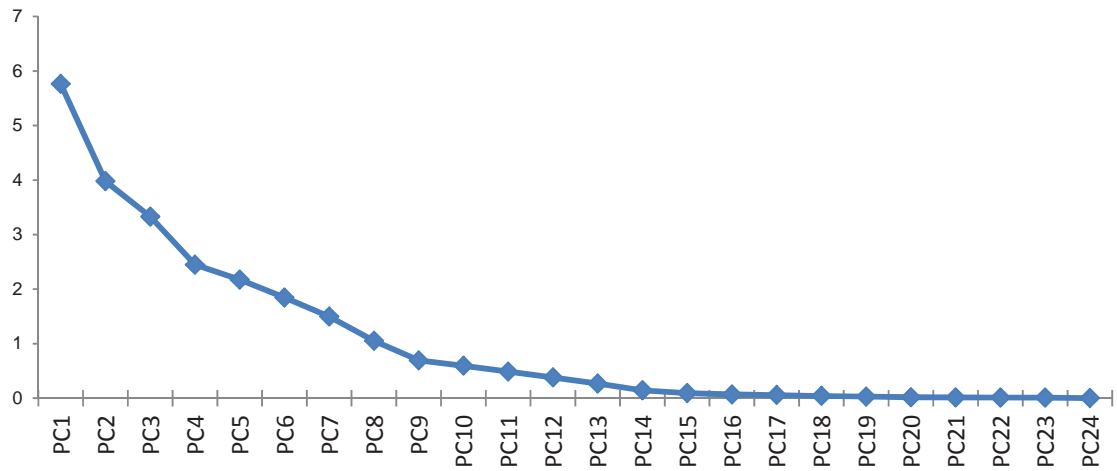
Vietnamese banks from de Waal *et al.* (2009) showed that within five determinants, the management quality only contributed less than 18% of the overall performance.

Table 13. Eigenvalues and variances of the PCs

Principal Component	Eigenvalue	% variance	Cumulative %
PC1	5.765	23.059	23.059
PC2	3.980	15.918	38.978
PC3	3.331	13.323	52.300
PC4	2.448	9.794	62.094
PC5	2.175	8.698	70.792
PC6	1.846	7.383	78.175
PC7	1.497	5.988	84.163
PC8	1.052	4.208	88.371
PC9	0.693	2.774	91.145
PC10	0.595	2.379	93.524
PC11	0.488	1.953	95.477
PC12	0.381	1.525	97.002
PC13	0.267	1.069	98.071
PC14	0.144	0.577	98.649
PC15	0.093	0.370	99.019
PC16	0.066	0.265	99.284
PC17	0.058	0.233	99.517
PC18	0.042	0.167	99.684
PC19	0.029	0.114	99.798
PC20	0.015	0.059	99.858
PC21	0.013	0.052	99.910
PC22	0.011	0.043	99.953
PC23	0.010	0.041	99.994
PC24	0.001	0.006	100.000

In contrast with the CAMELS system where six essential ratios are purposely chosen from those 24 ratios, the PCA approach helped reduce the original 24 ratios into 8 PCs. They were selected to be retained as essential components because: (i) their eigenvalues are greater than one (Guttman, 1954; Kaiser, 1960); (ii) they carry more than 88% (cumulative) information of the original data (Costello, 2009); and (iii) their scree plot shows an “elbow” movement between PC8 and PC9 (Cattell, 1966).

Figure 27. Scree plot of the PCA model



We constructed another performance index (PCA-PI) from these components using an equation similar to (3)¹⁵⁴ and compared it with our result from the CAMELS performance index (PI). Results from these tests (Tables 14 and 15) indicate that there is no significant difference between PCA-PI and PI and thus, suggesting that our analysis based on the CAMELS approach is reliable and consistent with the modern techniques.

Table 14. Comparing PCA-PI and PI

Sample	Frequency	Mean	Variance	Standard deviation	Minimum	Maximum
PCA-PI	96	0.856	0.016	0.127	0.497	0.990
PI	96	0.853	0.024	0.156	0.366	0.997

Table 15. Consistency tests between PCA-PI and PI

Type of tests	Observed values	Critical values	Conclusions
Mann-Whitney	-0.906	1.960	Accept the null hypothesis: There is no difference between the ranks of the two treatments
t-Test	0.126	1.985	Accept the null hypothesis: The difference between the means of the two samples is not significant
Wilcoxon	-0.490	1.960	Accept the null hypothesis: The difference between the samples is not significant

¹⁵⁴ With the CAMELS variables replaced by the 8 PCs.

4.1.4 Determinants of Vietnamese banks' performance

Regarding the characteristics of Vietnamese banks (i.e. assets size and ownership), we ran several regression models to determine the effect of bank's (assets) size and ownership on its performance, following the generalized equation (60). In particular, there are seven regression models as follows:

$$EQ = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (62)$$

$$NPLL = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (63)$$

$$ROA = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (64)$$

$$NIM = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (65)$$

$$LIQUID = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (66)$$

$$CGAPA = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (67)$$

$$PI = \beta_0 + \beta_1 TYPE + \beta_2 SIZE + \beta_3 TYPE * SIZE + \varepsilon \quad (68)$$

The associations between the dependent and explanatory variables are presented below.

Table 16. Regression results

Type of regression		β_0	β_1	β_2	β_3
EQ	OLS	44.1173***	-43.9788	-2.00796***	2.231
		(6.9154)	(37.1204)	(0.4260)	(1.9597)
NPLL	OLS	2.9484	68.84396***	-0.0809	-3.4718***
		(4.1176)	(22.1025)	(0.2537)	(1.1668)
ROA	OLS	4.7358***	-13.45497**	-0.1901***	0.6848**
		(1.1062)	(5.9381)	(0.0681)	(0.3135)
NIM	OLS	8.3845***	-18.5182***	-0.3159***	1.0012***
		(1.2750)	(6.8442)	(0.0785)	(0.3613)
LIQUID	OLS	-19.3492***	-50.0748	1.7234***	2.6671
		(6.5622)	(35.2244)	(0.4043)	(1.8596)
CGAPA	OLS	57.4708**	-44.2173	-1.6798	3.2535
		(28.5326)	(153.1566)	(1.7577)	(8.0855)
PI	Tobit	1.2327***	2.6695***	-0.0218*	-0.1406***
		(0.1827)	(0.9655)	(0.0112)	(0.0509)

Notes: *, ** and *** denote significance at 0.1, 0.05 and 0.001 levels, respectively.

Standard errors are presented within the brackets.

On the single-dimensional aspect, banks with governmental ownership have significantly higher bad loans and thus lower earnings/management quality in comparison with the privately owned banks. Meanwhile, bigger banks tend to have lower capital adequacy, lower management quality and earnings ability; however, their liquidity is improved. The interaction between TYPE and SIZE (via β_3) shows that smaller SOCBs will have lower NPLL but higher ROA and NIM. Overall, taking into account that the SOCBs have governmental ownership and are bigger than the JSCBs in size, one could accept the expected finding E2 (see Section 1.2.3) and conclude that their (single-dimensional) performance was dominated by the JSCBs. Thus, the equitization or privatization of the SOCBs should be speeded up.

In contrast, using the multi-dimensional aspect, we disagree with the above finding in concluding that the SOCBs seem to perform better than the JSCBs. It is arguable that the SOCBs while performing badly in some certain aspects (e.g., NPLL or ROA) could have advantages in some other aspects (e.g., LIQUID or CGAPA) and these affects may cancel out each other under a multi-dimension evaluation. Notice that similar findings were found in China (Du & Girma, 2011), Russia (Karas *et al.*, 2010), as well as in Vietnam - for different data sets (Vu & Turnel, 2010; Nguyen *et al.*, 2014). Therefore, there is a need for care when examining performance or efficiency through different approaches. In contrast, asset size tends to have a negative impact on the PI, although that effect is small. It suggests that smaller banks perform better than big banks, and thus, asset size control should be considered.

4.1.5 Summary

This section examines the current situation and performance of 12 Vietnamese banks for the period 2003-2010 using ratio analysis, a traditional but important method in banking and finance performance evaluation. Ratios are selected following the six categories of the CAMELS rating system, namely the Capital adequacy, Assets quality, Management quality, Earnings ability, Liquidity, and Sensitivity to market risks. Our finding suggests that during the 2003-2010 periods, the Vietnamese banking sector was soundly developed with an increasing capital base, management quality and liquidity, while bad loans and mismatch gaps were decreased. However, their overall performance was on a decreasing trend, in which the SOCBs were the worst performers. After the Global Financial Crisis 2007-2008, the system started to show some fragility (bad loans started to rise, liquidity of SOCBs fell but their mismatch remained high, etc.) suggesting that more monitoring and provisions are needed. In addition, the equitization (or privatization) of the SOCBs should be speeded up and assets size control should be taken into account in order to improve the performance of Vietnamese banks.

Although the examined period does not cover the whole financial liberalization process in Vietnam, according to (Figure 26, left), one can see that the PI was on an increasing trend in the later part of phase II of the Vietnamese banking development (2003-2004). The decreasing of PI in 2006-2008 could be related to the inner “boom and bust” of the country’s securities market in 2006 and the outer global financial crisis in 2007-2008. It is consistent with our expected finding E1 (Section 1.2.3) that performance of Vietnamese banks was increasing in phase II and early phase III, but it was then decreased around the

critical times of 2006 and 2008. Analysis covering a longer period will be presented in section 4.3.2 below.

Another expected finding, E2, was also examined. It was significant that the SOCBs were less efficient than the JSCBs in terms of single-dimensional performance; however, that relation was inversed with the overall performance index. One could argue that the SOCBs may perform badly in some certain aspects (e.g., NPLL or ROA) but they still have advantages in some other aspects (e.g., LIQUID or CGAPA) and these affects may cancel out each other under a multi-dimension evaluation. Therefore, there is a need for care when examining performance or efficiency through different approaches.

4.2 Evaluate the performance of Vietnamese banks using (Cost) Stochastic Frontier Analysis

In this section, we first analyze the cost frontier (section 4.2.1), the relevant cost efficiency of the sample banks (section 4.2.2), the scale economies issue (section 4.2.3), the technical progress (section 4.2.4), and the total factor productivity (TFP) change of Vietnamese banks in the 2003-2010 period (section 4.2.5). Determinants of these measures are tested in section 4.2.6 Section 4.2.7 presents a test for the hypothesis that the translog functional form is more appropriate than the original Cobb-Douglas one as well as the robustness test for the consistency of our SFA models with the relevant DEA models. The summary is given in section 4.2.7.

4.2.1 Cost frontier analysis

Technically, the parameters of the cost function (see equation (27), page 88) were estimated using a maximum-likelihood method using the command *-sfpanel-* (Belotti *et al.*, 2012) in the software STATA version 12 (StataCorp, 2011). This command allows the estimation of

the cost frontier in equation (27) following various approaches (for more details, see Belotti *et al.*, 2012), of which the popular approach of Battese and Coelli (1992) is employed in this section. We choose the actual cost as the dependent variable of our research,¹⁵⁵ whereas the total cost will be use as a robustness test in section 4.2.7 below.

Table 17. Estimated results of the SFA cost function

Variable	Parameter	Coeff.	S.E.	p-value	Variable	Parameter	Coeff.	S.E.	p-value
Intercept	α_0	-14.182	2.154	0.000	lny₂lny₂	β_{22}	0.101	0.050	0.045
lnw₁	α_1	-1.797	0.651	0.006	lnw₁lny₁	γ_{11}	0.241	0.087	0.006
lnw_{2a}	α_2	-0.901	0.398	0.024	lnw₁lny₂	γ_{12}	-0.241	0.087	0.006
lnw₃	α_3	3.698	0.657	0.000	lnw_{2a}lny₁	γ_{21}	0.029	0.040	0.461
lnw₁lnw₁	α_{11}	-0.294	0.107	0.006	lnw_{2a}lny₂	γ_{22}	-0.029	0.040	0.461
lnw₁lnw_{2a}	α_{12}	-0.126	0.053	0.017	lnw₃lny₁	γ_{31}	0.065	0.096	0.500
lnw₁lnw₃	α_{13}	0.420	0.092	0.000	lnw₃lny₂	γ_{32}	-0.065	0.096	0.500
lnw_{2a}lnw_{2a}	α_{22}	-0.064	0.064	0.316	t	ω_t	-0.201	0.140	0.150
lnw_{2a}lnw₃	α_{23}	0.190	0.081	0.019	t²	ω_{tt}	0.001	0.007	0.916
lnw₃lnw₃	α_{33}	-0.610	0.117	0.000	tlnw₁	ω_1	-0.048	0.023	0.038
lny₁	β_1	1.905	0.337	0.000	tlnw_{2a}	ω_2	-0.027	0.020	0.168
lny₂	β_2	-0.514	0.318	0.107	tlnw₃	ω_3	0.075	0.027	0.005
lny₁lny₁	β_{11}	0.034	0.053	0.522	tlny₁	φ_1	0.011	0.014	0.434
lny₁lny₂	β_{12}	-0.079	0.046	0.086	tlny₂	φ_2	-0.023	0.014	0.106

Coeff.: Coefficient; *S.E.:* Standard Errors.

Table 17 shows the significance of several parameters incorporating inputs' prices, value of outputs, and the interactions between some input prices and output quantities. Although not reported in this table, we observed that γ equals to 0.992 while its inversed logit value equals to 4.893 (with z-value and p-value are 4.260 and 0.000, respectively). It confirms the presence of inefficiency in the cost function as well as the necessity to adopt a frontier

¹⁵⁵ This is popularly used in the literature (e.g. Ferrier & Lovell, 1990; Sturm & Williams, 2004). See more discussions in section 3.5.2 above.

method to estimate the cost function. Accordingly, several interpretations could be made as follow.

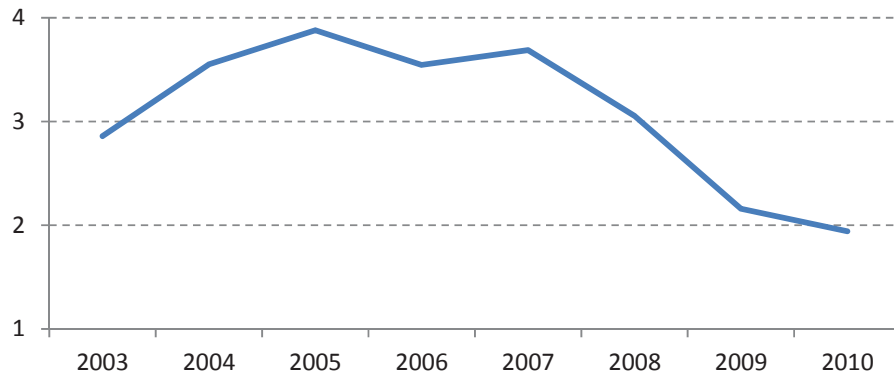
First, it suggests an increasing price of labour ($\ln w_3$), suggesting the bank is employing a higher quality workforce, which should result in an increase in the bank's actual costs. This is consistent with the recent finding from KPMG Vietnam (2013), and PricewaterhouseCoopers (2013, p. 5), among others. In contrast, when prices of deposits ($\ln w_1$) or capital ($\ln w_{2a}$) increased, it could reduce the fixed assets purchasing as well as limit the deposits expansion. As a result, these behaviours could help decrease the actual costs of the bank; however, at an impact smaller than that from an increasing labour price.

Second, the more the banks are lending ($\ln y_l$),¹⁵⁶ the higher costs they would have to bear, since banks now have to manage a bigger loan portfolio. In addition, if one takes into account the competition in term deposit rates in Vietnam,¹⁵⁷ one should notice that the net interest spreads of Vietnamese banks was decreasing. This is also consistent with finding using NIM ratio as in section 4.1.1 above.

¹⁵⁶ The examined loans in this study are performing loans only (see Table 9). The nonperforming loans problem, however, is another issue which should be controlled and monitored carefully (ADB, 2013; Business Monitor International, 2013).

¹⁵⁷ There was a race to attract savers via the term deposit rates from 2008 (Sacombank Securities, 2008; VietCapital Securities, 2008) where the rates stayed at around 14-16% per annum, until the SBV set the cap of 8% at the end of 2012 (Vietcombank Securities, 2013).

Figure 28. Lending-Deposit spreads in Vietnam (%)



Source: World Bank (2013)

This competitive pressure led to costs management inefficiency of Vietnamese banks since the benefits (incomes from performing loans) could grow slower than the costs (interest payments for deposits). On the contrary, more investments on other types of assets ($\ln y_2$) will help reduce the costs while increasing the aggregated output (and incomes) for banks, although the coefficient of investment is only significant at 11%. This type of economies of scope is often observed in the banking industry, for example, Vander Venet (2002) argued that universal banks are more (profit and) cost efficient than non-universal ones. We will examine the scale economies issue in section 4.2.3.

Third, deposits (and their price) play an important role in the Vietnamese banking system, as the interaction between deposits and other variables (e.g. capital, labour, loans, investments) are all statistically significant. It suggests that the costs of Vietnamese banks in general were strongly driven by the interest payments. This finding is consistent with

Ngo and Tripe (2010) where they argued that Vietnamese banks were using too many resources in paying interest to customers.¹⁵⁸

4.2.2 Cost efficiency analysis

Cost efficiency (CE) for each bank in each year is obtained using equation (29). Table 18 shows the yearly mean cost efficiencies of the Vietnamese banking system and of the SOCBs and JSCBs.

Table 18. Cost X-efficiency by type of banks

Average CE	2003	2004	2005	2006	2007	2008	2009	2010	2003-2010
All banks	0.939	0.938	0.936	0.935	0.934	0.933	0.931	0.930	0.934
SOCBs	0.967	0.966	0.965	0.964	0.964	0.963	0.962	0.961	0.964
JSCBs	0.925	0.924	0.922	0.921	0.919	0.917	0.916	0.914	0.920
Gaps	0.042	0.042	0.043	0.044	0.045	0.045	0.046	0.047	0.044

Testing for the difference between SOCBs and JSCBs		
Hypothesis	t-test	Mann-Whitney U-test
H_0 : SOCBs performed better than JSCBs	mean (I) \geq mean (II)	ranks (I) \geq ranks (II)
H_1 : SOCBs were less efficient than JSCBs	mean (I) $<$ mean (II)	ranks (I) $<$ ranks (II)
Critical value ($\alpha=0.01$, $df=65$)	-2.381	2.326
Observed value	2.380	-1.003
p-value	0.990	0.842
Decision	Do not reject H_0	Do not reject H_0

Note: Gaps measure the differences between SOCBs and JSCBs,
df: Degree of freedom.

From Table 18, it seems that the SOCBs were better than the JSCBs in managing their actual costs. The (cost efficiency) gaps between them were small and slightly increase over time, suggest that the SOCBs were still ahead of the JSCBs in term of cost management. Both the student t-test (mean comparison) and Mann-Whitney's U-test (ranks comparison) are statistically significant, strengthening the argument that the SOCBs performed better

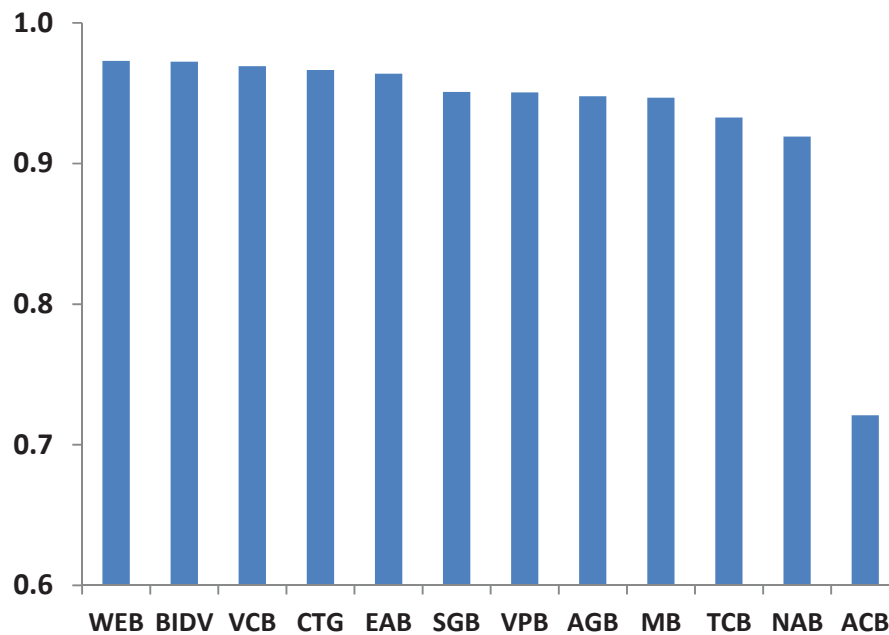
¹⁵⁸ Ngo and Tripe (2010) applied an input-oriented DEA model on data of Vietnamese banks in 2008 and found that, in order to improve these banks' efficiency, the required reduction in interest payments was far higher than that of wages and other expenses.

than the JSCBs.¹⁵⁹ This conclusion is in line with our finding using the performance index PI (section 4.1.2 above) as well as the literature on banking systems in developing countries (Karas *et al.*, 2010; Du & Girma, 2011; Nguyen *et al.*, 2014).

The average cost efficiency of the whole sector in the 2003-2010 period was 0.934, which is also the cost efficiency of the average bank, suggesting that the average bank should reduce its cost by 6.6% to reach the cost frontier. This measure is close to the result of Nguyen *et al.* (2014) where the average cost efficiency of Vietnamese banks in 2003-2010 and in 1995-2011 were 0.93 and 0.90, respectively. It also suggests that the Vietnamese banking sector performed as well as the Japanese's (in the 1993-1996 period, according to Altunbas *et al.*, 2000) and slightly better than the Chinese's (Ariff & Can, 2008; Du & Girma, 2011) and other transition economies (Fries & Taci, 2005). We conclude that although the Vietnamese banking system seems to be performing well, there are rooms for it to improve. Details are presented in the following sections.

¹⁵⁹ Previously, Vu and Turnel (2010) also found that the (mean) cost efficiency of the SOCBs was slightly higher than that of the JSCBs as well as for the foreign banks; however, these differences were not statistically significant. Our result covers a longer examination period and thus, may differ.

Figure 29. Cost efficiency of individual banks (2003-2010)



A closer look at individual bank (Figure 29) also shows that the three SOCBs (BIDV, VCB, and CTG) are among the best performers, while the bottom ones include TCB, NAB, and ACB (JSCBs). During the 2003-2010 periods, ACB was found to be the worst performer with the lowest average cost efficiency of 0.721. This is interesting as ACB is currently a problematic bank in Vietnam,¹⁶⁰ and therefore, this finding suggests a predictive ability for our model.

4.2.3 Economies of scale in the Vietnamese banking sector

As discussed previously, the scale economies measure (EOS) will help define the bank that was advantaged or disadvantaged from its scale during the 2003-2010 periods. According to Table 19, it seems that the SOCBs were driven by economies of scale while the situation was strong but not that much for the JSCBs: the proportion of $EOS > 1$ cases for JSCBs was

¹⁶⁰ In 2012, several executives of ACB were arrested and charged with “illegal business activities” which involved “deliberate wrongdoing causing serious consequences” and fraud (Business Monitor International, 2013, p. 41). Although this may be more of a political conflict, the economic base still exists.

around 78%.¹⁶¹ This difference between the scale economies of SOCBs and JSCBs is significant, according to a Mann-Whitney test, with the two-tailed p-value of less than 0.0001. Overall, during the examined period, there were 82 bank-year observations (85.42% of the whole sample) with economies of scale situation (EOS>1),¹⁶² which resulted in the average scale economies of 1.079. It suggests that these banks were operating below their optimal scale and thus, on average, by increasing the actual costs, they could increase their aggregated output.

Table 19. Economies of scale (EOS) estimates based on cost minimization,

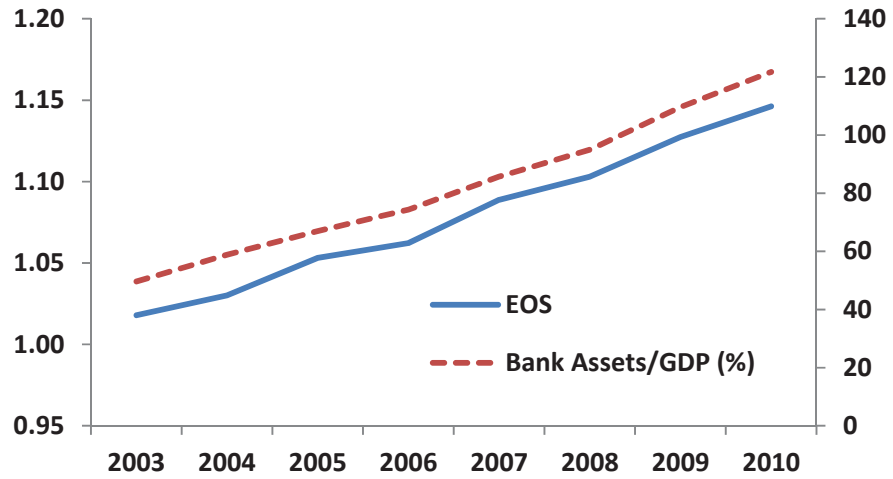
	Observation	Mean	Standard Deviation	Minimum	Maximum	Number of observations with EOS>1
SOCBs	32	1.138	0.051	1.046	1.247	32 (100%)
JSCBs	64	1.049	0.053	0.954	1.161	50 (78%)
All banks	96	1.079	0.067	0.954	1.247	82 (85%)
Mann-Whitney U-test				Critical value		-2.576
$H_0: ranks(SOCBs) = ranks(JSCBs)$				Observed value		-6.039
$H_1: ranks(SOCBs) \neq ranks(JSCBs)$				p-value		<0.001
				Decision		Reject H_0

The above finding is consistent with the literature, for example, the case of the Chinese banking system in the 1995-2001 period (for more details, see Du & Girma, 2011). One should notice that although the actual costs of the SOCBs are higher, since they dominate the Vietnamese banking sector and have a higher market share, it could bring their average costs down as their size increases. Consequently, it helps explain the expansion trend of Vietnamese banks in the recent decade. In particular, since the Vietnamese banks were having an advantage of economies of scale, it was justified for them to continuously increase their assets (see Figure 30 below).

¹⁶¹ This effect is smaller in our DEA model, where the proportion of IRTS cases in JSCBs was only about 53%.

¹⁶² On a bigger sample (but shorter period), Vu and Turnel (2010) found that increasing returns to scale occurred in 67.3% of the Vietnamese examined banks.

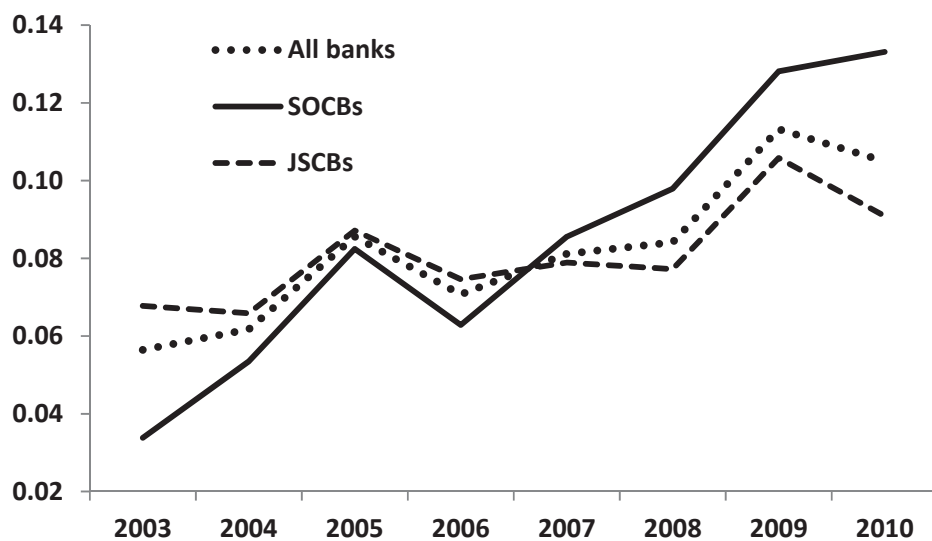
Figure 30. Yearly-averaged economies of scale (left axis) and the expansion of the banking sector (right axis)



4.2.4 Technical progress

We measure the technical change as the partial derivative of the estimated cost function with respect to time trend, as in equation (31) on page 90. The calculated figures will measure not only the pure effect of technical change (due to time variable) but also the technical change associated with change in outputs and input prices.

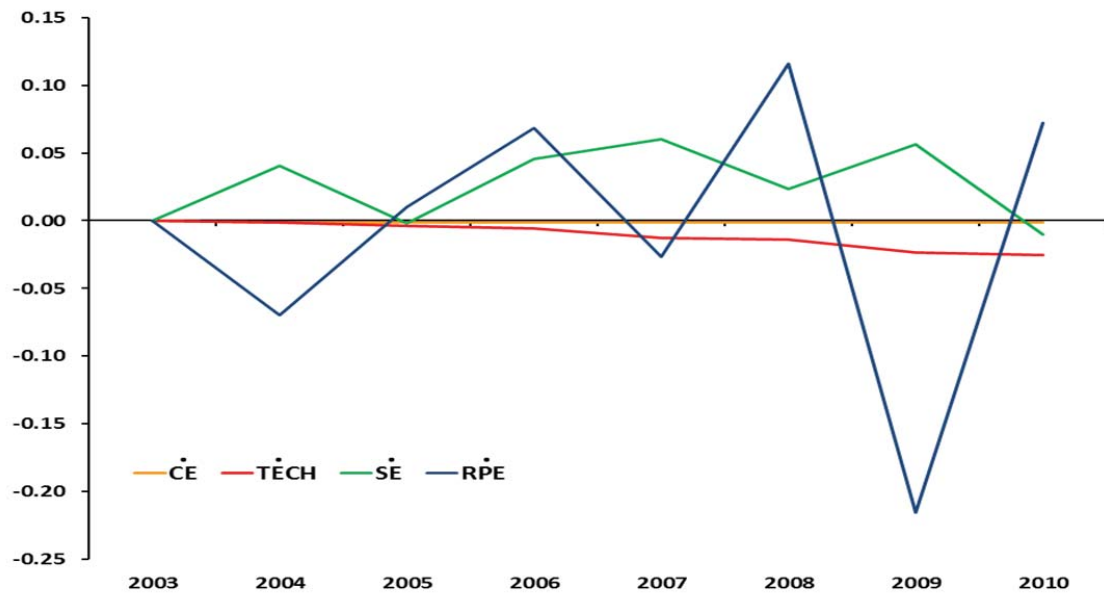
Figure 31. Technical progress (TECH) of Vietnamese banks



Among the 96 bank-year observations, there was only one case with technical progress smaller than zero, indicating that technical progress would help reduce costs for the bank (VPB in 2004). In all other cases, the positive value of TECH shows that during 2003-2010, the more the Vietnamese banks (invest to) improve their technology, the higher costs they could face. It is reasonable since technology in banking (e.g., core banking or information technology) requires a thorough change/upgrade in all the bank's branches and offices, which involves a huge amount of cost.¹⁶³ Generally, the technical progress seems to increase banks' costs by around 8.2% per year. However, the increase in costs due to technical progress of the SOCBs seems to be higher than that of the JSCBs, maybe because their scale and scope were bigger (and thus, technical investments would be higher).

4.2.5 TFP growth in terms of cost efficiency

Figure 32. Components of TFP growth in the Vietnamese banking system



¹⁶³ For example, the Asian Banker (2006) reported that from 2004 to 2007, Asian banks increased their spending on core banking systems and services from around U.S.\$730 million to U.S.\$900 million (estimated).

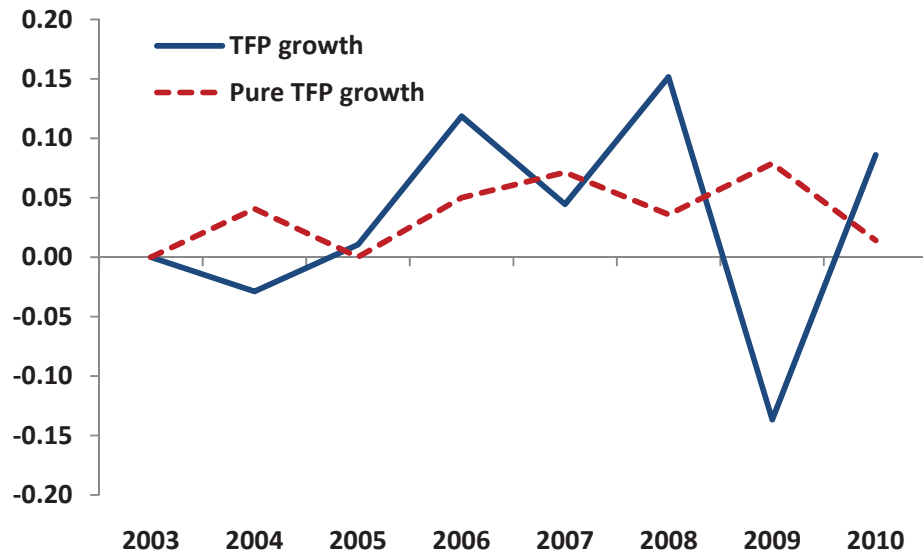
We measure the TFP growth in the Vietnamese banking system during the 2003-2010 period with respect to the cost function. The decomposition of TFP growth into cost efficiency change (\dot{CE}), technical change (\dot{TECH}), scale efficiency change (\dot{SE}), and residual price effect (RPE) helps us define the contribution of each component in the total productivity of Vietnamese banks. As shown in Figure 32, cost efficiency did not change much during the examined period (in fact, cost efficiency change slightly decreased) and thus, had minor effect on the TFP growth. Similarly, the technical change effect on TFP growth was also small, although it was on a decreasing trend.

Since our TFP growth is estimated from the observed data on output and input quantities (as well as the corresponding input prices), in term of cost efficiency, it could be biased as the allocation of inputs (or allocative efficiency) is not measured. This bias was accounted by RPE, which is highly variable, especially after 2006, suggesting the deviations of actual input cost shares from efficient input cost shares increased recently. This may relate to the effects of instability in the banking sector in Vietnam, after the “boom and bust” of the securities market in 2006 and the global financial crisis in 2007-2008 (Ngo, 2012).

Bauer (1990) suggested that one should also examine the pure TFP growth, *i.e.* without the RPE term.¹⁶⁴ It is obvious that pure TFP growth will not fluctuate as much as the original one, where (pure) TFP growing effect is small (maximum value is 7.9% in 2009) with the average growth rate of around 3.6% per annum (Figure 33). Note that in Figure 33, the shape of the pure TFP growth is similar to that of scale efficiency change, in line with our previous findings.

¹⁶⁴ Lovell and Grifell-Tatje (1999), among others, employed the parametric distance function approach to decompose the TFP change. Here, we use the derivative-based technique and thus, follow Bauer (1990) and Kumbhakar and Lovell (2003).

Figure 33. TFP growths of Vietnamese banks (2003-2010)



4.2.6 Determinants of cost efficiency

As discussed previously, variety in cost efficiency (as well as its components) might be affected from the characteristics of the Vietnamese banks during the 2003-2010 periods. We employ the Battese and Coelli (1995)'s model in terms of incorporating these factors (i.e. type of ownership and size of assets) directly into the cost frontier analysis.

Table 20. Estimated results of the SFA cost function with environmental factors

Variables	Parameters	Coeff.	S.E.	p-value
Intercept	α_0	-10.132	2.604	0.000
$\ln w_1$	α_1	-1.426	0.543	0.009
$\ln w_{2a}$	α_2	-0.663	0.350	0.058
$\ln w_3$	α_3	3.089	0.565	0.000
$\ln w_1 \ln w_1$	α_{11}	-0.204	0.087	0.018
$\ln w_1 \ln w_{2a}$	α_{12}	-0.130	0.047	0.006
$\ln w_1 \ln w_3$	α_{13}	0.334	0.076	0.000
$\ln w_{2a} \ln w_{2a}$	α_{22}	0.003	0.064	0.960
$\ln w_{2a} \ln w_3$	α_{23}	0.127	0.073	0.084
$\ln w_3 \ln w_3$	α_{33}	-0.461	0.101	0.000
$\ln y_1$	β_1	1.663	0.400	0.000
$\ln y_2$	β_2	-0.682	0.298	0.022
$\ln y_1 \ln y_1$	β_{11}	0.057	0.052	0.278
$\ln y_1 \ln y_2$	β_{12}	-0.054	0.051	0.285
$\ln y_2 \ln y_2$	β_{22}	0.055	0.056	0.327
$\ln w_1 \ln y_1$	γ_{11}	0.255	0.092	0.005
$\ln w_1 \ln y_2$	γ_{12}	-0.255	0.092	0.005
$\ln w_{2a} \ln y_1$	γ_{21}	-0.004	0.044	0.922
$\ln w_{2a} \ln y_2$	γ_{22}	0.004	0.044	0.922
$\ln w_3 \ln y_1$	γ_{31}	-0.068	0.080	0.399
$\ln w_3 \ln y_2$	γ_{32}	0.068	0.080	0.399
t	ω_t	-0.095	0.112	0.397
t^2	ω_{tt}	0.004	0.007	0.546
$\hat{\Delta} \ln w_1$	ω_1	-0.025	0.019	0.184
$\hat{\Delta} \ln w_{2a}$	ω_2	-0.020	0.018	0.262
$\hat{\Delta} \ln w_3$	ω_3	0.045	0.022	0.044
$\hat{\Delta} \ln y_1$	φ_1	0.019	0.012	0.111
$\hat{\Delta} \ln y_2$	φ_2	-0.029	0.013	0.025
TYPE	δ_1	-1.320	1.163	0.256
SIZE	δ_2	0.010	0.007	0.150
Sigma_u	σ_u	0.180	0.044	0.000
Sigma_v	σ_v	0.068	0.012	0.000
Lambda	λ	2.659	0.047	0.000
Number of observations		97		
Degree of freedom		65		
Log-likelihood		67.939		

Since λ is statistically different from zero, we conclude that the difference between the observed and the frontier is dominated by technical inefficiency (Schmidt & Lin, 1984), i.e.

this model could also provide insightful information on the cost inefficiency of Vietnamese banks.

On the other hand, the differences between cost efficiency derived from the basic model, i.e. following Battese and Coelli (1992), and the bank's characteristics model, i.e. following Battese and Coelli (1995), shows the role of these environmental factors. For example, if a certain bank obtains difference cost efficiency scores in the two models, it means that its cost efficiency is affected by the environmental factors. In contrast, if the scores did not change between the two models, it means that the cost efficiency was driven not by the environmental variables but by "pure" cost efficiency. Using the nonparametric Mann-Whitney tests for ranking comparison between cost efficiency scores of the two models, we observed that after the bank's characteristics are considered, the scores statistically decrease by about 7 percentage points, from 0.934 to 0.865 on average for all banks. Although the scores for SOCBs seems to be higher after bank's characteristics were incorporated (Table 21), we statistically could not reject the null hypothesis that the ranks of SOCBs without bank-characteristics are higher than that with the bank-characteristics in the 2003-2010 period. Similarities apply for the cases of comparison between JSCBs and all banks, before and after the characteristics incorporation. It suggests that when these characteristics (state-ownership and size) are considered, they tend to lower the cost efficiency of Vietnamese banks.

Table 21. Comparing the differences between cost efficiency from two models

Year	CE basic			CE with bank's characteristics		
	SOCBs (Ia)	JSCBs (IIa)	All banks (IIIa)	SOCBs (Ib)	JSCBs (IIb)	All banks (IIIb)
2003	0.967	0.925	0.939	0.975	0.816	0.869
2004	0.966	0.924	0.938	0.973	0.811	0.865
2005	0.965	0.922	0.936	0.965	0.788	0.847
2006	0.964	0.921	0.935	0.980	0.838	0.886
2007	0.964	0.919	0.934	0.979	0.857	0.898
2008	0.963	0.917	0.933	0.967	0.723	0.804
2009	0.962	0.916	0.931	0.975	0.841	0.885
2010	0.961	0.914	0.930	0.974	0.811	0.865
Mean	0.964	0.920	0.934	0.974	0.811	0.865

Mann-Whitney U-tests		
Test 1	Critical value	2.326
$H_0: rank(Ia) > rank(Ib)$	Observed value	-3.974
$H_1: rank(Ia) < rank(Ib)$	Decision	Do not reject H_0
Test 2	Critical value	2.326
$H_0: ranks(IIa) > ranks(IIb)$	Observed value	-6.715
$H_1: ranks(IIa) < ranks(IIb)$	Decision	Do not reject H_0
Test 3	Critical value	2.326
$H_0: ranks(IIIa) > ranks(IIIb)$	Observed value	-3.117
$H_1: ranks(IIIa) < ranks(IIIb)$	Decision	Do not reject H_0

4.2.7 Robustness tests of the SFA models

As discussed above, our SFA models need to justify several tests. Regarding the specification, the translog functional form should provide better goodness-of-fit compared to the original Cobb-Douglas functional form. Regarding robustness, results from SFA models should be consistent with results from the nonparametric models, i.e. the data envelopment analysis.

The former issue was done via a likelihood-ratio test, in which we compared the parameters of the translog and Cobb-Douglas models under the null hypothesis that including the translog variables has no effect on the analyzed model. We obtained a χ^2 of 38.42 and a significance level of 0.0002, suggesting that the Cobb-Douglas form is nested in the

translog form and thus, the translog function could provide more information about the sample and is a better choice.

Meanwhile, the latter issue was assessed by checking the Spearman's rank correlation between efficiency estimates of the SFA models and between SFA models and DEA models.¹⁶⁵ We estimated four DEA models (DEA1, DEA2, DEA3, and DEA4) and two SFA models (SFA_AC and SFA_TC) to measure the normal DEA, cost DEA, and cost SFA situations. Notice that the SFA_AC model is the one that was applied in our previous sections, from section 4.2.1 to section 4.2.6 above. We employ the variable returns to scale (VRS) condition in all four DEA models to measure efficiencies under technical change, in order to make them comparable with results from the SFA models. Similarly, we applied the input-oriented condition in the normal DEA models (DEA1 and 2) for the same reason. Explanations of these models were as below (see section 3.5.2, in particular Table 9 for more details).

¹⁶⁵ This technique was suggested by Bauer *et al.* (1998) for consistency testing between frontier efficiency methods, except that they (i) examined 683 U.S commercial banks over 12 years: 1977 to 1988; (ii) they included purchased funds as the fourth input variable; and (iii), they used interest rates as unit prices of the inputs.

Table 22. Different models for robustness test

Model	Inputs	Input price	Outputs	Dependent variable
DEA1: VRS-I DEA	Interest expenses ($x_1 * w_1$)		y_1	
	Occupancy expenses ($x_2 * w_{2a}$)		y_2	
	Labour expenses ($x_3 * w_3$)			
DEA2: VRS-I DEA	Interest expenses ($x_1 * w_1$)		y_1	
	Other expenses ($x_2 * w_{2b}$)		y_2	
	Labour expenses ($x_3 * w_3$)			
DEA3: VRS Cost DEA	x_1	w_1	y_1	
	x_2	w_{2a}	y_2	
	x_3	w_3		
DEA4: VRS Cost DEA	x_1	w_1	y_1	
	x_2	w_{2b}	y_2	
	x_3	w_3		
SFA_AC: Cost SFA	x_1	w_1	y_1	
	x_2	w_{2a}	y_2	C
	x_3	w_3		
SFA_TC: Cost SFA	x_1	w_1	y_1	
	x_2	w_{2b}	y_2	TC
	x_3	w_3		

where x_1 is total deposits; x_2 is physical capital, i.e. fixed assets; x_3 is number of employees; w_1, w_{2a}, w_3 are the input prices of x_1, x_2 , and x_3 , respectively; w_{2b} is the input price of physical capital in the case of excluding occupancy and labour expenses; y_1 is customer loans (excluding NPLs); y_2 is other earning assets; C is actual costs (regarding w_{2a}); and TC is total costs (regarding w_{2b}).

Table 23. Spearman's rank correlation among efficiency scores of various models

	DEA1	DEA2	DEA3	DEA4	SFA_AC	SFA_TC
DEA1	1.000					
DEA2	0.967***	1.000				
DEA3	0.758***	0.728***	1.000			
DEA4	0.750***	0.728***	0.995***	1.000		
SFA_AC	0.535***	0.555***	0.428***	0.430***	1.000	
SFA_TC	0.093	0.081	-0.060	-0.057	0.147	1.000

Note: *** indicates 1% level of significance

As seen in Table 23, the DEA models are significantly and highly correlated as expected (Bauer *et al.*, 1998). The differences (in Spearman's correlation coefficients) between the use of actual costs and total costs are not much (i.e. between DEA1 and DEA2, or between DEA3 and DEA4) compare to differences among different models (e.g. between DEA1 and DEA3). It suggests that for the DEA approach, model specification is more sensitive than variable definition.

On the other hand, the SFA model corresponding with actual costs (SFA_AC) is better than the SFA model corresponding with total costs (SFA_TC) in terms of rank correlation. We observe that the SFA_AC model is significantly correlated with all DEA models, although as expected, the coefficients are not high.¹⁶⁶ The SFA_TC model, in contrast, shows no correlation with all the other models. It suggests that it is justified to use the traditional approach (of measuring capital price via occupancy expenses divided by total fixed assets). It also suggests that, in transition economies such as Vietnam, where electronic banking activities are not popular and therefore the non-interest non-occupancy expenses are proportionally small in a bank's costs, examining actual costs should be preferred. Additionally, the weak and insignificant correlation between the two SFA models calls for

¹⁶⁶ Using data of the U.S banks, Bauer *et al.* (1998) found that the correlation coefficients between DEA and SFA models were less than 0.2 (but still significant).

caution on mis-measured input price of capital as this issue could lead to bias in SFA efficiency measurement. Consequently, our research model (SFA_AC) and its findings are robust and could provide meaningful information on the cost efficiency of the Vietnamese banking sector in 2003-2010.

4.2.8 Summary

We employed stochastic frontier analysis (SFA) in order to measure and decompose the TFP growth of 12 major banks in Vietnam from 2003 to 2010 regarding their cost frontier. The main findings are as follows.

First, the actual costs of Vietnamese banks in the 2003-2010 period was positively and strongly affected by the increasing labour price and the expansion of (performing) customer loans. In contrast, more investments on other earning assets, the increasing of (deposits) interest payments or capital investments will help reduce the actual costs. In addition, investing in machinery and technology, which are parts of the bank's fixed assets, will increase the actual costs and slow down the TFP growth rates of the bank. Therefore, banks in Vietnam should change their strategy from scale (in terms of lending portfolio, number of employees, and equipment) into scope (in term of diversification on other earning assets).

Second, although the average cost efficiency of our sample was high (0.934 for the 2003-2010 period), the statistically significant difference in cost efficiency between the SOCBs and JSCBs suggests that some privately owned banks should be strongly monitored due to their lack of efficiency in cost management.¹⁶⁷ In particular, the current chaotic situation of

¹⁶⁷ Although when the banks' characteristics (state-ownership and size) are considered, in overall, they tend to lower the cost efficiency of all Vietnamese banks (see section 4.2.6 above).

ACB, which could be explained with regard to its worst performance in the past periods, suggests that one could use cost frontier analysis as a predictive tool for policymaking. This finding is in line with what was found using the performance index approach (PI) where banks with state-ownership tend to have higher performance; which in turn consistent with findings of previous studies in Vietnam (Vu & Turnel, 2010; Nguyen *et al.*, 2014) as well as in other developing countries (Karas *et al.*, 2010; Du & Girma, 2011). It then strengthens the argument that in developing countries like Vietnam, it is not necessary that the state-owned banks perform worse than private banks (expected finding E2). In contrast, the state-owned banks can have some advantages (e.g. large capital, more liquid, more branches and customers, etc.) that help them perform better than the private ones.

Third, the expanding trend in the Vietnamese banking system is in line with the fact that increasing returns to scale was dominated in the system. However, that expansion (which is primarily based on lending activities as discussed above) could in turn lead to instability, especially if the nonperforming loans could not be controlled. As a result, quantity (scale or scope expansion) and quality (loans management) should be assessed in parallel.

Fourth, the TFP of Vietnamese banks grew during the examined period, thanks to the fluctuation in the residual price effects. When this bias is omitted, TFP growth was lower associated with scale efficiency and thus, suggesting that if scale becomes a problem for the banking system (as observed recently), its TFP growth could also be slowed down. Once again, we observed that the TFP growth was increasing in the first part of the examined period and then decreased in the later one, following our expected finding E1 in section 1.2.3 above.

If the findings using another approach, e.g. DEA, also are consistent, we can strongly conclude on the effect of Vietnamese bank's ownership and size on their performance. They are presented in the following section.

4.3 Evaluate the performance of Vietnamese banks under financial liberalization using Data Envelopment Analysis

This section provides a supplementary analysis on the multi-dimensional performance of the Vietnamese banking system. In this section, we first employ a traditional technique for measuring productivity and its change in the 2003-2010 period: the Malmquist Index DEA (MI-DEA) approach (section 4.3.1). We also construct a new model for evaluating TFP change in the Vietnamese banking system using the Fisher Index DEA (FI-DEA) approach (section 4.3.2). Summary of the two approaches are presented in section 4.3.3.

4.3.1 Productivity changes in the 2003-2010 period: the MI-DEA approach

4.3.1.1 Panel analysis

We first consider the case where a full panel data from all 12 banks in the 2003-2010 period is analyzed. Since we would like to compare our results with the overall performance index (PI) constructed in section 4.1.2, a constant-returns-to-scale, non-oriented SBM DEA is applied. The CCR condition is chosen because in calculating the PI we applied a DEA-like model without any model restriction (except for the non-zero-weight restriction), e.g. returns to scale restriction, assurance region, oriented, etc. In addition, since PI is a (normalized and transformed) maximization problem of our maximization and minimization CAMELS variables, in order to account for both input minimization and output maximization, we adopted the non-oriented SBM technique in our

Panel-DEA model. The software DEA-Solver-Pro (SAITECH Inc., 2012) is employed for the DEA's calculation in this section, as well as the following sections.

In the first place, we can see that the Panel-DEA's efficiency scores are substantially lower than the PI.¹⁶⁸ It may relate to the fact that these scores were generated as a relative measure between these 12 banks while the PI is calculated regardless of this constraint. In addition, only four DMUs are regarded as efficient (WEB 2004, SGB 2005, VPB 2006, and ACB 2007),¹⁶⁹ suggesting that the discriminatory power of the Panel-DEA frontier is weak and thus, the PI should be preferred. However, the Spearman's correlation coefficient between the ranks of these two measures is (moderately) strong at 0.445 and statistically significant at 1%, suggesting that the two models rank the examined banks in a similar way.¹⁷⁰

The yearly average efficiency retrieved from our Panel-DEA model also has similar shape with the PI, especially for the recent years where efficiency of Vietnamese banks fell to its bottom in 2008 and recovered slightly in 2009-2010 (Table 24). The Panel-DEA efficiency scores show particularly low values (on average) because there is a wide divergence in estimated scores for individual banks for individual years: simply, a number of banks in a number of years were being particularly inefficient.¹⁷¹

¹⁶⁸ Panel-DEA scores using VRS assumption is higher and significant under a Mann-Whitney ranks test. The Spearman's correlation between them and the PI, however, is even stronger than the case of CRS assumption, with a coefficient of 0.717 and p-value of less than 0.001.

¹⁶⁹ We also ran a super-efficiency SBM DEA model to test for outlier but it seemed that these four are not.

¹⁷⁰ We also calculate the SBM-DEA changes and PI changes through years. The Spearman's correlation coefficient between the ranks of these two measures is positively significant at 1%; while the Mann-Whitney rank comparison test also suggests that at 1% level of significance, the difference between these two measures is not significant.

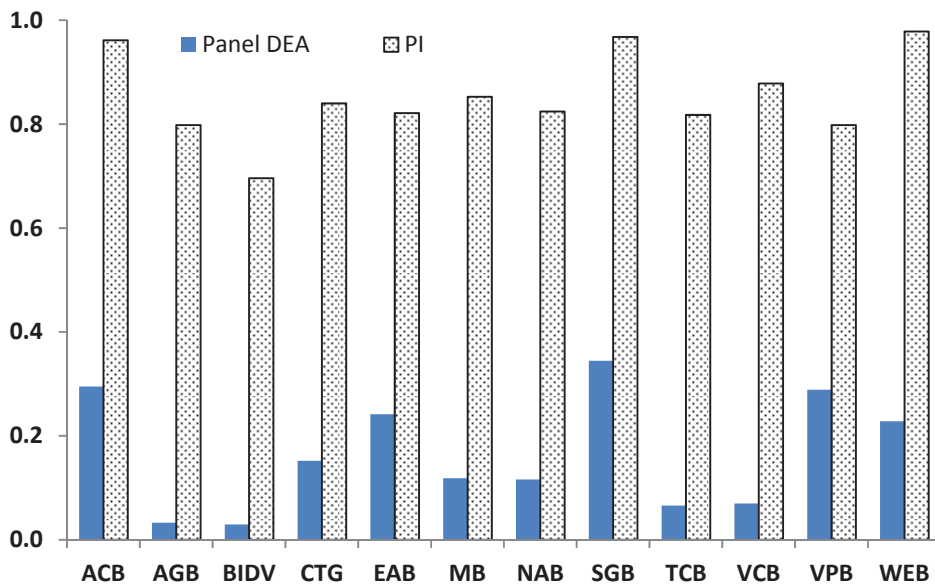
¹⁷¹ One could also argue that because this model treated 12 banks in each year from 2003 to 2010 as individual DMUs assuming they all operated using the same technology or in other words, they were operating under a common frontier. However, since the Vietnamese banking system changed a lot during the

Table 24. Efficiency scores vs. performance indices

	2003	2004	2005	2006	2007	2008	2009	2010
Panel-DEA (Average)	0.095	0.194	0.211	0.184	0.282	0.101	0.115	0.139
PI (Average)	0.910	0.926	0.929	0.857	0.851	0.709	0.827	0.816

In particular, the two models identify similar top- and bottom-tier banks for the 2003-2010 period (Figure 34), where ACB, SGB and WEB are best performers while BIDV and AGB are among the worst performers.

Figure 34. Performance of individual bank (2003-2010, average)



4.3.1.2 MI-DEA analysis

We then compute the Malmquist index for productivity changes of the examined banks in the 2003-2010 period using the same data set, i.e. the CAMELS ratios of 12 Vietnamese

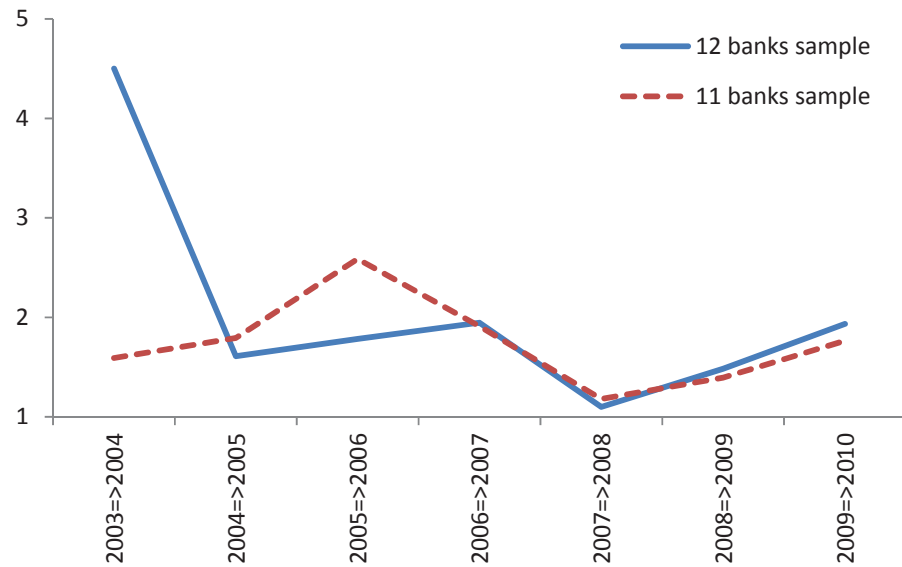
second and third phase of its development (see section 1.2.2.2), this assumption was not strong and thus, the efficiency scores calculated may be biased.

banks from 2003 to 2010, also following the SBM CCR assumption. As previously discussed, the availability of bank-level data limits us with a balanced data for 12 banks among 8 years (2003-2010). This creates a problem as the discriminatory power of our MI-DEA is not strong, since in one year we have only 12 banks while the total number of input and output variables are six (CAMELS ratios) and thus, violating the ‘rule-of-thumb’ mentioned in footnote 56 of section 2.2.4.4 above. This limitation requires another study on the productivity change of Vietnamese banks, especially one that can cover the whole financial liberalization period since 1990. We introduce a way to measure the banks’ productivity over time using macro-level data in section 4.3.2 below. This section, nevertheless, provides additional information on the performance and productivity of the Vietnamese banking sector during the 2003-2010 period.

The average Malmquist productivity index of all Vietnamese banks in 2003-2010 was 2.157,¹⁷² suggesting that in this period, the Vietnamese banking system did show some improvements in terms of technical and technological efficiencies. This figure, however, seems to be affected by a big increase in technical efficiency of VPB in 2003-2004 (which was 6.404 on average and thus, made its Malmquist index reach 7.878 in the same period). After VPB was excluded from our model, the average Malmquist index fell to 1.746 (see Figure 35). This 11 banks sample also helps strengthen our expected finding E1 in which performance (and productivity) of Vietnamese banks was expected to increase in 2003-2006 and then decrease in 2007-2008.

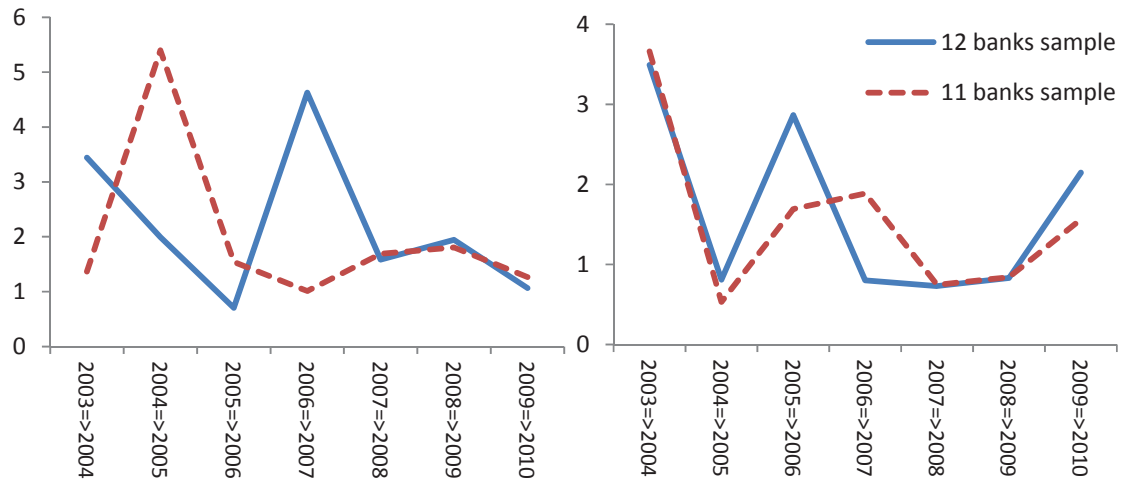
¹⁷² The Spearman’s correlation coefficient between the ranks of our MI-DEA results and the PI changes is also positively significant at 1%, consistent with findings in section 4.3.1.1.

Figure 35. MI-DEA overall scores



Nevertheless, our MI-DEA results suggest that although there was a decline in productivity of Vietnamese banks in 2006-2008, the banking system in Vietnam recovered since 2009 and started to show some improvements. These improvements, however, came mostly from the advancing of technology rather than from the technical efficiency (see Figure 36) and thus, may not persist in the future. Particularly, one can see that the pure technical efficiency of Vietnamese banks was decreasing (even before the effects of the global financial crisis – the case of 11 banks sample), signaling for the instability of the Vietnamese banking system in the next years. Notice that Nguyen (2012) found a similar thing in the 2007-2010 period: the (yearly average) MI-DEA scores of 20 Vietnamese banks increased from 1.203 to 1.424 thanks to the increasing of technological progress (from 1.200 to 1.499), while the technical efficiency decreased from 1.002 to 0.950.

Figure 36. Technical efficiency changes (left) and Technological changes (right) in the Vietnamese banking system



4.3.1.3 Analysis for the determinant of the MI-DEA scores

Based on equation (60), we check for the association between our DEA scores (among Panel-DEA and MI-DEA models as well as for the case of 12 banks versus 11 banks) and the bank's characteristics. We observed that the case with 11 banks provides better estimations than the case of 12 banks, suggesting that DEA results are sensitivity to outliers. Nevertheless, the findings in Table 25 show that there is no association between bank's ownership and size with their panel-DEA efficiency scores. This result suggests that Vietnamese banks were operating in a fairly competitive situation where size and ownership of the bank could not significantly affect its production performance. In contrast, banks with state ownership can have higher efficiency (EFCH11) and productivity (TFPCH11) changes over time, consistent with findings from PI and SFA approaches above. Again, we reject our expected finding E2 by concluding that in Vietnam, the SOCBs were better than the JSCBs in terms of productivity improvement. We, however, believe that because our sample is small that the MI-DEA measures may not reflect the true

productivity changes of the Vietnamese banking system and thus, finding significant correlations may be difficult.

Table 25. Regression results for determinant of DEA measures

<i>Measure</i>	Dependent variable <i>Explanation</i>	Type of regression	Coefficients of independent variables		
			<i>TYPE</i>	<i>SIZE</i>	<i>TYPE*SIZE</i>
EF12	Panel-DEA efficiency scores for 12 banks	Tobit	-0.717 (1.414)	-0.010 (0.016)	0.031 (0.075)
EF11	Panel-DEA efficiency scores for 11 banks	Tobit	-1.097 (1.681)	-0.010 (0.020)	0.047 (0.089)
EFCH12	MI-DEA measure for efficiency change over time for 12 banks		5.266 (36.082)	-0.269 (0.398)	-0.251 (1.894)
TECHCH12	MI-DEA measure for technical change over time for 11 banks	OLS	25.167 (19.872)	0.058 (0.219)	-1.287 (1.043)
TFPCH12	MI-DEA measure for TFP change over time for 11 banks		12.570 (41.462)	-0.283 (0.458)	-0.652 (2.176)
EFCH11	MI-DEA measure for efficiency change over time for 11 banks		44.553* (24.195)	-0.129 (0.272)	-2.289* (1.270)
TECHCH11	MI-DEA measure for technical change over time for 11 banks	OLS	19.283 (19.791)	0.069 (0.223)	-0.967 (1.039)
TFPCH11	MI-DEA measure for TFP change over time for 11 banks		22.642* (13.014)	0.065 (0.146)	-1.173* (0.683)

Notes: *, ** and *** denote significance at 0.1, 0.05 and 0.01 levels, respectively.

Standard errors are presented within the brackets.

4.3.2 Productivity changes in the 1990-2010 period: the FI-DEA approach

4.3.2.1 Technical efficiency of Vietnamese banks: the time-series DEA model

We first analyze the technical efficiency of the Vietnamese banking system using our time-series DEA model in equation (47) (section 3.3.4.2, page 100), using the macro-level data of the whole Vietnamese banking system (see Table 10). Here, we extend the approach of Ngo (2012) in several aspects. First, instead of using (total) deposits as input, we differentiate demand deposits from time and saving deposits and use the latter one as capital input, regarding the fact that demand deposits have characteristics of an output (Hancock, 1985; Bauer *et al.*, 1998; Gilbert & Wilson, 1998). We also use the number of

employees working in the financial/banking sector as an input variable proxies for labour. Second, since the Spearman's correlation between M2 and the other two potential outputs (demand deposits and GDP) are high (0.9896 and 0.9182, respectively) and both significant at 1%, we only use M2 as the single output variable. Notice that this figure was extracted from the ADB's data and thus might be different from the figure of SBV.

In the first place, the time-series DEA scores show us the technical productivity of the Vietnamese banking system in the period of 1990-2010. According to Figure 37, we can see that the performance of the Vietnamese banking system was low at the beginning of the liberalization, reflecting the reason why the banking sector needed to be reformed. It then gradually increased during 1991-1993 period thanks to the liberalization process, specifically with the re-join of Vietnam into regional and international financial institutions such as IMF, WB, and ADB in October 1993.¹⁷³ This led to a sharp increase in time deposits attracted (about three times 1993 value) but the output M2 was not increased as much and thus, it resulted in a decreasing in performance. The banking system regained its developing trend after that; however, it fell again into trouble in 1999 due to the (lagged) spillover effects of the East Asian crisis 1997. Since the level of financial liberalization in Vietnam was low at that time,¹⁷⁴ that effect was not serious and recovery was seen in the banking sector in 2000. For the post-2000 period, there were some fluctuations in the performance of the Vietnamese banking sector due to the bank run incident in 2003,¹⁷⁵ the

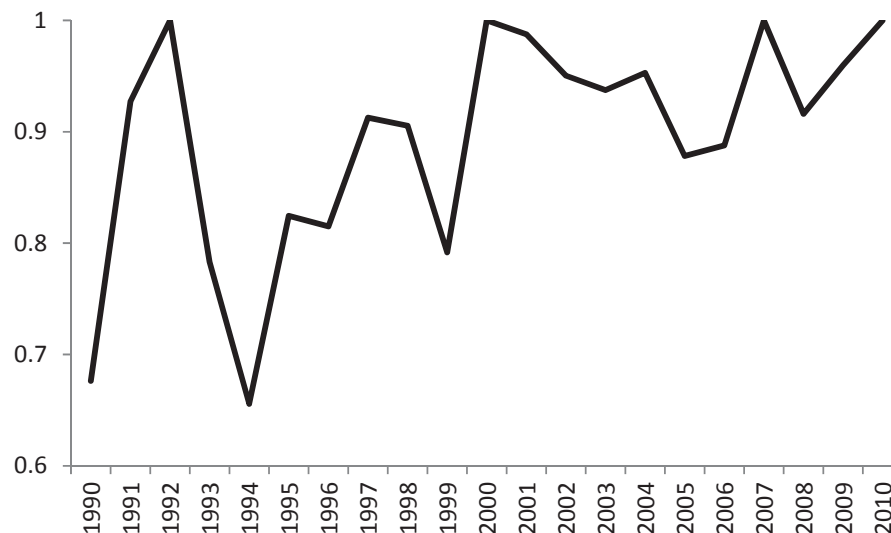
¹⁷³ Notice that 1994 was also the year when the U.S removed its sanctions on Vietnam.

¹⁷⁴ Oh (1999) argued that the financial deepening in Vietnam was about half of South Korea and Indonesia; and one-third of Thailand and Singapore; as in the end of 1997.

¹⁷⁵ The Asia Commercial Bank (or ACB in short) was one of the biggest private commercial bank in Vietnam. In October 2003, there was a rumour that its general director had fled the country that led to a temporary bank run situation. The SBV had to guarantee that there was no problem with ACB and it would support the bank if depositors still wanted to withdraw their money (Anonymous, 2003).

boom and bust of the securities market in 2006-2007,¹⁷⁶ and the Global Financial Crisis 2007-2008. Nevertheless, for the whole period of 1990-2010, average efficiency score of Vietnamese banking system remains high at 0.893, suggesting the positive impact of financial liberalization to banking performance. Previous studies on the efficiency of Vietnamese banks also ended up with similar results, for example, the average technical efficiency score was 0.918 in 2001-2003 (Nguyen, 2007), 0.915 in 2003-2006 (Nguyen & DeBorger, 2008), or 0.917 in 2008 (Ngo & Tripe, 2010).¹⁷⁷

Figure 37. Time-series DEA efficiency scores of the Vietnamese banking system



Along with the CCR condition, we also employ the BCC condition to test for scale efficiency, following equations (38)-(40) on page 94. As CCR efficiency is the product of BCC efficiency and scale efficiency, average scale efficiency is estimated as 0.944 while

¹⁷⁶ The VNIndex of the securities market, after its establishment in 2000 and sluggishly developed in 2000-2005, faced a rapid increase from February 2006 and reached its highest record in March 12, 2007 with 1,170.67 points. It then sharply decreased to the bottom of 235.50 points in February 24, 2009 (<http://www.hsx.vn>).

¹⁷⁷ A slightly difference between our result and these studies may relate to the non-oriented SBM DEA we used, as well as the difference in using input/output variables. In particular, the result of Ngo (2012) was lower (0.695 on average) than what we found here because the former study might be biased due to the highly correlation between its output variables.

mean of BCC efficiency is 0.946. To check for the difference between the two treatments (CRS and VRS efficiency scores) in terms of ranking individual banks, we employed the nonparametric Mann-Whitney tests on the full sample (1990-2010) as well as sub-samples (1990-2009 and 1991-2010).¹⁷⁸ We concluded that in the 1990-2010 period, the difference between CRS and VRS scores is statistically significant at 5% level, thus scale efficiency played an important role in the performance of Vietnamese banks.

4.3.2.2 Decomposing the productivity change of Vietnamese banking system (1990-2010)

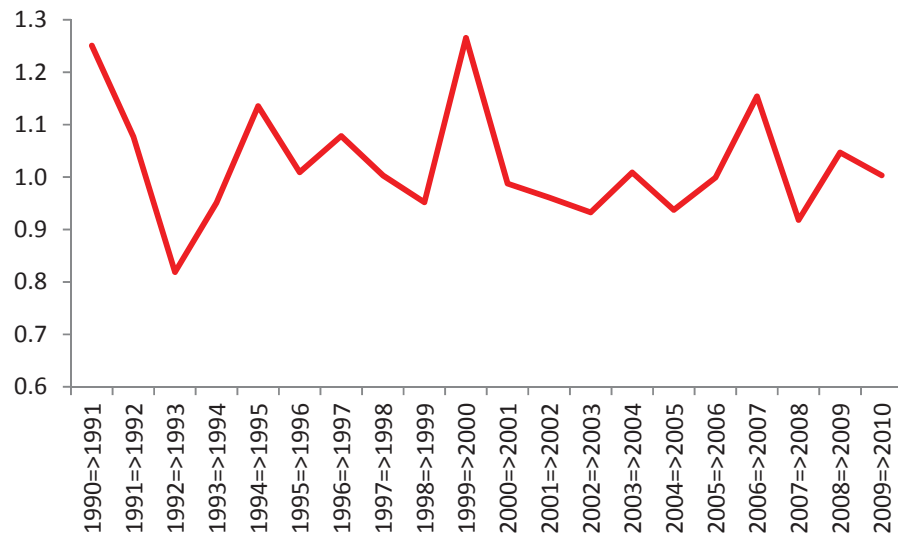
In order to analyze the productivity and its change of the banking system in Vietnam during the 1990-2010 period, we calculate the Fisher TFP index (FI) following equation (54) in page 104 and then decompose it as in equations (55) - (58) in pages 104 - 105.

The overall FI reveals a decreasing trend of productivity in the Vietnamese banking system, with a sharp decline in mid-1990s, a recovery in 1999-2000, and another fluctuation in the post-GFC (2007-2010) period.¹⁷⁹ It helps explain the decreasing of efficiency of Vietnamese banks in the mid- and late-1990s (see Figure 38) as the contribution of labour and capital (time deposits) to the production of broad money is reduced over time. It also suggests that if Vietnamese banks could not improve their productivity, their efficiency will remain the same in the future.

¹⁷⁸ This is to check if scale efficiency in 1990 or 2010 had any (extreme) effects on the scale efficiency of the whole period.

¹⁷⁹ Our findings are different from Nguyen (2012) for the 2007-2010 period majorly because of the differences in variables used. Differences between MI-DEA and FI-DEA were proven to be minor (Ngo & Tripe, 2014).

Figure 38. The Fisher TFP index (FI) of Vietnamese banks

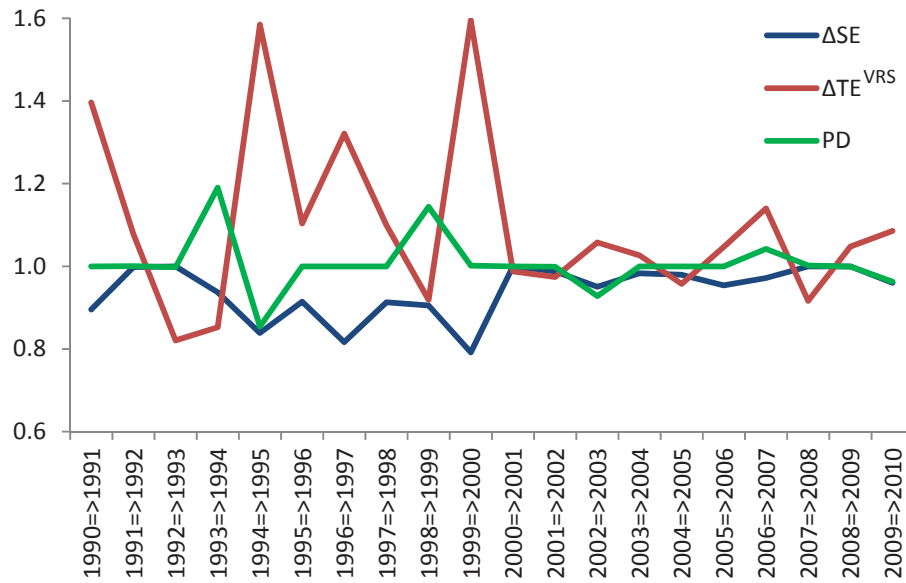


A closer look at the components of the FI (i.e. the pure technical efficiency change ΔTE^{VRS} ,¹⁸⁰ the scale efficiency change ΔSE , and the price deflator PD) in Figure 39 shows that the main reason for this decline was due to the technical efficiency regression.¹⁸¹ High fluctuations were observed in the first-half of the examined period, but the effects were lower in the second-half. This finding suggests that the pure technical inefficiency has been a more serious issue than the problem of finding the best inputs mix for the Vietnamese banking sector. However, for 2009-2010, we find that the FI scores were dragged down by the relatively low scale efficiency change and price deflator, while ΔTE was still greater than one. It suggests that in the near future, Vietnamese banks should focus more on reducing their scale and monitoring the input costs.

¹⁸⁰ In the variable returns to scale (VRS) condition.

¹⁸¹ Notice the similar shapes between FI scores in Figure 38 and ΔTE scores in Figure 39.

Figure 39. Components of the Fisher TFP index



4.3.2.3 Determinants of Vietnamese banks' efficiency

Under the argument that performance of the Vietnamese banking sector in the 1990-2010 period could be (positively) affected by the financial liberalization process, in this section, we are going to test for the associations between several variables representing the level of liberalization and the efficiency and productivity measures. The information of these variables was presented in Table 5 and Table 11 above. We choose these variables not only because of their popularity (e.g. Lane & Milesi-Ferretti, 2007; Umutlu *et al.*, 2010; Hamdi & Jlassi, 2014; Herwartz & Walle, 2014; Law *et al.*, 2014) but also because of their role in the financial liberalization order: a country liberalizes its financial sector by first reducing budget deficit, then lower reserve requirement, remove interest rates controlling, etc. (see Figure 1 in section 1.2 above). Our starting equation has the form of

$$Y = f(KA, BD, CB, TB, NB, NS, BC, RR, LI, RD, C0/C1) \quad (69)$$

where Y are the time-series DEA efficiency scores (section 4.3.2.1) or FI-DEA productivity measures - ΔTE^{VRS} , ΔSE , PD , and FI (section 4.3.2.2), respectively. Notice that we use the dummy variable $C0$ for the zero-year crisis model or $C1$ for the one-year crisis lag model to analyze the effect of the AFC 1997 or GFC 2007 on the performance of the Vietnamese banking sector.

We first test for the association between our time-series efficiency scores and those liberalization factors using the backward stepwise Tobit regression technique, as discussed in section 3.4 above. The results are interesting (Table 26).

First, we observe that the zero-year model became a valid model after nine steps while the one-year lag model only needed six steps. In addition, the latter model still detects the role of the crisis variable ($C1$), whereas the efficiency of Vietnamese banks decreased one year after the AFC 1997 or GFC 2007 occurred, while the former model could not ($C0$ was omitted in step 7). It suggests that effects from regional and global crisis on the Vietnamese banking sector, and thus its economy, did not happen immediately but was lagged. This lag reflects the limited nature of cross-border linkages between the domestic banking system and the regional/global ones, which is commonly found in other developing countries as well (IMF, 2009). Consequently, researchers should follow the lag model in terms of analyzing the effects of crisis in this situation.

We then figure out that financial openness (KA), capital account balance (CA), bank concentration (BC), reserves requirement (RR), and real interest rate on deposits (RD) are all have significant impacts on the efficiency of the Vietnamese banking sector, regardless of the lag models. The signs of the estimated coefficients of these variables are mainly as expected: higher capital account balance represents more (foreign) investments and thus

could boost up the domestic banking sector; lower reserves requirement ratios, which is in line with the liberalization process, and higher deposits interest rates also allow for more savings and investments; while a lower ratio of bank concentration represents a higher participation of private banks in the system, which in turn also improve the performance of the whole banking system. The exceptional one is financial openness (KA): it has a negative association with the performance of the banking system in Vietnam. In line with Barth et al. (2006; 2013), we argue that since the quality of institutional policy in Vietnam have not been well developed, which may lead to the negative effect of the KA index on the Vietnamese banks' performance, caution should be made in liberalizing its banking and financial sectors. We, however, aware that those conclusions were made base on a small sample analysis and thus, more works are needed to confirm the argument.¹⁸²

Nevertheless, these findings support the argument that financial liberalization could make the banking sector more efficient, while the (lagged) effect from the regional and global crises may worsen it (consistent with our expected finding E1 in section 1.2.3).

¹⁸² We tried to improve the robustness of our regression estimates using the bootstrapping technique (Efron, 1979; Efron & Tibshirani, 1993); however, the new results are even worse than the original ones, i.e. all explanatory variables become insignificant.

Table 26. Tobit regression for the time-series DEA efficiency scores (backward stepwise procedure)

	Step 1		Step 2		Step 3		Step 4		Step 5		Step 6		Step 7	
	Coef.	$P > t $	Coef.	$P > t $	Coef.	$P > t $	Coef.	$P > t $	Coef.	$P > t $	Coef.	$P > t $	Coef.	$P > t $
Zero-year crisis regression														
KA	-0.415	0.133	-0.397	0.138	-0.304	0.040	-0.344	0.020	-0.205	0.065	-0.181	0.042	-0.226	0.012
BD	0.009	0.511	0.010	0.368	0.008	0.427								
CB	-0.002	0.759	0.032	0.229	0.039	0.058	0.042	0.050	0.046	0.040	0.044	0.042	0.039	0.078
TB	0.033	0.217												
NB	0.005	0.140	0.005	0.142	0.004	0.139	0.005	0.119	0.001	0.696				
NS	0.066	0.652	0.064	0.664										
BC	-0.004	0.236	-0.004	0.225	-0.005	0.091	-0.006	0.031	-0.005	0.060	-0.005	0.062	-0.007	0.007
RR	-0.047	0.012	-0.045	0.009	-0.048	0.003	-0.045	0.004	-0.028	0.006	-0.029	0.005	-0.023	0.013
LI	0.014	0.123	0.014	0.119	0.015	0.090	0.013	0.122						
RD	0.006	0.034	0.006	0.026	0.006	0.014	0.006	0.020	0.005	0.039	0.006	0.025	0.006	0.022
C0	0.179	0.070	0.184	0.059	0.182	0.060	0.145	0.085	0.094	0.237	0.105	0.163		
One-year crisis lag regression														
KA	-0.343	0.208	-0.355	0.183	-0.348	0.190	-0.235	0.015	-0.219	0.010	-0.187	0.027		
BD	0.005	0.675	0.004	0.707										
CB	0.080	0.028	0.078	0.026	0.081	0.021	0.088	0.005	0.088	0.005	0.073	0.015		
TB	-0.008	0.251	-0.007	0.256	-0.008	0.185	-0.008	0.205	-0.008	0.146				
NB	0.001	0.746	0.002	0.541	0.002	0.551	0.000	0.685						
NS	0.086	0.554	0.077	0.579	0.062	0.641								
BC	-0.005	0.117	-0.005	0.050	-0.006	0.035	-0.006	0.009	-0.006	0.009	-0.007	0.003		
RR	-0.034	0.031	-0.036	0.008	-0.037	0.005	-0.039	0.003	-0.040	0.002	-0.029	0.003		
LI	-0.002	0.834												
RD	0.011	0.009	0.011	0.009	0.011	0.008	0.011	0.005	0.012	0.002	0.009	0.005		
C1	-0.202	0.050	-0.193	0.036	-0.185	0.037	-0.191	0.031	-0.196	0.025	-0.159	0.069		

Coef. – Regression coefficient; $P > |t|$ – Probability of the *t*-test statistic.

The conjunction between these liberalization factors and the FI components is also examined. After eliminating some irrelevant factors (using the backward stepwise technique), this conjunction is presented as in Table 27. Some conclusions can be made as follows.

First, the country's openness had no impact on the price deflators (PD). It means that changes in domestic prices had a weak relationship with international prices. This also supports the argument above on the limited cross-border linkages between the Vietnamese banking system and the regional/global ones (IMF, 2009). Second, the associations between KA and pure technical efficiency change (ΔTE^{VRS}) as well as total factor productivity change (FI) were negative, consistent with findings using the time-series efficiency scores in the previous paragraph. Third, the size of the banking sector (via NB), inflow investments (via CB), reserves control (via RR), and interest rates control (via LI) are important factors that can affect the productivity (ΔTE^{VRS} and FI) of the domestic banks, mainly following the expected direction/signs (see Table 5). Fourth, the lag effect seem to be more significant on the total factor productivity measure (FI) rather than its components (e.g. ΔTE^{VRS} or ΔSE).

In terms of total factor productivity change of the Vietnamese banking system over time, one could argue that it should be improved if external factor is monitored (more supervisions are put on the openness of the sector) while internal factors are improved (more privatization and expansion of the domestic banking sector), with caution on the lag effect of regional/global financial crises.

Table 27. OLS regression for the FI-TFP growth

Zero-year crisis regression	ΔTE^{VRS}		ΔSE		PD		FI	
	Coef.	$P> t $	Coef.	$P> t $	Coef.	$P> t $	Coef.	$P> t $
KA	-0.860	0.000	0.157	0.011			-0.875	0.004
BD								
CB	0.129	0.002	-0.037	0.000	-0.050	0.008		
TB					0.013	0.005		
NB	0.025	0.001	-0.007	0.000	-0.004	0.031	0.008	0.010
NS					0.150	0.003	0.358	0.007
BC			-0.002	0.013				
RR	-0.106	0.001	0.023	0.000	0.059	0.001		
LI	0.058	0.003	-0.013	0.002	-0.022	0.006		
RD					-0.006	0.017	-0.005	0.077
C0	0.398	0.010	-0.122	0.002	-0.118	0.054		
Constant	-1.090	0.182	1.638	0.000	0.976	0.000	-0.605	0.242
One-year crisis lag regression	ΔTE^{VRS}		ΔSE		PD		FI	
	Coef.	$P> t $	Coef.	$P> t $	Coef.	$P> t $	Coef.	$P> t $
KA	-0.589	0.006	0.205	0.000			-0.684	0.016
BD	-0.072	0.028	0.011	0.031				
CB	0.179	0.001	-0.041	0.001	-0.072	0.006	0.046	0.026
TB	-0.023	0.090			0.017	0.002		
NB	0.008	0.014	-0.006	0.001			0.007	0.011
NS					0.074	0.017	0.300	0.019
BC								
RR	-0.056	0.014	0.012	0.028	0.044	0.001		
LI			-0.007	0.067	-0.006	0.060		
RD					-0.009	0.010		
C1					0.133	0.053	-0.142	0.059
Constant	1.146	0.010	1.385	0.000	0.397	0.055	-0.018	0.972

Coef. – Regression coefficient; $P>|t|$ – Probability of the t-test statistic

4.3.3 Summary

In this section, we conducted several DEA models to evaluate the efficiency and performance of the Vietnamese banking system under the effects of financial liberalization.

The panel DEA and MI-DEA models were conducted using banking-level data from 2003 to 2010. They showed that the performance of the examined banks was on an increasing trend prior to the crisis and then dropped strongly during the crisis (including the “bust” of

the Vietnamese securities market in 2006 as well as the Global Financial Crisis in 2007-2008); but a recovery was seen later in 2009-2010. However, this was not a sustainable recovery because it depended on technology rather technical efficiency of the banks (see Figure 36).

Our time-series DEA and FI-DEA models employed the macro-level data of the whole banking system and thus, could cover the period of 1990-2010. During that time, the time-series efficiency of Vietnamese banks was generally increased, especially after 1994, but with some fluctuations around crisis times (e.g. the AFC 1997 or GFC 2007). However, the productivity changes (as well as its components) were in an opposite direction: it had mainly decreased in the same period. The main reason for this movement was due to the technical efficiency regress, consistent with Nguyen (2012), which suggests that for the Vietnamese banking sector, it is more important to improve the pure technical inefficiency rather than focusing on the scale inefficiency (Nguyen, 2007) or price deflators.

The regression stage advised that financial liberalization could increase the efficiency of Vietnamese banks, but policy makers should be aware of the institutional quality, as well as the lag effect from regional/global crises. As a consequence, the macroeconomic environments regarding financial liberalization, the development and privatization of the banking sector, and the monetary policy should be carefully controlled.

4.4 Comparison between different approaches and models used in this Chapter

So far, we have employed several models to evaluate the efficiency and productivity of the Vietnamese banking system. It is expected that findings from these models should be consistent and thus, by using different models, we could gain an overall view on the examined object. The comparison between the three approaches and their corresponding

five models used in this chapter is presented in Table 28. We compare them in terms of approach, model, measurement, input/output variables used, and their empirical results. Although there are some minor differences, the findings from these models are generally consistent and thus, help us analyze the expected findings in section 1.2.3 above (discussed below).

First, we observed that except for the panel-DEA model, the average efficiency or performance score of the Vietnamese banking system was high, ranging from 0.853 (ratio analysis) to 0.934 (cost efficiency analysis). By examining a longer period, the time-trend-DEA ended up with a score of 0.893, staying between the two. The parametric tests (for means and variances) as well as nonparametric test (for ranks) showed insignificant differences between estimates of the time-series DEA and the other two models, suggesting that this model could provide additional information on the performance evaluation in case of data limitation.

Second, in terms of productivity changes, it seems that the MI-DEA estimates were biased, since it is not consistent with the cost TFP and Fisher TFP indexes.¹⁸³ Once again, one could refer to the discriminatory power of DEA when the number of DMUs is limited (Dyson *et al.*, 2001) and thus, could avoid this problem by using the FI-DEA instead of MI-DEA.

Third, in terms of performance or efficiency trend, although all models detected that efficiency and productivity of Vietnamese banks was decreasing recently, the DEA models could provide a broader view since they can define the increasing in pre-2000 period. This helps conclude that in general, the performance of the Vietnamese banking system slightly increased in the 1990-2010 period, but with some fluctuation after the 2000s due to impacts

¹⁸³ The difference between these two was not significant in terms of ranks and means with the corresponding p-values of 0.959 and 0.510, respectively.

from the regional and global crises. It supports our first expected finding E1. Consequently, time-series DEA and FI-DEA models are justified to be complements for ratio analysis or SFA.

Fourth, the fact that a few of the same banks were defined as worst performers (AGB, BIDV) within different models, except for the TFP analyses, suggested that more supervision and monitoring should be applied on those banks. In combination with the bank's characteristics, one could argue that equitization/privatization of the SOCBs should be speeded up in order to transform their ownerships, reducing their sizes, and improving their performances. These consistencies also support our third expected finding E3.

Fifth, regarding bank-characteristics and their roles on efficiency/productivity, we see that state-owned banks tend to performed better than privates ones, but large banks are worse than small banks.¹⁸⁴ It rejects our second expected finding E2; however, it is observable in developing countries since state-owned banks operate with more advantages than private banks (Karas *et al.*, 2010; Du & Girma, 2011).

Sixth, regarding the determinants of TFP changes in the Vietnamese banking system, only the FI-DEA model could provide some insightful information on the effect of macroeconomic environments (liberalization factors) on the productivity of the banks. It does not mean that the other methods, Cost TFP and Malmquist TFP indexes, are not appropriate; however, it suggests that they should be tested using a bigger sample. Researchers should also be aware that in developing countries like Vietnam, the impacts of regional/global crises on the domestic banking sector are having a lag effect.

¹⁸⁴ The interaction between state ownership and bank size also has negative impact on bank's efficiency.

Table 28. Overall comparison between models used

Approach	Ratio Analysis (RA)	Stochastic frontier Analysis (SFA)	Data Envelopment Analysis (DEA)		
Model	(Financial) Performance Index	Translog Cost formulae	Panel-DEA	MI-DEA	Time-series DEA
Measurement	Overall performance	Cost efficiency	"Vertical" Efficiency	Malmquist TFP index	"Horizontal" Efficiency
Inputs	n.a	x1, x2, x3	NPLL, CGAPA	NE, TD	
Outputs	EQ, NPLL, ROA, NIM, LIQUID, CGAPA	y1, y2	EQ, ROA, NIM, LIQUID	M2	
Average measurement score	0.853	0.934	0.165	2.157 (12 banks) 1.746 (11 banks)	0.893
Period	2003-2010	2003-2010	2003-2010	2003-2010	1990-2010
Trend	Decreasing	Decreasing	Slightly increase, fluctuate during 2007-2010	Decreasing, recovery in 2009-2010	Increasing, fluctuate during crisis times
Best performers	SGB, WEB	WEB, BIDV	SGB, ACB	VPB, ACB	1992, 2000, 2007, 2010
Worst performers	BIDV, AGB	ACB, NAB	AGB, BIDV	TCB, MB	1992=>1991, 1999=>2000
Determinants	Type(+); Size(-); Type*Size(-)	Type*Size(-)	Not significant	Type(+); Type*Size(-)	KA(-); CB(+); RD(-); NB(+); NS(+); RD(-); C1(-)

Note: For variables within this table, please refer to Table 8, Table 9, and Table 10 in the previous sections.

5 Conclusions and Suggestions for future research

5.1 Thesis summary

Substantial amounts of research have been done on the finance-growth nexus as well as the development of the banking sector under financial liberalization. Researchers following the arguments of Goldsmith (1969), Shaw (1973), and McKinnon (1973) argue that finance can facilitate economic growth and thus financial deregulation or liberalization is important, especially for transition economies (Patrick, 1966; World Bank, 1989; King & Levine, 1993a; Demirgüç-Kunt & Levine, 2001; Kroszner *et al.*, 2007; Brissimis *et al.*, 2008). The other approach, followed by Robinson (1952) and Lucas (1988), questioned the relationship between financial liberalization and growth and argued that financial liberalization results from economic development (Kitchen, 1986; Tobin, 1989). They showed that financial liberalization is important for growth but up to a certain level (Rajan & Zingales, 1998; Easterly *et al.*, 2000), because a positive relationship between financial intermediation and economic growth can be achieved only if the banking system is efficient (De Gregorio & Guidotti, 1995). Since the Global Financial Crisis 2007/08, more studies have re-examined the finance-growth nexus with a positive long-term relationship found, i.e. financial liberalization can facilitate growth in long-term corresponding to a certain level of institutional quality (Hasan *et al.*, 2009b; Beck, 2012a, b; Laeven & Valencia, 2013; Law *et al.*, 2013).

Relative to this thesis, recent studies in the banking sector have shown that although liberalization allows banks to undertake riskier lending (Kingsbury *et al.*, 2012; Mayes & Morgan, 2012), if it is controlled, then there can be a bilateral relation between liberalization and bank efficiency (Hasan *et al.*, 2009a; Koetter & Wedow, 2010;

Chortareas *et al.*, 2013). Empirical evidence suggests that differences in bank-specific characteristics (e.g. size, ownership) and institutional environment characteristics (e.g. openness of the economy or concentration level of the banking sector) can explain the differences in efficiency between different banks in different countries (La Porta *et al.*, 2002; Demirgüç-Kunt *et al.*, 2004; Barth *et al.*, 2006; Chortareas *et al.*, 2012; Barth *et al.*, 2013; Chortareas *et al.*, 2013). Therefore, a useful way to re-examine the finance-growth nexus under liberalization is to analyze the efficiency of the banking sector over time, having regard to the changes in those factors.

Based on this argument, this thesis focused on evaluating the efficiency of the Vietnamese banking system and its productivity change over time under the effects of financial liberalization. This mission can be done in a so-called two-stage analysis, in which the first stage defines the efficiency and productivity of the Vietnamese banking sector, and the second stage determines if those efficiency/productivity measures are affected by changes in the bank-specific and environmental characteristics over time.¹⁸⁵ Notice that those changes resulted from the financial liberalization process in Vietnam and thus can be used as proxies for the liberalization. In combination with the literature, regarding the financial liberalization process as well as the development of the banking system in Vietnam, the thesis expects to be the first major study on the performance of the Vietnamese banking system under the effects of the financial liberalization during the 1990-2010 periods. In order to fulfill that mission, besides use of regression in the second-stage analysis, the thesis employed three different approaches, namely ratio analysis, stochastic frontier analysis (SFA), and data envelopment analysis (DEA), in the first-stage.

¹⁸⁵ Notice that the two stages can be combined into a single-stage analysis in the stochastic frontier analysis approach, following Battese and Coelli (1995).

Ratio analysis is a traditional approach that measures efficiency and performance of a bank via several important ratios such as net interest margin (NIM), returns over average assets (ROA), returns over average equity (ROE), nonperforming loans over total loans (NPL), cost-income ratio (CIR), etc. To reduce the number of ratios used, one can use factor analysis, principal component analysis, or follow the CAMELS rating system. In banking comparisons, these ratios are used individually (i.e., banks cannot be compared in both profitability and liquidity at the same time), and efforts to combine them into a single measure of the overall efficiency had failed. To overcome this obstacle, the thesis proposed a way to incorporate all (CAMELS) ratios into a single performance index (PI) employing the optimization technique of DEA that could be used for multi-dimensional performance evaluation.

In the literature, the measure that can handle multi-dimensions, including financial and production aspects as well as multiple input and output variables, is X-efficiency. X-efficiency is measured as deviations between the examined institution and the efficient frontier, which could be estimated through a (stochastic) regression function of the observations (SFA) or could be enveloped as a piecewise surface which ‘floats’ on top of the observations (DEA).

Each approach above has its own strengths and weaknesses; however, there should be a consistency between DEA, SFA, and ratio analysis. Using the banking-level data (2003-2010) and macro-level data (1990-2010), the thesis seeks answers of four expected findings. These findings helped revealing the major trend in performance of Vietnamese banks during the liberalization period as well as determining factors affected to that performance.

Expected finding 1 (E1): *The efficiency or performance of Vietnamese banks generally increased during the 1990-2010 periods; however, with some adjustments around critical times in 1997 and 2007.*

The first expected finding (E1) assumed that the banks' performance generally increased during the liberalization periods, except around the times of crises (BIS, 2009; BOT, 2010). In the case of the Vietnamese banking system, due to the characteristics of our data, we sub-divide our analysis into two periods: the 1990-2010 period and the 2003-2010 period. The critical times of crises in this case were 1997 and 2007 corresponding to the Asian Financial Crisis (AFC) and the Global Financial Crisis (GFC), respectively. Our findings confirmed that the negative association between crises and bank performance exists (BIS, 2009; BOT, 2010), but with a one-year lag effect, using data of the Vietnamese banking system. Consequently, research on the impacts of regional/global crises on developing countries should be aware of that effect. In general, however, the positive relationship between financial liberalization and bank efficiency is observed in Vietnam, consistent with that of other developing countries (Isik & Hassan, 2003; Atallah *et al.*, 2004; Das & Ghosh, 2009; Fethi *et al.*, 2011).

Expected finding 2 (E2): *The performance of the State-Owned Commercial Banks (SOCBs) in Vietnam was lower than that of the Joint-Stock Commercial Banks (JSCBs) during the financial liberalization.*

The second expected finding (E2) dealt with ownership and size of the individual bank, in which banks with governmental ownership and/or bigger (assets) sizes are assumed to be outperformed by private and/or smaller banks (La Porta *et al.*, 2002; Bonin *et al.*, 2005b). In some cases, however, the state-owned banks can perform better than the private ones.

Although future studies are needed (since our sample was small and thus, the results may not be accurate), our findings using different models/approaches (e.g. PI, SFA or MI-DEA) consistency show that the SOCBs were more efficient than the JSCBs¹⁸⁶ due to the fact that they have more advantages (e.g. capital and labour – FI-DEA model or liquidity – PI model). This suggests that the Vietnamese banking system is similar to that of the Chinese or Russian (e.g. Karas *et al.*, 2010; Du & Girma, 2011), rather than that of other countries as in La Porta *et al.* (2002) or Bonin *et al.* (2005b). However, results from the FI-DEA shows that equitization of the SOCBs should be speeded up in order to transform their ownership, reducing their sizes, and improving their performance.

Expected finding 3 (E3): The efficiencies of Vietnamese banks are consistent through difference measurement approaches, namely the ratio analysis, stochastic frontier analysis, and data envelopment analysis.

The third expected finding (E3) is that efficiencies of Vietnamese banks are consistent through difference approaches (Bauer *et al.*, 1998). Here, we observed the consistencies between these approaches in terms of scores, trends, and best and worst performers. It suggests that results from our analyses are robust and thus the conclusions are reliable. The findings also suggested that the proposed time-series DEA, as well as the FI-DEA models, could be an alternative to the panel-DEA and MI-DEA models since they could provide additional information on the performance measures, especially in case of data limitation. It is therefore justify for future research to test for the use of those new models.

¹⁸⁶ This is also consistent with previous studies on Vietnam banks (Vu & Turnel, 2010; Nguyen, 2012; Nguyen *et al.*, 2014).

Expected finding 4 (E4): Results from the new model (a combination of ratio analysis and data envelopment analysis) are more robust than individual results from the ratio analysis or data envelopment analysis themselves.

The last expected finding (E4) proposed that the new RA-DEA model (a combination of ratio analysis and data envelopment analysis) is more robust than individual results from the ratio analysis. This argument resulted from the fact that ratio analysis and DEA are complementary (Thanassoulis *et al.*, 1996) and thus, the new model should be superior to the (component) ratio analysis. Our findings, however, did not totally support this. We could not find consistent results between the ratio analysis model (PI scores) and the ratio-based DEA ones (Panel-DEA efficiency scores) in terms of scores, trends, and determinants; even though the correlation between the two measures is positive and significant at 1% level. In addition, we found them ended up defining similar banks as the best and worst performers for the examined period. We then suggest that it could be tested on bigger sample.

5.2 Thesis contributions

The thesis reviewed the (triangle) relationship between financial liberalization, economic growth, and banking development. It pointed out the causality effect where financial liberalization could improve the efficiency of the banking sector (Isik & Hassan, 2003; Ataullah *et al.*, 2004; Das & Ghosh, 2009; Fethi *et al.*, 2011), but on the other hand, it also could lead to instability in the banking system (Bhattacharyya *et al.*, 1997; Leightner & Lovell, 1998; Denizer *et al.*, 2007). The recent Global Financial Crisis raised questions on how and at what level financial liberalization could be done so that for banking development, improvements are achieved but instabilities are avoided. The thesis answered

these questions employing a new sample (the Vietnamese banking system), covering a long period (1990-2010), and consistently applying different approaches and models.

Studies regarding performances of the banking sector in Vietnam are limited, especially published articles in international ranked journals (Vu & Turnel, 2010; Vuong, 2010; Nguyen *et al.*, 2012a; Vu & Nahm, 2013). In addition, due to data limitations, these studies focused on the efficiency of individual banks that together account for most of the assets of the Vietnamese banking system within the last decade, rather than look at the efficiency of the system as a whole, and for a longer period. The thesis is the first study that examines the efficiency and productivity of the whole Vietnamese banking system throughout the financial liberalization period, since the day that the banking sector transformed from a one-tier into a two-tier system in 1990. Our empirical findings provided additional evidence for the relationship between financial liberalization and banking development. Precisely, we were able to conclude that deregulation (i.e., equitization of the SOCBs) and liberalization (i.e., size of the banking sector, reserved requirement loosening, etc.) could facilitate the efficiency and productivity of the Vietnamese banking system. On the other hand, since the institutional quality in Vietnam is still weak, too much openness might lead to a negative effect on the performance of the domestic banking system, especially under the effects of the regional or global financial crises.

Three approaches, including both the traditional (ratio analysis) and modern (SFA and DEA) ones, were employed in the thesis. Our discussions and conclusions were based on comparing and contrasting the results obtained from these approaches (and the models therein) and thus, could provide a multi-perspective view on the performance of the

Vietnamese banking system under effects of the financial liberalization process. To the best of our knowledge, this is the first study to do so.

The thesis also proposed several new models for performance evaluation, which can contribute to the literature on efficiency and productivity studies.

The first model is the Performance Index model, which belongs to the ratio analysis approach, where financial ratios were aggregated into a performance index. This index is superior to the single-dimensional financial ratio (Beaver, 1966; Altman, 1968; Barnes, 1987) because it can provide a multi-dimensional view on performance. It also differs from the usual DEA studies employing ratios as output variables and input is assumed to equal to one (Ozcan & McCue, 1996; Halkos & Salamouris, 2004), because it measures the absolute performance or efficiency of the examined bank, rather than the relative efficiency of DEA.

The second model follows the DEA approach, where financial ratios were used as both inputs and outputs of the DEA model. Our model is different from Avkiran (2011) because we employed the CAMELS system in defining the maximization and minimization ratios which will be treated as outputs and inputs, respectively. This variables selection process could overcome the issue of unlimited number of ratios (Paradi & Zhu, 2013).

Our third model measures and decomposes the productivity and its change over time using the Fisher Index approach. Traditionally, productivity and its change were measured following two steps: (i) DEA was used to calculate the “intertemporaneous” (Tulkens & vanden Eeckaut, 1995b) efficiency of individual DMUs in each year and (ii) Malmquist Index of productivity over time was calculated between two years using the distance function technique. The thesis showed that we can measure the productivity change by (i) calculating the “k-specific intertemporal” (Färe *et al.*, 1985; Tulkens & vanden Eeckaut,

1995a) efficiency of a DMU in several years using DEA and (ii) employing the obtained “shadow prices” to calculate the Fisher Index of productivity over these years. Additionally, our decomposition of the FI TFP helps reveal the role of allocative efficiency which was not measured in Fare *et al.* (1994). Evidence from the Vietnamese banking system suggests that this new model could provide additional information on the performance measures, especially when the number of examined DMUs is limited.

5.3 Thesis limitations

The thesis, however, still faced some challenges and difficulties that limit its research scope. There is the difficulty in obtaining banking-level data prior to 2000 due to the under-development of the Vietnamese financial and banking system at that time. It also includes the problem of the dual-financial reporting systems, the International Financial Reporting Standard (IFRS) and the Vietnamese Accounting Standard (VAS), which sometimes makes it difficult to unify the observed financial data, especially in early 2000s. The challenges and limitations also includes the difficulty of collecting data at the bank branch level, obtaining data from foreign-owned banks, or defining suitable CAMELS, etc. Therefore, while they are left out in this thesis, there is a need for future research on those matters.

5.4 Suggestions for future research

The thesis has examined the performance of the Vietnamese banking system during its financial liberalization. It could be interesting if analyses on other countries with similar economic conditions, e.g., Indonesia, Malaysia, Philippines, could also be done hence we can have a comparison within the region. In this case, we could also test for a common frontier between ASEAN countries as well as determine the factors that can affect the national banking systems.

The thesis also provided evidence about the advantages of our new research models (see section 5.2), however, as discussed in the previous section, our research sample on the Vietnamese banking system was still small and the data was still limited. Therefore, it would be desirable to test these models on a bigger sample, for example, the U.S. commercial banking system. This kind of research will help strengthen the robustness of our research models and thus our research findings.

Our second-stage DEA studies employed Tobit regression under the assumption that DEA efficiencies are bounded between 0 and 1 (Fethi & Pasiouras, 2010). Ramalho, Ramalho, and Henriques (2010) and Ramalho and Silva (2013), however, argued that the fractional regression models should be the most natural way of modelling bounded and proportional DEA measures. This is therefore caution to test for the use of fractional regression in the second-stage of our DEA models in the future.

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