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In order to demonstrate efficiency concept, this study supposed that under constant return to scale assumption there is a set of banks which utilize two inputs to produce one output as in Figure 10. The Isoquant contains a variety set of normalized input choices which can produce one unit of . The production possibility set if bounded by this line due to the fact that inputs cannot be reduced any more to generate a unit of . The dashed line which contains is the budget line. It represents a set of input choices which incurs same cost. This section assumed that there are two banks which can operate at P and Q respectively. Up to this point, the questions: whether those banks are efficient or not, if efficient, which method can decompose efficient into other kind of efficiency in terms of cost and scale, and whether a bank is more efficient than another one, have been remained unanswered. W. W. Cooper, L. M. Seiford and J. Zhu (2011) mentioned the definition of efficiency which is extended of Pareto-Koopmans’ one as follows: Definition 1 (Efficiency–Extended Pareto-Koopmans Definition): " Full (100%) efficiency is attained by any DMU if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs" (W. W. Cooper, L. M. Seiford and J. Zhu, 2011, p. 3). This definition enables DEA to establish relative efficiency without concerning about the weights or the importance of inputs and outputs. However, in reality, W. W. Cooper, L. M. Seiford and J. Zhu highlighted that the true efficiency is unknown particularly in social science as well as in management. Hence, they mentioned another definition which extended this one so that DEA can rank efficiency based on practicality of data without prior understanding of theoretical level of efficiency. Definition 2 (Relative Efficiency). " A DMU is to be rated as fully (100%) efficient on the basis of available evidence if and only if the performance of other DMUs does not show that some of its inputs and outputs can be improved without worsening some of its other inputs or outputs" (W. W. Cooper, L. M. Seiford and J. Zhu, 2011, p. 3). According to Definition 2 – relative efficiency, the banks which operate on the frontier line is relative efficient to the others. This is known as basic efficiency or technical efficiency. Besides, when having prior knowledge of units cost, it is possible to make a connection between technical, allocative and overall efficiency to have more comprehension about efficiency.

## 3. 1. 2. 1 Technical efficiency, allocation efficiency and cost efficiency

Farrel (1957) suggested two measurement of efficiency: technical efficiency and allocation efficiency. Technical efficiency is a scalar measurement which is related to the ability of employing minimum inputs to produce a given unit of outputs, while Allocation efficiency is a scalar measurement which is related to the ability of choosing optimal ratio of inputs which minimizes total cost incurred when producing a given unit of outputs. Firstly, In Figure 10, the bank which operates at is not efficient. This is because, inputs consumed by this bank can be reduced to point without worsening output . Farrell (1957) suggested that the ratio of is technical efficiency (TE) for the bank which operates at P. since P belongs to the production possibility set, therefore, TE ratio is always less or equal than . Secondly, point is where the optimal ratio of inputs cost lies on. The bank that operates at the intersection minimizes the total cost consumed, consequently; if reducing inputs by , the bank will gain allocative efficiency or price efficiency. The ratio of is known as allocation efficiency. Thirdly, the ratio of is called overall efficiency or cost efficiency.

## 3. 1. 2. 2 Scale efficiency

In his study, Farrel (1957) assumed that the production exhibits a constant return to scale. If a bank can produce , then is also feasible. This assumption, however; is a scarcity in reality. This is because it is achieved only when banks operate at optimal scale; the reasons for this are imperfect competition, and financial restrictions (David A. Grigorian and Vlad Manole, 2002). Moreover, Banker et al (1984) highlighted that when measuring efficiency with constant return to scale, the efficiency of scale is included embraced into it. Therefore, they innovated new model – variant return to scale (VRS) which adds convexity condition on the model to divide technical efficiency (TE) into scale efficiency (SE) and pure efficiency (PE or ) and spate them from each other. The drawback of this method is that, although it is known that a DMU is operating at scale efficiency or not, it is unknown that whether an inefficient scale DUM is operating at decreasing ore increasing return to scale (L. R. Murillo-Zamorano, 2004). This is why another model – non-increasing return to scale need to be solved (the models with different assumption: CRS, VRS and NIRS will be represented in the below section). A DMU which has is operating at efficient scale, a DMU which has is operating at increasing return to scale and a DMU which has is operating at decreasing return to scale.

## 3. 1. 2. Data envelopment analysis

The development of Farrel (1957) in efficiency measurement, which dealt with only sing input/output case, was not highly practical. This is due to the fact that DMUs often consume multiple inputs to produce multiple outputs. Therefore, few researchers had paid much attention to this field until the development of DEA by Charnes et al (1978). DEA which is a non-parametric approach is a series of linear programming utilized to measure relative efficiency of Decision Making Units (DMU’s). A Decision Making Unit is referred to as an organizational unit which consumes similar variety of inputs to produce similar variety of outputs (Igor Jemrić and Boris Vujčić, 2002). In DEA, efficiency is measured relatively, which means other DMUs’ productivity will be assessed by the best performed DMUs forming the " best-practice" frontier. Charnes et al (1978), under threes assumptions of constant return to scale, convex production technology and strong disposability of inputs and outputs, suggested a ratio of weighted outputs (virtual output) over weighted inputs (virtual input) to measure efficiency of a as follows. Where are weights for inputs and outputs of . The optimal weights can be varied and different from other DMUs’ weights. The weights, Moreover; is determined from the observed data. DEA does not require a set of fixed weights in advanced. Estimated weights will maximize efficiency of , while satisfying that with the same weights of , efficiency of other DMUs will lie between and (Charnes et al, 1978).

## 3. 1. 2. 1 CCR Model

According to Charnes, Cooper and Rhodes, a fractional programming can be drawn as follows: Since () means () () will be the solution, this mathematical program have infinite solutions. Charnes et al (1978) suggested that it can simply solved by converting it into linear programming. This can be done via normalizing the numerator or denominator. If the objective is to maximize the weighted sum of outputs, the problem becomes Output-oriented DEA; otherwise, if the objective is to minimize the weighted sum of inputs, the problem is Input-oriented DEA. Based on study of Charnes et al (1978), through normalizing the numerator, the problem is equivalent toIf and are inputs and outputs matrix respectively, can represent in Matrix form: Finally the dual problem of this problem is: When solving the optimal value is the efficiency score of . If is equal to then the is considered to be relatively efficient; whereas if is less than (due to the constraints, ) lies between and ) then the is said to be relatively inefficient. The efficient DMUs will construct a " best-practice" frontier which is the frontier production function (Igor Jemrić and Boris Vujčić, 2002). This model originally developed by Charnes et al(1978) was known as CCR model. which is under the CRS technology is referred as technical efficiency or

## 3. 1. 2. 2 BBC Model

which is under the VRS technology is referred as technical efficiency or . As mentioned above, the convexity condition in this model is that .

## 3. 1. 2. 3 NIRS Model

which is under the NIRS technology is referred as technical efficiency or . The NIRS model differs from BBC model or VRS model and CCR model is that .

## 3. 2. Production possibility set and Malmquist total factor productivity index

## 3. 2. 1. Production possibility set

Suppose that we have domestic banks which consume inputs to produce outputs at time . K. Tone (2004) introduced an integrated production possibility set with the assumptions that , for all and that each DMU has at least one positive input and one positive output: Where is unit row vector in , is semi-positive in and are upper and lower bound which determine different kinds of DEA model, corresponding to CCR, BBC, IRS and DRS models respectively, takes four values and .

## 3. 2. 2. Malmquist total factor productivity index

Up to now, only how to measure efficiency has been introduced in this paper. However, it has not mentioned any methods to calculate the productivity growth of banks from one period to another period. As regards time series data, it is necessary to establish an index to measure productivity growth and decompose it into specific sources of change for a better understanding of how productivity change. Consequently, this paper utilizes Malmquist total factor productivity (TFP) index to perform the calculation of productivity change, which is based on the application of DEA to evaluate the distance function (For more extension of decomposition technique of Malmquist TFP see C. A. Knox Lovell (2003)). It is equal to: Where EFFCH is the relative efficiency change index, or catch-up effect and TECHCH is the technological change or frontier-shift effect. Note that: means relative efficiency makes progressed, whereas implies no change in relative efficiency and finally, indicates a deterioration in relative efficiency. means technological innovation, implies no change or status quo, while indicates a deterioration in technology. implies improvements in TFP of the decision making unit (DMU) from t to t+1, means there is no change in TFP and finally, indicates that TFP deteriorates.

## 3. 2. 3. Malmquist TFP with DEA

To calculate the TFP index change between two periods of time, and , K. Tone (2004), in his paper suggested a method, the radial MI (Malmquist index), in which four distance functions: , , , which base on DEA technique, have to be computed. As the result of this, we solve 4 problems below.

## 3. 3. Chance-constrained data envelopment analysis

Chance-constrained Data Envelopment Analysis (CCDEA) was developed to solve the disadvantage of non-stochastic variation of inputs and outputs in the deterministic DEA model. As mentioned in the Introduction section, the major drawback of deterministic DEA is that it does not allow efficient units to be out of the frontier. To deal with misspecification and measurement error, chance-constrained programming emerged, dating back to Charnes and Cooper (1959), C. A. Knox Lovell (1993). Chen (2002) made an comparison between chance-constrained DEA and stochastic frontier analysis to evaluate the performance of banking system in Taiwan. Chen (2005) used Chance-constrained DEA results to calculate Malmquist TFP for 46 banks in Taiwan: With assumptionsInputs are deterministic. Dependence between the performance of banks, for all and . Variance of each stochastic output of all outputs is equal to 1, at all banks, that means: . Observed outputs functions as an unbiased estimate of real performance, .

## 3. 4. Uncertainty in both input and output – the extension model

In reality, the process of production usually contains unsystematic factors (K. C. Land et al (1993)). There is not only the stochastic variation in outputs but also the stochastic variation of inputs. This is due to the fact that inputs are merely the results of other production process. For example, in agriculture, stochastic variation of outputs can be caused by unpredictable weather. Stochastic variations of inputs like cultivation time, amount of fertilizer and pesticide are affected by the dissimilarity of each famer’ behavior and experience. In education, it is reasonable to find out that even two schools with similar student requirement entrance and teachers’ education level have different number of students who pass university. In banking system, loan and deposit can be affected by customers’ behavior like crowd psychology which is not fully captured. Therefore, this section extend the model of Chen (2005) by taking into account both input and output as stochastic to measure the efficiency for 33 domestic banks in Vietnam. Hence, 4 new problems have to be solved. With 3 assumptions: Dependence between the performance of banks, , for all and . Variance of each stochastic output of all outputs is equal to 1, at all banks, that means: , Observed outputs , functions as an unbiased estimate of real performance,

## 3. 5. Comparison between three Models

After estimating efficiency scores of three models, model A, model B and model C, this paper conducts two Banker’s asymptotic statistical tests (Banker, 1993) to assert that whether there is any difference between efficiency between three models. Test1. Assumption. The three inefficiency scores , which are calculated from three models A, B, C distribute exponentially with parameters respectively. The test statistics follows the F-distribution with degree of freedom: Test 2. Assumption: The three inefficiency scores , follow half-normal distribution. The test statistics follows the F-distribution with degree of freedom as below for each case:

## 3. 6. Analysis of factor affecting Vietnamese commercial banks’ efficiency

After evaluating efficiency through deterministic DEA and chance-constrained DEA, this paper conducts Tobit regression method to determine which factors influence 33 Vietnamese banks’ efficiency. The reason for the selection of Tobit model is that it allows estimation of the dependent variable (efficiency) which lies between and .

## 3. 6. 1. Variables selection

The selection of variables is based on CAMELS – evaluation criteria which contains C – capital adequacy, A – asset quality, M – management quality, E – earnings, L – liquidity and S – sensitivity to market risk. Besides, this paper follows Fethi et al (2000), N. V. Hung (2006) paper and Chen (2011) in selecting variables as below.: A dummy variable will represent the ownership status of a bank. means SOCBs, while means the others. This variable is taken into the Tobit model to test the hypothesis that whether ownership affects banks’ efficiency or not.: the proportion of business profit over business cost which reflects the ability of adjusting inputs and outputs to achieve efficiency is included into the model. A bank will gain more efficiency if it can keep this ratio as large as possible.: Capital adequacy ratio or the capital intensity – the ratio of equity over total asset. De Young et al (1997) highlighted that rising perilousness of loan portfolio of banks which have relatively limited capital is considered to be a moral-hazard incentive. This activity can make profit as well as efficiency for banks in short run, whereas in long run it will cause nonperforming loans to be high. Therefore, this variable is included into the model to represent the capital strength of a bank.: The proportion of a bank’s total asset over total asset of all observed banks. This variable is put into the model to test whether market share affects banks’ efficiency or not.: The proportion of loan to total asset. Saibal Ghosh (2009) highlighted that one of the most un-safe asset of a bank is loan and an increase in this ratio means that banks will face to more risk in the balance sheet. However, if a bank can cautiously manage it own loan sufficiently, it will increase interest income, profit as well as loan market-share. As a result, this ratio reflects management ability of banks’ managers.: The ratio of fixed asset over total asset of a bank. It is used to analyze risk and efficiency, if this ratio is high the probability. During the period of 2006 to 2010, there are changes in macroeconomics and banking technology, four dummies variables - and represent for 2007, 2008, 2009, 2010 respectively will be included into the model. The weakness of this study is not including non-performing loan which can significantly impact on efficiency, into Tobit regression model. This is because bad loan is a variable which is particularly complicated to collect in Vietnam for a continuous period of years. Secondly, in Vietnam, four SOCBs dominate the market, with their total asset being at around 66% over the studied period. Therefore, the variable and are closely corrected at around 0. 91. This is why this paper, in Tobit regression in empirical study, does not include into the model.

## CHAPER 4. EMPIRICAL STUDY

## 3. 1. Model specification

Joseph C. Paradi, Sandra Vela and Zijiang Yang (2003) when analyzing early works of other researchers on bank and bank branch performance using DEA approach, highlighted that inputs and outputs are chosen differently according to variety of behavioral objectives. Behavioral objectives include: Production approach: each bank branch or DMU utilizes labor and capital to make loans and deposits. Intermediation approach: taking into consideration of the procedure of transforming deposits into loans. Profitability approach: considering the revenue that DMU makes by utilizing labor, assets and capital. This study employs the Intermediation approach to determine inputs and outputs of above models. The Intermediation approach takes into account the procedure of transforming deposits into loans, considering banks as a financial intermediary (Berger and Humphrey, 1997). There are some reasons for this selection. First, the study wants to focus on bank’s function as a financial intermediary. Second, according to Berger and Humphrey (1997) when examining efficiency of different banks, intermediation approach is more sufficient than other approaches because it incorporates interest expense which contributes to about to of total operation cost. Based on Chen (2005) and Mlima and Hjalmarsson (2002), when applying the Intermediation approach, this study determined inputs and outputs as follows: From the Table 1 above, it is noticeable that multicollinearity problem will occur if all inputs and outputs are chosen. This is because, deposit mainly contributes to Interest expense; Number of staffs is highly correlated with employment payment or wage; Received interest revenue is largely due to Loan (Chen, 2005). As a result, the paper carries out a sensitivity analysis from Chen (2005) to decide which inputs and outputs to choose. This procedure consists of following steps: Computing technical efficiency of 7 models, in which model A is based one. Computing Spearman Rank Correlation Coefficients between those models. Find out the most sufficient model with rejection criteria: Rejected model has results which highly correlated with the results of model A and/orRejected model has more number of efficient DMUs than model A. With 33 domestic banks and using average 2010’s data, the result of this procedure is listed below: Based on 2 criteria introduced by Chen (2005), model 1 or model 4 can be utilized. It is reasonable due to the fact wage and number of employments can be a proxy for each other. This study will use model 1; consequently, 3 inputs (Employment payment, net fixed assets and Deposits) and 2 outputs (Loans and Non-interest revenue) will be employed.

## 3. 2. Descriptive statistics

Number of Vietnamese banks varies each year because some new banks open and some banks closed or merged. This dataset only contains the banks which continuously operate from 2006 to 2010. The data used in this study is from annual report of 33 domestic commercial banks in Vietnam from 2006 to 2010. As the scope of this study only focus on domestic banks in Vietnam, there are only two types of banks in this study, including 4 state-owned commercial banks and 29 joint stock commercial banks. There are five variables will be selected in this thesis, including three input variables and two output ones. The inputs include net fixed asset, wage and deposit, while the outputs are loan and non-interest revenue. Net fixed asset is taken approximately by subtracting loan and investment from total asset (Chen, 2005). All variable is measured in Million Vietnam Dong. Adjustment of the data is Vietnam GDP deflator which takes 1994 as the based year.

## 3. 3. Estimation of the results

After selecting models’ variables for 33 domestic commercial banks in Vietnam from 2006-2010, technical efficiency, scale efficiency, pure efficiency and total factor productivity are estimated for 3 models – CCDEA with stochastic constraints for both inputs and outputs (Model A), CCDEA with stochastic constraint in outputs (Model B) and DDEA (Model C). The estimation process is programmed with Matlab 2009 (see Appendix 2 for more detail of the results of efficiency estimation). Furthermore, the paper conduct Banker’s asymptotic test of difference in efficiency score and find out that the results of three Models concur with each other. Section 3. 3. 1 and 3. 3. 2 will introduce the result from chance-constrained model (Model A), the result of Model B and Model C will be introduced in section 3. 3. 3 to compare between three model. After that, Banker’s asymptotic test will be conducted to make a statistical comparison between them in section 3. 3. 4. Finally, section 3. 3. 5 will analysis factors that affect Vietnamese banking system’s efficiency.

## 3. 3. 1 Analysis of efficiency estimates

Table 4 shows that on average, 33 Banks in Vietnam operated under the efficient frontier. The deterministic DEA overall efficiency score or technical efficiency score was 0. 77, implying that inputs were wasted at around 23% of inputs to produce the same amount of outputs. As regards different types of ownership, although some JSBs are known as more actively than SOCBs, when taking JSBs altogether, the results represent contrarily. In the studied period, SOCBs technical efficiency score was higher than that of JSBs, with the difference being around 10. 5%. Besides, since technical efficiency is the multiplication of scale efficiency and pure efficiency, those values reflect how efficient Vietnamese banks were. From Table 3, average pure efficiency during 2006-2010 was less than scale efficiency (0. 836 and 0. 922 respectively); therefore, scale efficiency had greater effect on overall efficiency than pure efficiency. In other words, pure efficiency was the main source of inefficiency in the Vietnamese banking system. The results also exhibits that scales efficiency was the main contributor to JSBs’ overall efficiency (0. 923), it, however, had an adverse effect on SOCBs’ efficiency score. The situation was inversed with the pure efficiency. SOCBs demonstrated that their management of allocating resources is better than that of JSBs, with the pure efficiency score of SOCBs and JSBs being at 0. 940 and 0. 822 respectively. As regards scale efficiency, 33 Vietnamese commercial banks are divided into three groups each year, from 2006 to 2010. The criteria depends on the total asset of these banks – 11 banks with lowest total asset, 11 banks with medium total asset and 11 banks with largest total asset. Firstly, Table 4 shows that there was a trend of operating at decreasing return to scale for the largest asset-group. The percentage of banks which operated at decreasing return to scale was 100%, 90. 9%, 72. 7%, 63. 6% and 72. 7% in 2006, 2007, 2008, 2009 and 2010 respectively. This means that to achieve scale efficiency, 11 banks whose own largest total assets should decrease their size and concentrate on improve new sophisticated and high quality services. Secondly, from Table 4 it is noticeable that the middle asset group, if exclude the financial crisis year 2008, was continuing their increasing return to scale. The percentage of banks which had increasing return to scale was increasing over time, with the number being at around 36. 4%, 45. 5%, 72. 7% and 54. 5% in 2006, 2007, 2009 and 2010 respectively. Particularly, in 2010, in this group, there was 36. 4% of banks operating at efficient scale. Consequently, these banks could expand their sizes in order to gain scale efficiency. Thirdly, the pattern of the lowest asset group was unstable during studied period. This is due to the fact that these banks with low total asset were the most vulnerable ones to macroeconomic changes and SBV’s policies. SVB’s policy – interest rate cap, for example, which can cause these banks to be faced with liquidity shortage and puts pressure on raising capital for them.

## 3. 3. 2 Analysis of productivity enhancement

The result in Table 5 exhibits that there was a small deterioration of 0. 5% in Malmquist TFP index, with the number being around at 0. 995. Although there had a major contribution of scale efficiency growth (102%) and pure efficiency growth (103. 9%) to the TFP, technological regress (4. 9%) deteriorated it during the studied period. This means that bank’s technology was becoming the inefficient factor to banks’ productivity enhancement. The reason for this was that Vietnamese bank’s technology was underdeveloped compared to the development of sophisticated quality services like Online banking, Automatic transfer, Mobile banking, SMS banking, Call center and Master card pay-pass which require high implementation of new technology. Other reasons were that technological advancement was not fully employed during the studied period and that Vietnamese banks still used technology requiring a lot of labors. Regarding change in TFP during 2006-2010, it is noticeable that the culprit of the slightly deterioration in TFP was the financial crisis which happened in 2008. The number of TFP index in 2008 was only 0. 842 and this year was considered to be the most difficult one for Vietnamese banking system for the last 20 years. Banks had to be faced with a significant number of changes in government’s policies. For example, there were three decreases and five increases in based interest rate and the situation was similar for refinancing interest rate and re-discount interest rate. Additionally, the government’s policies on interest rate cap had caused liquidity shortage in a lot of banks and led to an interest rate race during this time. Furthermore, when considering the progress of different types of Vietnamese banks: SOCBs and JSBs from Table 5, the estimated result shows that both JSBs and SOCBs did not make any improvement in TFP index during 2006-2010. SOCBs’ TFP index was around at 99% while JSBs’ TFP index was 99. 6%. The TFP index of JSBs on average was slightly higher than that of SOCBs about 0. 6%. This implies that JSBs’ employment of input resources was becoming better than SOCBs. Additionally, JSBs continued to improve their management of allocating resources (PECH= 1. 058), whereas SOCBs did not (PECH= 0. 974).

## 3. 3. 4 Model A, Model B efficiency and productivity enhancement

## Table 7 shows the average efficiency from three models – Model A, Model B and Model C. It is noticeable that there is merely a little difference between efficiency scores from three models. The efficiency scores are decreasing from Model A to Model B and then Model C. This is because the production frontier in three models are different, with the Model A frontier line is softer than that of Model B and that of Model B is softer than that of Model C. In other words, Model A and Model B allows at some probability level that an efficient DMU can lie outside the frontier line; however, Model C does not (Chen, 2011).

As for Mamquist productivity index, the same situation happens to the results of three models, with the malmquist TFP indices are 0. 99505, 0. 99653 and 0. 99680.

## 3. 3. 4 Comparison between three Models

From section above, it is necessary to find out whether the efficiency scores from three models are different or not. Conducting Banker (1993) asymptotic test for 2006’s efficiency scores, comparison between three models A, B and C is showed in the table below. The null hypothesis is accepted for both exponential and half-normal distribution of efficiency; therefore, there are no difference between efficiency results in three Model A, B and C. This means that for the data of Vietnamese banks from 2006 to 2010, there are no difference in efficiency scores between deterministic DEA and chance-constrained DEA. Although the chance-constrained DEA is integrated with a flexible production frontier and the stochastic behavior of banks as well as customers, similar structures are implemented in both chance-constrained DEA and deterministic DEA. Consequently, the results can concur with each other (Chen, 2011).

## 3. 3. 5 Factors affecting Vietnamese banks’ efficiency during 2006-2010

After estimating efficiency through three models, the CCR efficiency scores from them will be employed as a dependent variable in three Tobit models to determine which factors have effect on it. Since the efficiency scores rage from zero to one, therefore Tobit model is utilized. Below, three estimated models which take efficiency scores from model A, B and C respectively will be presented. Firstly, the ratio of business revenue over business cost is positive and statistically significant at 1% level. As this ratio represents the ability of adjusting inputs and outputs to achieve efficiency, a Vietnamese bank can gain efficiency through efficiently managing their functional form between them. Secondly, the capital adequacy which is measure by equity over total asset has significant positive effect on efficiency. The key cause is that when acquiring sufficient capital, banks may overcome the moral-hazard incentives which can cause damage to banks’ efficiency (Berger and De Young, 2010). In their study they highlighted that thinly capitalized banks tend to make profit through investing on high risk loan portfolio, bringing them efficiency and profit in short-run. This, however, causes higher non-performing loan in long-run which has adverse effect on these banks’ efficiency. This result implies that, in short run, a bank can be more efficient if it can increase its capital adequacy ratio. Thirdly, market-share coefficient is statistical significant at 10% level. As a result, a bank which dominates the market will have higher efficiency. This is due to the fact that a bank with large market share will enjoy its reducing operation cost and making larger profit. Fourthly, loan to total asset ratio is found having significant effect on efficiency, with the level of significance being at 1%. This suggests that major profit of Vietnamese banks is still interest revenue. Therefore, increasing loan to a sufficient level will increase efficiency. Fifthly, non-interest revenue over total asset is statistically significant at 1%. This ratio represents for the diversification of banks’ operations. Basically, banks in Vietnam mainly earn profit by making loan. However, in a highly competitive financial market these days, with the foundation of a number of new banks and the emergence of foreign banks, deposit and credit market have to be divided smaller among these banks. Banks which want to attract customers have to increase quality of services as well as to expand other sophisticated products needed to satisfy their customers. Consequently, this ratio exhibits that more efficiency can be achieved through expanding other high quality services along with traditional services such as making loan.

## CHAPTER 5. CONCLUSIONS

Two approaches to data envelopment analysis – deterministic and chance-constrained DEA are employed in this paper to asset 33 Vietnamese domestic banks from 2006 to 2010. While deterministic DEA considers the multiple inputs and multiple outputs as pre-determined, chance-constrained DEA takes into account the stochastic variation of them. Therefore, it expands the deterministic DEA problem by adding the procedure that only with a probability of an inefficient bank will do better than the production frontier. This leads to the problem which can convert to a set of non-linear program. Employing both methods, this paper finds that observed banks, on average, operated under efficient frontier, with the results from chance-constrained DEA in both outputs and inputs (model A), chance-constrained DEA in outputs (model B) and deterministic DEA (model C) being at and respectively. In other words, observed banks waste 33% (Model A) of input resources to produce the same amount of outputs. Additionally, the results show that there is a decreasing return to scale to which ten largest capitalized observed banks have to face in each year; the situation is reversed for the middle capitalized ones which face to increasing return to scale. Moreover, since the Malmquist TFP from model A is , implying that 33 Vietnamese banks experience a degradation in productivity at As regards ownership, the SOCBs is found to be more efficient than JSBs with the efficiency scores being at and respectively. JSBs, however, are utilizing their resource more efficiently, with its malmquist TFP being greater than that of SOCBs at around 0. 6%, whereas JSBs are enjoying their enhancement in pure efficiency, SOCBs, in contrast, are enjoying their scale efficiency enhancement. Using Banker’s asymptotic tests are conducted to test whether these models are distinctive or not. The test results show that with Vietnamese banks’ data from 2006 to 2010, there is no difference between them. Nevertheless, the variability in banks’ efficiency has been included into chance-constrained DEA model which overcomes the disadvantage of deterministic DEA. In addition, Tobit model is conducted to explain for the underlying causes of efficiency of Vietnamese banks, giving significant suggestions to banks’ managers. The paper finds that profitability of banks is an indicator of higher overall efficiency. Strongly capitalized banks have greater efficiency than thinly capitalized banks. A bank’s loan to total asset ratio and market share positively affects its efficiency. Also, the fact that a bank diversifies its services is another factor causing efficiency