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Does ownership affect bank performance? An analysis of Vietnamese banks in the post - WTO entry period

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Abstract
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Keywords
period, post, entry, banks, vietnamese, analysis, performance, bank, affect, ownership, does, wto

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Does Ownership Affect Bank Performance? An Analysis of Vietnamese Banks in the Post-WTO Entry Period

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This study investigates the impact of financial reforms, bank characteristics, and time trends on the performance of the Vietnamese banking sector under the assumption that ownership can result in a divergence of technologies utilised by different bank groups (including state-owned, private, and foreign banks), and the fact that these groups may respond differently to the same environmental variables. By combining a meta-frontier analysis with double-bootstrap two-stage DEA the authors analyse the impact of environmental variables on bank efficiency across separate groups operating under different technologies. Accordingly, this paper, firstly, employs ownership as an ex ante rather than an ex post factor as used in all earlier studies when examining the influence of this environmental variable on bank efficiency. Using data for Vietnamese banks covering the period 2007-2012 our results show that the performance of bank groups is significantly different, and that state-owned banks are more efficient and have a smaller technology gap to the meta-frontier in comparison with foreign and private banks. Moreover, these different bank groups react dissimilarly to a number of variables, for instance, state-owned banks have a negative, while private banks have a positive, relationship to the loan to asset ratio.

JEL Codes: G21, D24

Keywords: Vietnam, bank efficiency, meta-frontier, data envelopment analysis, bootstrap, regulations, business environment

1. Introduction

O'Donnell *et al*. (2008) state that characteristics of the physical, social and economic environment in which production takes place can result in different technologies being used by firms in different industries, regions and/or countries. These authors highlight the impact of the operating environment on firm efficiency and conclude that "such differences have led efficiency researchers to estimate separate production frontiers for different groups of firms" (O'Donnell *et al*., 2008, pp.231-232). In the banking sector, ownership type is an important characteristic of the business environment that can influence the performance and differentiate the technology sets of banks. However, an important research question is how significant is the impact of type of ownership on bank performance? In developed countries where the banking sector is fully or mostly occupied by the private sector, and, due to a competitive and transparent business environment, all banks regardless of their ownership are treated equally, the impact of type of ownership on bank operations is trivial. Accordingly, in such circumstances, we suppose that the technology sets are the same across different ownership types of banks.

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However, in a handful of transition and newly emerging economies, such as Vietnam's, the banking sector is still dominated by state-owned commercial banks (SOCBs), while transformation to a competitive and privately-controlled banking sector has been implemented in most other transition countries (Bonin and Schnabel, 2011). This difference can be explained by different policies adopted. If governments conduct consistent reform measures to construct a competitive and fair business environment for banks, private banks (PBs) with profit-based incentives are expected to perform better than their publicly owned counterparts and play a more substantial role in the banking sector (Bonin *et al*., 2005a; 2005b; Denizer *et al*., 2007). On the other hand, governments desiring to maintain control and exert influence over the banking sector for political or other purposes would implement supportive measures for SOCBs and discriminate against domestic and foreign private banks (Karas *et al*., 2010; Vernikok, 2012). The consequence of this is that a level and homogenous business environment for SOCBs and PBs groups cannot be created. In a case such as this, we assume that the SOCBs and PBs groups are likely to operate under different technology sets and this requires us to estimate bank efficiency separately based upon different bank groups.

In the bank efficiency literature, earlier studies have considered ownership as an *ex post* factor in regression models (see, for example, Kraft *et al*., 2006; Das and Ghosh, 2006; Sturm and Williams, 2004; Denizer *et al*., 2007; Kumbhakar and Wang, 2007; Berger *et al*., 2009; Azofra and Santamaria, 2011; Barry *et al*., 2011; Bertay *et al*., 2014; Strobel *et al*., 2014). These studies analyse the effect of ownership on bank performance via a two-stage process; first, all banks are pooled to measure their efficiency and then bank efficiency, as the dependent variable, is then regressed against a set of explanatory environmental variables including ownership. Consequently, the impact of a particular variable on bank performance is similar regardless of ownership. This approach, however, seems to be inconsistent if bank ownership types respond differently to the same variable. The reason for this inconsistency is that bank groups under different ownership may operate in different environments which differentiate them by regulations, strategy, management objectives and capability of accessing the production frontier. Thus, it is reasonable to separate banks by ownership before regressing bank efficiency against a set of environmental variables.

In this paper we apply the meta-frontier approach of O'Donnell *et al*. (2008) which allows for measuring and analysing the impact of explanatory variables on bank efficiency in separate groups classified by ownership criterion. In addition, we choose a truncated regression suggested by Simar and Wilson (2007) (the so-called double-bootstrap two-stage DEA) as the appropriate method that can overcome the biased nature of DEA estimates in comparison with OLS and Tobit methods. To investigate the better performing groups, we use the test of Simar and Zelenyuk (2007) that is based on aggregate technical efficiency and the subsampling bootstrap technique.

This paper contributes to the theory of bank efficiency in several unique ways. First, it shows how to apply the method of aggregating technical efficiency in a banking system to measure and compare the bank efficiency of different sub groups. Second, by combining the meta-frontier analysis with double-bootstrap two-stage DEA, the authors provide a new approach to analyse the impact of variables on bank efficiency in separate groups operating under different technologies. Accordingly, this paper employs ownership as an *ex ante* rather than an *ex post* factor, unlike previous studies, when examining the influence of this environmental variable. This approach originated from the fact that different forms of ownership can result in a

divergence of technologies utilised by bank groups and different responses to the same explanatory variables (e.g, credit policy, loan to asset ratio).

Data for Vietnamese banks from 2007-2012 is utilised in this paper. This is because this country is still in a transition process to becoming a fully market oriented economy. The State owned enterprise sector (SOE), including SOCBs, plays a central role in Vietnam' economic development strategies and the Government expects the sector to be the key driver of growth; and to be the material force for the State to orient, regulate and stabilise the macroeconomy (Beresford, 2008; Anh *et al*., 2013). By transforming SOEs in general, and SOCBs in particular, into business groups and eventually sizable corporations, the State has not only favoured them with many resources (especially land, capital, credits, public purchase contracts) but has also created an unfair field of competition, notably a legal framework and policies that discriminate against the private sector, especially domestic private enterprises (Anh *et al*., 2013). Thus, we assume that ownership has significantly influenced banking operations and resulted in divergent technology sets for state-owned, private, and foreign banks.

The structure of this paper is as follows. Section 2 overviews the Vietnamese banking sector since this country abandoned its centrally planned economy and adopted a market oriented economy. Section 3 reviews previous studies on Vietnamese bank efficiency. Section 4 describes the data, specifies inputs/outputs used to measure bank efficiency and specifies explanatory variables used in regression models. The methodology utilised, including theories of the meta-frontier, double-bootstrap two-stage DEA is presented in section 5. Section 6 includes the empirical results and analysis. Lastly, Section 7 concludes, highlighting the key findings from this paper.

2. Vietnamese banking sector

At its sixth National Congress in December 1986, Vietnam's Communist Party made a decisive step to abandon its centralised economic model and to adopt a socialist market-oriented economy – which became known as "Doi Moi" (Renovation) (Harvie and Hoa, 1997; Beresford, 2008). Accordingly, the mono-bank system, which only served the needs and demands of the state sector, was split into a two-tier banking system with the State Bank of Vietnam (SBV) playing the role of central bank on one tier and state-owned commercial banks (SOCBs) on the other. The new system permitted private banks in the form of joint stock banks (JSBs) and foreign banks through a limited presence in joint-venture banks. In the 1990s a large proportion of SOCB loans were allocated to inefficiently operating state-owned enterprises (SOEs) as a legacy of the period of central planning (Oh, 1999). JSBs not only faced difficulties in terms of financial capacity but also in terms of management capability. The East Asia Financial Crisis (EAFC) and an economic slowdown between 1998 and 2000 provided impetus for the government to reform the banking sector (Kovsted *et al.*, 2005). The reform measures included building a consistent regulatory and supervisory framework; improving the quality of domestic banks, especially focusing on SOCBs through separating policy lending, writing off bad loans, recapitalisation and technical support, risk management and other governance issues. However, the banking sector remained off-limits to overseas investors.

The country's entry into the WTO in January 2007 resulted in an increased presence of foreign banks from April 2007, when 100 per cent foreign-owned banks were allowed to operate in Vietnam (Pincus, 2009). This entry also prompted additional reforms to enhance the

competitiveness and efficiency of domestic banks, including partial equitisation of the SOCBs and permitting foreign investors to become involved in the domestic banking sector through equity participation. Total foreign investment in Vietnam's joint-stock commercial banks, however, was limited to 30 percent of the bank's chartered capital.

Opening the banking market to foreign investment generated concerns about the competiveness of domestic banks. Both SOCBs and JSBs faced difficulties including low efficiency, out-of-date technology and limited capital. The government's 2006 Decree 141 intensively and rapidly increased the minimum notional capital levels of all credit institutions (NAEC, 2012; IMF, 2012). The decree states that any commercial banks that could not meet the levels by the end of 2010 would be forced to merge, reduce the scope of their activities, or have its bank license revoked. Consequently, all small JSBs struggled to increase their capital levels by up to 10 times in a five-year period (NAEC, 2012). Calling for equity participation from large banks, private business groups and SOEs became an appropriate measure which, in return, resulted in complicated and popular cross-ownerships with JSBs (NAEC, 2012; IMF, 2012). Most loans were allocated to related parties rather than to the most profitable projects, resulting in a higher non-performing loan rate for JSBs. A lack of regulations on cross-ownership and weak capability of supervisory departments worsened this situation. Lastly, low transparency in the banking environment easily generated corrupt activities between bankers and supervisors in order to "pass" stringent regulations. The SBV substantially loosened its regulations when permitting 13 rural banks to transform into urban banks during the period 2006-2007 (NAEC, 2012). In 2005, the total capital of these banks was estimated at 165 billion Vietnamese dong (VND), or 13.75 billion VND on average for each bank. However, according to Decision 141 issued in May 2006, by the end of 2008 each urban bank had to achieve a chartered capital level of at least 1000 billion VND and of 3000 billion VND by the end of 2010. Consequently, transformed banks raced to increase their capital and they called upon capital contributions from the big banks and business groups (mainly SOEs).

Overall, the banking sector was influenced remarkably by the post-WTO reforms in Vietnam. It was necessary to assess the effects of these reforms on banking performance and, accordingly, identify further policies that would further improve bank efficiency.

3. Vietnamese bank efficiency – a review of the literature

Most previous studies on Vietnamese bank efficiency have focused on the pre-WTO period 2000 to 2006, and covered two major aspects: efficiency measurement and analysing the effects on this of specified environmental variables.

Both the DEA and SFA (Stochastic Frontier Analysis) methods have been utilised in the literature to measure bank efficiency. Nguyen (2007) was the first study to investigate the efficiency of Vietnamese banks covering the period 2001-2003, with a limited sample of banks (13 out of about 50 commercial banks). Using a DEA method he found that the average bank technical efficiency score was about 60 percent, and the banks' inefficiency was associated with both allocative and technical problems. Nguyen and De Borger (2008) used a bootstrap technique to construct confidence intervals for DEA-based efficiency of 15 banks from 2003 to2006. They found that state-owned banks were more efficient than private banks. Vu and Turnell (2010) employed the SFA method to measure Vietnamese banks' cost efficiency. The bank sample in this study covered 54 banks and foreign-bank branches operating in Vietnam

during the period 2000-2006. They concluded that, on average, cost efficiency did not improve and SOCBs attained a higher efficiency level than private banks. Nalm and Vu (2013) reused the sample data of Vu and Turnell (2010) to estimate the efficiency and productivity of Vietnamese banks. Based on a directional distance function they measured profit efficiency and its sub components of technical and allocative efficiency. A generalised Malmquist productivity index was also derived and decomposed into pure technical efficiency change, scale efficiency change and technological change. The findings were: (1) in terms of profit efficiency, on average, banks operated quite far below the frontier of the best practice banks, mainly due to allocative inefficiency rather than technical inefficiency; (2) the price efficiency and profit efficiency scores of the SOCBs were much higher than JSBs and FBs due to their market power in setting prices; (3) during 2000-2006 the banking industry achieved modest productivity growth due to technological progress. Nguyen *et al*. (2014) used a DEA Window Analysis to measure bank efficiency from 1995-2011 using a sample of 33 banks. It was found that the state owned banks were more efficient than private banks and that the EAFC and later Global Financial Crisis exerted an insignificant effect on bank performance.

A few studies have analysed the effects of environmental variables on bank efficiency. Nguyen *et al.* (2013) estimated the efficiency of 32 Vietnamese banks during the period 2001-2005. The average efficiency score was found to be about 80 percent. Furthermore, they employed a Tobit model investigating the association between ownership type, bank size, labour quality and market share on bank inefficiency. They found that state ownership negatively affected efficiency, and bank size and market share had a positive relationship with efficiency.

All of the aforementioned studies, however, ignored the effect of WTO-entry reform measures on Vietnamese bank efficiency. Besides, the banking environment is considered homogenous in all these studies while as mentioned before this is not the case in the Vietnamese banking industry. Therefore, this paper contributes to the literature by investigating bank performance in Vietnam under the assumption that ownership type can differentiate the technology sets of banks using the double-bootstrap two-stage DEA approach proposed by Simar and Wilson (2007) and the meta-frontier approach suggested by Battese and Rao (2002), Battese *et al*. (2004) and O'Donnell *et al*. (2008). This technique has never been applied to investigate banking performance in a highly discriminatory banking environment as is the case in Vietnam.

4. Methodology

4.1 Metafrontier analysis

4.1.1 The metafrontier

In general terms this research considers an industry consisting of n firms. Each firm employs p inputs to produce q outputs. Let $x \in \mathbb{R}_+^p$ denote a (1×p) vector of inputs and $y \in \mathbb{R}_+^q$ denote a (1×q) vector of outputs. Under a given technology, the production set of the industry can be defined by:

$$\wp = \{(x, y) \in \mathbb{R}_+^p \times \mathbb{R}_+^q : x \; can \; produce \; y\} \qquad (4.1)$$

The production set is built using two components: boundary and interior. The production boundary (or metafrontier) is identified by the best-practice firms or efficient firms. It is

convenient to represent the technology using the output-oriented[1] distance function and technical efficiency of firm k as being equal to:

$$D_o^k(x^k, y^k) = inf\{\theta^k : (x^k, y^k/\theta^k) \in \wp\} \ (\theta^k \leq 1) \qquad (4.2)$$

If the value of the distance function is equal to unity ($D_o^k(x^k, y^k) = 1$), firms are located on the boundary and considered technically efficient, otherwise they are inside the production interior ($D_o^k(x^k, y^k) < 1$) and are relatively inefficient.

4.1.2 Group frontiers

The industry can be classified into L groups operating under L different group-specific technologies. These sub-technologies can be characterised by the following group-specific production sets and group output distance functions:

$$\wp^g = \{(x, y) \in \mathbb{R}_+^p \times \mathbb{R}_+^q : x \ can \ be \ used \ by \ firms \ in \ group \ g \ to \ produce \ y, g = 1, \dots, L\}$$
(4.3)

and

$$D_o^{G,k}(x^k, y^k) = inf\{\theta^k : (x^k, y^k/\theta^k) \in \wp^g\} \qquad (4.4)$$

The boundaries of the group-specific production sets are referred to as group frontiers. The meta-production set of the industry envelops all L group production sets $\wp \equiv \wp^1 \cup \wp^2 \dots \cup \wp^L$ and the group-specific production sets are subsets of the unrestricted meta-production set.

In this paper, according to ownership, there are three group-specific frontiers belonging to state-owned banks, private and foreign banks.

4.1.3 Meta-technology ratio

The gap between the group frontier and the meta-frontier (technology gap) at a particular input/output combination ($x^k,\ y^k$) can be identified by the meta-technology ratio (MTR):

$$MTR(x^k,\ y^k) = \frac{D_o^k(x^k, y^k)}{D_o^{G,k}(x^k, y^k)} \qquad (4.5)$$

where $D_o^{G,k}(x^k, y^k)$ and $D_o^k(x^k, y^k)$ are distance functions identified by the distances to the group frontier and meta-frontier, respectively. The value of MTR is smaller or maximally equal to unity and the higher the value of MTR means the smaller the gap between firm technology and industry technology. The MTR of the group can be identified to measure how close the group frontier is to the meta-frontier by averaging all individual MTRs of firms within each group.

The equation (4.5) is also equivalent to:

$$D_o^k(x^k, y^k) = D_o^{G,k}(x^k, y^k) \times MTR(x^k, y^k) \qquad (4.6)$$

Equation (4.6) can be explained as the relative efficiency of an individual firm to the meta-frontier ($D_o^k(x^k, y^k)$) representing the state of knowledge, which can be decomposed into two components: a component that measures the distance from input-output points to the group frontier ($D_o^{G,k}(x^k, y^k)$) representing the state of knowledge and the physical, social and

economic environment that characterises groups and the other measures the gap from the group-frontier to the meta-frontier ($MTR(x^k, y^k)$).

From a Vietnamese banking perspective, equation (4.6) is useful to assess the possible payoffs from policies of the Government on the operating environment of bank groups classified by ownership through the group MTR. The larger the value of this ratio means the closer the distance from the group frontier to the meta-frontier and that the group operates in a better physical, social and economic environment than the other groups.

4.2 DEA technical efficiency

4.2.1 Measuring technical efficiency

Under the assumption of free disposability of inputs and outputs and variable returns to scale[2], the DEA estimate of the production set can be defined as:

$$\hat{\wp} = \left\{(x, y) \in \mathbb{R}_+^p \times \mathbb{R}_+^q : \sum_{k=1}^n z_k y_k^i \geq y^i, i = 1, \dots, q;\ \sum_{k=1}^n z_k x_k^j \leq x^j, j = 1, \dots, p;\ \sum_{k=1}^n z_k = 1, z_k \geq 0\right\} \quad (4.7)$$

Farrell's measure of technical efficiency (δ) is the reciprocal of the distance function (Simar and Wilson, 2007). The DEA output-oriented estimator of δ can be written in terms of the linear program as:

$$\hat{\delta} = \delta(x, y \in \hat{\wp}) = max\left\{\delta > 0 : \sum_{k=1}^n z_k y_k^i \geq \delta y^i, i = 1, \dots, q;\ \sum_{k=1}^n z_k x_k^j \leq x^j, j = 1, \dots, p;\ \ \sum_{k=1}^n z_k = 1, z_k \geq 0\right\} \quad (4.8)$$

Equation (4.8) can be used to estimate the technical efficiency scores of Vietnamese banks. The estimation for each individual bank will be conducted by scaling the distances to the meta-frontier and the group frontier.

Bootstrapping in DEA

While DEA has a number of advantages, such as it is possible to apply to small sample sizes and multiple outputs, it does not allow for random errors and due to its non-parametric nature it cannot be used to test for the statistical significance of estimates of technical efficiency scores. Furthermore, estimates of the distances to the production frontiers can be underestimated due to the inherent problem with mainstream DEA analysis, as not all efficient firms within the population are included in the sample (Coelli *et al*., 2005; Simar and Wilson, 1998; 2007). In a graphical context, estimated frontiers are downward-biased in comparison with the true frontiers. Consequently, estimators of technical efficiency scores based on the estimated frontiers can be biased. So far, bootstrap methods seem to be the only viable alternative that can overcome the downward-biased nature of DEA estimates and to make inference on $\delta(x, y)$ (Simar and Wilson, 2013).

Simar (1992) was the first to suggest applying bootstrap techniques in the production frontier framework for parametric, nonparametric and semi-parametric approaches (Xue and Harker, 1999; Casu and Molyneux, 2003; Simar and Wilson, 2013). Bootstrapping is based on the idea that, through resampling, the data generating process is repeatedly simulated to make an arbitrary number of simulated samples. Then, these samples can be utilised to generate simulated estimates[3]. The known bootstrap distribution of the resulting estimates will mimic the

unknown sampling distribution of the original estimator (Simar and Wilson, 1998). Based on the simulated estimates we can derive biased-corrected estimators as well as confidence intervals of the true technical efficiency.

In the next part of this paper, two bootstrap methods will be presented. First, sub-sampling bootstrap will be applied to make confidence intervals for group technical efficiency. Second, parametric bootstrap will be used to determine the statistical properties of coefficients in a double-bootstrap two-stage DEA procedure.

4.2.2 Measuring group technical efficiency

Many studies have applied the simple average method to estimate and compare group efficiency scores, and they may conclude that this group is more efficient than the others (Das and Ghosh, 2006; Ataullah and Le, 2006, Denizer *et al*., 2007; Sufian and Habibullah, 2011). Their conclusion, however, engages two issues. First, they ignore the relative importance of particular firms in each group when all firms are deemed to be the same. Second, they use point estimates of group efficiency scores to compare amongst different groups. Hence, it is possible to make inference errors (Simar and Zelenyuk, 2007).

The first issue will be addressed by the weighted average method if the weight of each firm in each group is appropriately identified. Based on the theory of economic optimisation, Färe and Zelenyuk (2003) propose that industry efficiency is the average of the efficiency of individual firms with the weight equal to their cost or revenue shares in the industry.[4] Their theorem is that "an industry maximum revenue is the sum of its firms' maximal revenues" (Färe and Zelenyuk, 2003, p.615). This theorem is adapted in the context of groups by Simar and Zelenyuk (2007) and becomes "the maximal revenue of the groups of firms is equal to the sum of the maximal revenue of all its member firms" (Simar and Zelenyuk, 2007, p.1371). The new theorem can be used to acquire several important results for efficiency aggregating. The first is that the revenue efficiency of a group is equal to the weighted sum of its individual firm revenue efficiency where the weight is the revenue shares of firms in a group. The second is that the aggregate technical efficiency of a group is equal to the weighted sum of the firm technical efficiency (where the weight is that of revenue shares).

As mentioned above, bootstrap methods can be used to make statistical inference of a firm's technical efficiency. Accordingly, the second issue can be circumvented if these methods can be applied in the context of groups and to provide confidence intervals for aggregate technical efficiency. Simar and Zelenyuk (2007) proposed an algorithm to measure bias-corrected aggregate efficiency scores of groups using a subsampling bootstrap in the DEA context.

Simar and Zelenyuk (2007) test on the difference between two bank group efficiency scores

In reality, it is important to compare the efficiency scores of two groups of a sample divided by exogenous criteria. This paper applies the bootstrap-based test of Simar and Zelenyuk (2007) to investigate the equality of aggregate/mean efficiency scores between private and state-owned banks; foreign and private banks; foreign and state-owned banks in Vietnam. In brief, there are two groups (group A and Z) used to compare aggregate/mean efficiency scores. We can postulate as:

H_o: $\overline{\delta^A} = \overline{\delta^Z}$ against H_1: $\overline{\delta^A} \neq \overline{\delta^Z}$

Due to the multiplicative nature of efficiency, Simar and Zelenyuk (2007) propose estimating the ratio of the group A aggregate/mean efficiency score over the group Z: $RD_{A,Z} = \frac{\overline{\delta^A}}{\overline{\delta^Z}}$ and its DEA estimate is computed as $\widehat{RD}_{A,Z} = \frac{\overline{\hat{\delta}^A}}{\overline{\hat{\delta}^Z}}$. Nonetheless, we cannot use this point estimate to provide any decisions on the equality of the two groups' aggregate/mean efficiency scores due to inference errors. Instead, we can use its bootstrap confidence interval for testing. After identifying the confidence interval at α significance degree of $RD_{A,Z}$, then we can conclude which hypothesis is rejected using the rule: reject H_o if the confidence interval for $RD_{A,Z}$ does not overlap unity, and do not reject otherwise. In particular, if the confidence interval lies above unity then we can conclude that $\overline{\delta^A} > \overline{\delta^Z}$.

4.2.3 Double-bootstrap two-stage DEA

After obtaining technical efficiency scores under group and meta frontiers, the next step is to explore the relationship between these DEA inefficiency scores as dependent variables and environmental variables. Simar and Wilson (2007) show that Tobit and OLS regressions that are widely used in the literature provide biased inferences of coefficients due to 1) natural correlations amongst DEA estimates and 2) the downward-biased nature of DEA estimates. To overcome this problem, they proposed a statistical model based on a double-bootstrap process which allows adjusting the bias of DEA estimates (so-called double-bootstrap two-stage DEA).[5] Such a regression analysis to determine the effect of environmental variables on bias-corrected DEA efficiency scores gives consistent and unbiased coefficients. Formally, a true model of regressing true efficiency scores on environmental variables is described as:

$$\delta_i = z_i\beta + \varepsilon_i \geq 1 \qquad (4.9)$$

where β *is* a vector of parameters, and $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$ is a continuous iid random variable, independent of the z_i vector of environmental variables. However, the true efficiency scores (δ_i) are unobservable; thus, they are replaced by DEA estimates from the first stage driven from group frontier or meta frontier analysis. Due to the fact that output-oriented technical efficiency scores under the Farrell (1957) approach are larger than unity ($\delta_i \geq 1$), so we have $\varepsilon_i \geq 1 - z_i\beta$, for all $i = 1, \ldots, n$. Hence, to account for the boundary issue, a truncated regression is conducted. A parametric bootstrap is also used to improve accuracy of the coefficients (β) and variance of random variable (σ_ε^2) inference.

The double-bootstrap two-stage DEA can be combined with meta-frontier analysis through a three-step procedure as below:

(1) Applying the double-bootstrap two-stage DEA for each group we can obtain DEA estimates and bias-corrected technical efficiency scores. The coefficients are also obtained reflecting the impact of environmental variables on efficiency within each group. The mean technical efficiency scores of each group are calculated.

(2) A similar procedure is also implemented with the whole sample and equivalent results are also obtained.

(3) Based on Equation (4.5) the meta-technology ratio (MTR) is calculated.

5. Data and model specification

5.1 Data source

An unbalanced panel data of Vietnamese banks is collected from the financial statements of commercial banks in Vietnam including their balance sheets and income reports. Information, including structure of bank equity, bank entry, mergers and acquisitions, are collected from annual SBV reports.

There are four types of banks in Vietnam, that include: state-owned commercial banks (SOCBs), joint stock banks (JSBs), joint venture banks (JVBs), and foreign banks (FBs). In general, SOCBs are predominantly owned by the state with the SBV being the representative entity. Although several SOCBs were privatised and their equities were sold to foreign and domestic private investors, the bulk of these banks are still owned by the State. JSBs are banks with major equities owned by private entities and a minor part can be owned by foreigners but not exceeding 30 percent of the total. JVBs are established by a domestic entity with one or several foreign counterparts, in which the foreign investors own at least half of the bank capital. FBs are banks where the total capital is contributed by foreign investors. Due to the fact that both FBs and JVBs contribute to less than 10 percent of banking assets and they are predominantly owned or totally owned by foreigners, we classify them in a group called foreign and joint venture banks (FJVBs). Consequently, there are three groups considered in this study: JSBs, SOCBs and FJVBs (Table 1). In total, we have 195 bank-year observations.

Table 1: Number of Vietnam banks by ownership category in the period 2007-2012

	2007	2008	2009	2010	2011	2012
SOCBs	5 (5)	5 (5)	5 (5)	5 (5)	5 (5)	5 (5)
JSBs	33 (19)	36 (24)	37 (25)	37 (25)	37 (25)	34 (24)
JVBs	5 (2)	5 (2)	5 (2)	4 (2)	4 (3)	4 (3)
FBs	0	0	5 (1)	5 (2)	5 (3)	5 (3)
Total	**43 (26)**	**46 (31)**	**52 (33)**	**51 (34)**	**51 (36)**	**48 (35)**

Note: the figures in brackets are the number of banks in the sample.

Source: State Bank of Vietnam reports from 2007 to 2012

5.2 Inputs and outputs

There are two common approaches to the choice of inputs and outputs; intermediation and operating. Under the intermediation approach, banks are seen as financial institutions intermediating funds between savers and borrowers (Das and Ghosh, 2006). The operating approach views banks as business units with the final goal of generating revenues from total cost (Leightner and Lovell, 1998). We choose the operating approach in this study as our focus is the banks' profit maximising abilities rather than their efficiency in providing financial services. This aspect has never been considered in similar previous studies of Vietnamese banks. The inputs are interest and non-interest expenses and outputs are interest and non-interest incomes. Interest expenses are the cost of deposits and other borrowings. Non-interest

expenses include fees and commission expenses, operating expenses and other expenses. Non-interest income consists of fees and commission income, net gain/loss from non-traditional services (stock, gold, foreign currency trading activities) and other income. Interest incomes are revenues from loans and advances.

5.3 Specification of a regression model

Once technical efficiency scores have been measured, it is important to identify the possible impact of environmental variables on bank performance through regression analyses. It is apparent that the efficiency score is the dependent variable. However, defining independent variables is more complicated and depends on the specific circumstance of the study. In this paper, environmental variables are classified into three classes including 1) bank-specific variables, 2) time trend variables and 3) variables indicating the impact of new policies on banks. It is worth noting that each variable will appear in a meta-frontier DEA model that pools all bank groups (consisting of state-owned, private and foreign bank groups) and group-frontier DEA models that includes banks of a specific group.

Bank-specific variables

Loan to asset ratio (LA)

During the period 2007-2012, Vietnam experienced a credit boom with an about 35% average annual growth rate. In the short-term this dramatic increase brought about high profitability but also created a potentially high NPL rate in the long run. The loan to asset ratio (LA) helps us analyse the impact of the SBV's expansionary monetary policy and credit risk preference of banks/bank groups on the efficiency of banks (Hasan and Marton, 2003; Havrylchyk, 2006; Yildirim and Philoppatos, 2007; Chortareas *et al*., 2013).

Equity to asset ratio (EA)

The equity to asset ratio (EA) is used as a proxy of financial soundness that reduces uncertainties and risks and contributes to lower inefficiency (Fries and Taci, 2005; Grigorian and Manole, 2006; Kumbhakar and Wang, 2007; Jiang *et al*., 2009).

Return on assets (ROA)

Return on assets (ROA) is included in the model as a proxy for the profitability of banks (Das and Ghosh, 2006; Hermes and Vu, 2010; Glass *et al*., 2014). We assume a positive association between the profitability of a bank and its efficiency.

Time trend (T)

To control for the effect of time, a time trend variable (T) is considered which takes the value 1 for 2007, 2 for 2008, and so on to capture the evolving nature of efficiency. The time variable and its effect on bank efficiency have been investigated in the literature (for example: Williams and Nguyen, 2005; Lensink *et al*., 2008).

Policy changes

The below variables are chosen to show the association between Vietnam's policy changes in the banking sector and banks' performance in the post-WTO period.

FSI: dummy variable for foreign strategic involvement in domestic banks

Foreign investors can take part in domestic banks by purchasing the equity of either SOCBs or JSBs. Nevertheless, the proportion of equity sold to foreign investors cannot exceed 30 percent of the total. To measure the impact of foreign strategic involvement, we use a dummy variable, FSI, indicating banks with foreign involvement following the work of Bonin *et al.*, 2005a; 2005b. Berger *et al*. (2009) investigated mechanisms that transfer positive impacts of minor foreign ownership on to the efficiency of Chinese domestic banks. One mechanism is that minor foreign shareholders can participate in the board of directors of banks and exploit their positions to improve the quality of corporate governance and risk management. The other mechanism is that through overseas strategic investors, domestic banks are encouraged and more confident to go public and list their equities in the stock exchange. From the Vietnamese perspective, we also assume a positive relationship between foreign involvement and domestic bank performance.

E: dummy variable for privatised SOCBs

In the post-WTO period the SOCBs were targeted for privatisation but this process had to ensure that the government held a predominant fraction of the banks' capital. A dummy variable, E, is used for those SOCBs which were partially privatised and zero for those not involved in this process. Following the agent-principal theory, state ownership can negatively influence the performance of banks and state-owned banks will become more efficient after being privatised (Shleifer and Vishny, 1997; La Porta *et al*., 2002).

RU: dummy variable for JSBs transformed from rural to urban banks

A number of rural JSBs were permitted to transfer to urban ones. It is expected that this would help these transformed banks increase their scope of operation and consequently improving their efficiency; however, poor management and weak capital capability are substantial challenges (WB, 2012; VELP, 2012). The dummy RU is employed to indicate transformed JSBs from the others.

BG: dummy variable for JSBs with SOEs being the shareholders

A number of SOEs were allowed by the government to participate in the banking sector and become holding companies of JSBs. Subsequently, a complex so-called cross-ownership relationship between these SOEs and JSBs was established. Being the major shareholders, SOEs can impact the decision making process of these banks and channel bank credit to projects that are of relevance to them. Thus, cross-ownership can obstruct contestability and facilitate collusion between banks and SOEs (Kraft *et al*., 2006). In this case we assume that cross-ownership negatively impacts the efficiency of JSBs. To capture this a dummy variable (BG) is included in the model capturing JSBs with at least 20 percent of their total equity owned by one or several SOEs.

Table 2: A summary of environmental variables

Variables		Description
1.Bank-policy changes		
Selected for business group participation in JSBs	BGs	Dummy indicating JSBs have experienced equity participation by SOEs.
Selected for SOCBs equitisation	E	Dummy indicating SOCBs have experienced equitisation between 2005 and 2012.
Banks with foreign capital participation	FSI	Dummy indicating a bank sold a minor proportion of its equity (not exceeding 30 percent) to foreign investors.
Rural-urban transformed banks	RU	Dummy indicating JSBs which transformed from rural banks.
2.Bank-specific variables		
Loan to asset ratio	LA	The ratio of loans to assets measures the risk preference of a bank.
Equity to asset ratio	EA	The ratio of equity to assets measures the financial soundness of a bank.
ROA	ROA	Return on assets measures the profitability of a bank.
3.Time trend variable		
Year	T	Trend variables (2007=1, 2008=2, … , 2012=6).

Table 3 statistically describes the inputs, outputs and explanatory variables through several criteria: min value, max value, mean value and standard deviation. The period 2007-2012 witnessed substantial data volatility which can be justified by the fact that the Vietnamese banking sector experienced a rapid growth process especially after accession to the WTO in 2007. A loose and expansion monetary policy conducted over a long period was simultaneously intensified by a considerable capital inflow from overseas. Moreover, a number of rural banks were allowed by the SBV to transform to urban banks. Before the transformation process these rural banks were very small and mostly focused their operations on lending to SMEs and farmers in remote areas.

Table 3: A statistical description of the variables

Indicators	Min	Max	Mean	S.D
Inputs and outputs (in million VND)				
Interest expense	2654	29960362	3571972	5478808
Non-interest expense	16139	10855988	1019756	1726190
Interest income	30873	45748103	5082872	7794469
Non-interest income	26820	5356782	578471	942392
Regressors				
LA	0.1293	0.9442	0.5104	0.1477
EA	0.0296	0.8006	0.1405	0.1052
ROA	0.0001	0.0769	0.0162	0.0108
T	1	6	3.6564	1.6702
BG	0	1	0.3795	0.4853
E	0	1	0.0923	0.2895
FSI	0	1	0.2564	0.4367
RU	0	1	0.2513	0.4338

Notes: “LA” is the loan to asset ratio. “EA” is the equity to asset ratio. “ROA” is the return to assets ratio. “T” is a time trend variable. “BG” a dummy variable indicating JSBs with equity participation from business groups. “E” a dummy variable indicating SOCBs after privatisation. “FSI” is a dummy variable indicating domestic banks with foreign strategic investors. “RU” is a dummy variable indicating rural-urban transformed JSBs.

6. Empirical analysis

6.1 Technology gap analysis and bank group performance

Technology gap analysis amongst groups

Using both basic DEA and double-bootstrap two-stage DEA methods, we can see from Table 4 that the frontier of the FJVB bank group is located furthest from the meta-frontier compared with the other groups. The evidence of this is that the MTR estimated by basic DEA is 0.9092 relatively smaller than those of the JSB and SOCB groups which are 0.9478 and 0.9571, respectively (Table 4). The FJVB’s MTR estimated by bias-corrected technical efficiency scores (0.8812) is also smaller than those of the JSB and SOCB groups (0.9540 and 0.9485). It is obvious that it is more difficult for the FJVB group compared to other bank groups to mimic the meta-frontier. Equivalently, the JSB and SOCB bank groups are more able to achieve the

industry level of efficiency than their FJVB counterpart. This is due to the fact that foreign banks and joint venture banks are not treated equally to that of domestic banks after Vietnam's accession to the WTO in 2007. According to commitments of the Vietnamese government to the WTO, Vietnam allowed foreign investors to join in its banking sector from 2007. Nonetheless, a full national treatment to foreign investors was only implemented from 2011.[6]

There are conflicting results when comparing the technology gap from the JSB group-frontier and the gap from the SOCB group-frontier to the meta-frontier. If basic DEA estimators are utilised the gap from the frontier for the SOCB group is smaller than that of the JSB group (0.9478 versus 0.9571, respectively). Nevertheless, this result is in contrast to the case of applying bias-corrected scores to calculate group MTRs. Accordingly, the MTR of the JSB group is 0.9540, which is larger than that of the SOCB group which is equal to 0.9485. However, estimates of MTR based on bias-corrected efficiency scores are more reliable than those estimated by DEA which have been proven to be dependent and downward biased.

The value of the mean DEA technical efficiency scores of the SOCB group is estimated to be at 1.0942 using the meta-frontier (Table 4). This value is lower than that of two other bank groups (JSB= 1.2476 and FJVB= 1.2545) indicating that SOCBs are the most efficient bank group in the period 2007-2012. A similar conclusion is also attainable when we use bias-corrected technical efficiency scores (Table 4). However, a limitation of such comparisons is that the difference between the mean technical efficiency estimators of the two groups is too small, and any measurement or data processing errors may reverse these conclusions. Therefore, we use a more reliable test to justify differences amongst bank group efficiencies.

Table 4: *Mean efficiencies and MTRs of Vietnamese bank groups for the period 2007-2012*

	Meta-frontier model Mean technical efficiency		*Mean MTR*	
	TE	*TEBC*	*TE*	*TEBC*
JSB	*1.2476*	*1.3114*	*0.9478*	*0.9540*
SOCB	*1.0942*	*1.1540*	*0.9571*	*0.9485*
FJVB	*1.2545*	*1.3713*	*0.9092*	*0.8812*

Notes: "TE" presents technical efficiencies using basic DEA. "TEBC" presents bias corrected technical efficiencies estimated by double-bootstrap two-stage DEA. "MTR" is the meta-technology ratio. JSB is a joint stock bank group; SOCB is a state-owned bank group and FJVB is a foreign and joint-venture bank group.

Bank group performance

In this section, three bank groups (SOCBs, JSBs, and FJVBs) are divided into pairs and the Simar and Zelenyuk (2007) test is utilised to identify which group performs better in each pair. Both aggregate and mean technical efficiency are used for comparison purposes.

Table 5: *Simar and Zelenyuk (2007) tests*

	Bias-corrected Estimation	*Standard Error*	*Confidence interval bounds at different significance degrees*					
			90%		*95%*		*99%*	
RD_ag JSBs/SOCBs	*1.1783****	*0.0290*	*1.1224*	*1.2173*	*1.1116*	*1.2232*	*1.0905*	*1.2349*
RD_meanJSBs/SOCBs	*1.1203****	*0.0392*	*1.0509*	*1.1844*	*1.0405*	*1.1942*	*1.0148*	*1.2178*
RD_ag JSBs/FJVBs	*1.0231*	*0.0435*	*0.9668*	*1.1104*	*0.9586*	*1.1273*	*0.9471*	*1.1732*
RD_mean JSBs/FJVBs	*0.8251****	*0.0629*	*0.7289*	*0.9321*	*0.7085*	*0.9558*	*0.6742*	*0.9975*
RD_ag SOCBs/FJVBs	*0.9362***	*0.0230*	*0.9116*	*0.9826*	*0.9078*	*0.9999*	*0.8990*	*1.0316*
RD_mean SOCBs/ FJVBs	*0.8292****	*0.0400*	*0.7676*	*0.8960*	*0.7511*	*0.9167*	*0.7211*	*0.9574*

*Notes: RD_ag JSBs/SOCBs and RD_mean JSBs/SOCBs are the ratios of aggregate and mean technical efficiency scores of JSBs over those of SOCBs, respectively. The same expression can be used for other pairs of bank groups. At each significance degree there are two columns indicating the upper and lower bound of the ratios. The ratios are significantly larger or smaller than unity at a significance degree if both its equivalent upper and lower bounds are larger or smaller than unity, respectively. The coefficients with **, or *** are significant at 5, or 1 percent, respectively.*

Table 5 shows that the ratios of aggregate and mean technical efficiency of JSBs on those of SOCBs are 1.1783 and 1.1203, respectively, and both are larger than unity and significant at 1%. It shows that the aggregate and mean technical efficiency scores of the JSBs group are larger than those of the SOCBs and JSBs. Hence, it can be concluded that the JSBs group is less efficient than the SOCBs group. The ratio of mean technical efficiency scores of JSBs over FJVBs is 0.8251, which is smaller than unity and significant at 1% indicating an outperforming of JSBs. Lastly, the ratios of aggregate and mean technical efficiency scores of SOCBs over FJVBs are 0.9362 (at 5%) and 0.8292 (at 1%), respectively. These results support the outperforming of SOCBs over FJVBs. Therefore, there is evidence to support that the SOCBs group is the most efficient in comparison with the JSBs and FJVBs groups using both aggregate and mean criterion. This result is in line with the results for Kraft *et al*., 2006; Denizet *et al*., 2007; and Karas *et al*., 2010 conducted in Croatia, Turkey, and Russia, and they suppose that the deficiency of the business environment in banking sector is the cause for the superior performance of public banks. This issue can be understood as follows. First, state owned banks obtain guarantees of solvency from the Government and, therefore, they make loans and receive deposits more easily than their private rivals. On the other hand, private banks struggle with a lack of access to capital, poor governance and risk management, cross-ownership with industrial groups which increases possibilities of insider-trading, resulting in a deterioration of assets.

The business and policy environment in which Vietnamese banks operate, as mentioned in Section 2, is similar to these countries. The state-owned banks in this country are majority owned by the central bank; hence, they are guaranteed of solvency and obtain privileges from the State including, for example, access to capital. In contrast, low transparency and a weak

regulatory and supervisory framework have undermined the performance of domestic private banks in Vietnam. Cross-ownership is popular in most JSBs and their investments in real-estate and the stock market have not been well controlled, which has resulted in a high NPL rate and increased risk in the financial sector. Consequently, the poor performance of JSBs, with most loans allocated to SMEs and consumers, can result in poorer economic growth, productivity, competitiveness and employment generation.

6.2 An analysis of environmental variables

In this section bank efficiency scores by group are regressed on a set of environmental variables including those proxied for bank characteristics, policy changes, and time trend. For regression purposes we employ the double-bootstrap two-stage DEA method in the meta model and focus on three group models (JSB, SOCB model and FJVB models) in which the impact of variants are examined in accordance with ownership. Table 6 below presents the empirical results on the impact of explanatory variables on bank efficiency.

Table 6: Regressing environmental variables on bank technical efficiency scores estimated by meta- and different group-frontiers using double-bootstrap two-stage DEA.

	Meta model	*JSB model*	*SOCB model*	*FJVB model*
Intercept	*0.8758****	*1.0382****	*1.2439****	*1.2654****
BG	*0.0596*	*0.1000****		
E	*-1.1360****		*-0.0135*	
FSI	*-0.0597*	*-0.0968***		
RU	*0.1502***	*0.1107****		
LA	*0.6513****	*0.4922****	*-0.2493****	*0.0009*
EA	*1.4799****	*0.8951****	*3.1664****	*0.9069****
ROA	*-9.7233****	*-8.8291****	*-13.8348****	*-14.8928****
T	*-0.0341***	*-0.0345****	*-0.0148***	*-0.0093*

*Notes: "BG" is a dummy variable that indicates JSBs with equity participation from business groups. "E" is a dummy variable that indicates SOCBs after privatisation. "FSI" is a dummy variable that indicates domestic banks with foreign strategic investors. "RU" is a dummy variable that indicates rural-urban transformed JSBs. "LA" is the loan to asset ratio. "EA" is the equity to asset ratio. "ROA" is the return to assets ratio. "T" is a time trend variable. The coefficients with **, or *** are significant at 5, or 1 percent, respectively.*

The meta-model includes all the above-mentioned variables. The JSB model excludes E because privatisation only occurred for the SOCBs group. The SOCB model excludes BG and RU because equity participation by business groups and rural-urban transformed banks occurred only for JSB group members. Privatisation and selling equity to foreign strategic

investors as a component of the privatising process happened at the same time so that we cannot distinguish between the two dummies E and FSI in the SOCB model. In this model, we exclude FSI instead of E because FSI is one of the many components of E (see Section 2 for details). All four reform measures (BG, E, FSI, and RU) only occurred for domestic banks resulting in their exclusion from the FJVB model.

Impact of reform measures in the post–WTO period

(i)Participation in the banking sector of state-owned and private business groups (BG)

One of the reform measures in the post-WTO period is that the SBV required commercial banks to intensively increase their capital. To catch up with the new capital requirement, numerous JSBs called for equity contributions from business groups. Subsequently, a cross-ownership between banks and these industrial groups was established.

The BG coefficient, representing the impact of the relationship, is insignificant in the case of the meta-model. However, it has a positive sign and is significant at the 1% level in the JSB model. Joint stock banks with equity participation from industrial groups are less efficient than other banks in the same group. This finding is in line with those of Trivieri (2007) and supports a negative relationship between cross-ownership and bank efficiency. This result can be explained by the reality that these industrial groups, by holding a role as major shareholders of JSBs, have channeled credit to highly profitable but risky investment items, for example, property, or projects belonging to related parties rather than the most profitable and productive ones. Subsequently, these inappropriate loans resulted in a high level of bad loans. Furthermore, the capability of these groups to manage these JSBs is questionable, particularly where their businesses focus on industrial areas and not the financial sector.

(ii) Privatisation of SOCBs (E)

The coefficient of variable “E” (indicating privatisation of SOCBs) is found to be negative (-1.1360) at the 1% level of significance for the meta-model. This result demonstrates that privatised SOCBs are more efficient than other banks regardless of their ownership. However, on the other hand, it is important to know whether the SOCBs after being privatised would perform better than other SOCBs? Using the SOCB-model, the value of the “E” coefficient is negative (-0.0135) but insignificant; consequently, any conclusions on a higher efficiency level of equitised SOCBs compared to other SOCBs is not reliable. It can be expected that privatisation in general, and the participation of foreign investors in particular, would improve the performance of SOCBs. Nevertheless, the impact of privatisation on SOCBs is not clear and possibly more time is needed for it to be effective.

(iii) Foreign strategic investors (FSI)

In the case of the JSB model the nexus between bank efficiency and FSI is positive and significant at 5%. It seems that the participation of foreign investors helps private banks improve their efficiency. This finding is in line with Berger *et al*., (2009) when they found a positive relationship between minority foreign ownership and bank performance in the Chinese banking sector. In the meta model the coefficient of FSI is also positive but it is not significant. This can be explained by the fact that the influence of the variable FSI on SOCBs is not clear, as mentioned previously.

The impact of FSI on JSBs can be observed clearly if compared with their public counterparts. The reason behind this is that private banks are more flexible with strong profit incentives; hence, they are quicker to catch up with and adapt new styles of management from foreign investors with the expectation that it would save operating costs and reduce risks and uncertainties. SOCBs, in contrast, are not autonomous when the majority of equity is still owned by the SBV (IMF, 2012). Any new proposals from strategic investors need to be approved by the SBV before being applied.

(iv) Transforming rural to urban JSBs (RU)

Transformed JSBs perform more inefficiently than not only other JSBs but also banks belonging to any other ownership form. The evidence of this is that estimates of the RU parameters are positive at 0.1107 and 0.1502 under the JSB and meta model, respectively. There are two possible reasons for this. First, governance capability was inadequate. Transformed banks had to cover a significantly larger range of operations than they had done before. To be new urban banks their customer base and assets increased many times after only two or three years and more branches were opened nationwide. The second is from insufficiently selective decisions of the SBV on rewarding licences to rural banks, resulting in a rapid growth of credit by inexperienced bankers which involved high risk taking and failed to adequately diversify their assets. In reality, many small transformed JSBs have used the bulk of their credit to purchase property and stocks.

Impact of specific bank characteristics

(i)Loan to asset ratio (LA)

The loan-to-asset ratio expresses the level of risk that a bank prefers. The regression results demonstrate a diversity of bank group responses to this variable. In the JSB model the estimate of the LA parameter is 0.4922 with a 1 percent significance degree, indicating a negative relationship between private bank performance and level of risk preference. By contrast, a positive association is obtained with an estimator parameter value of -0.2493 at the same confidence level for the case of SOCBs. This issue can be clarified by considering different lending behaviour between SOCBs and JSBs in the post-WTO period. While private banks engaged themselves in risky but highly profitable projects in property and stock markets, public banks had to clean their assets and be more cautious in their lending activities as a requirement of the privatisation roadmap scheduled by the SBV. Under the FJVB model, foreign and joint venture banks seem to be neutral with regard to the loan to asset ratio where its coefficient is close to zero (0.0009) and is insignificant.

(ii)Equity to asset ratio (EA)

The equity to asset ratio is a criterion to identify the safety degree of a bank and a banking system. A bank with a higher EA ratio is safer in terms of capital and is in a stronger position to defend risks relating to equity losses. All four models give similar results at the same 1 percent significance degree, showing a negative association between the EA ratio and bank efficiency[7]. We find that risk-averse banks with a relatively lower level of earning assets outstanding are unlikely to attain a higher level of technical efficiency.

We can justify this finding based on several arguments. First, lending activities contribute about 90% of bank profit; thus, at the same level of equity, banks with a lower equity to asset ratio would provide more loans and receive more profit. Second, banks' CEOs prefer to distribute after-tax profit to shareholders rather than keep it for recapitalisation, and this explains why the growth rate of equity is lower than that of assets and why a bank can earn more profit but the EA does not increase.

(iii)Return on assets (ROA)

The ROA is a ratio of before-tax profit to total assets and is utilised to measure bank profitability. The meta model and the other three group models come to a consensus on a positive relationship between ROA and bank performance. This result is also consistent with that obtained by Das and Ghosh (2006); and Fang *et al*. (2011).

Time trend (T)

The coefficients for the variable T in all four models are negative, indicating an increasing trend of technical efficiency during the 2007-2012 period that also witnessed an expansionary monetary policy by the SBV. Banks were allowed to easily open branches nationwide and a number of new bank entrants were permitted. Most rural banks were approved to transfer to urban banks which are characterised by a significantly larger range of operations and customer base. In addition, an overseas inflow of capital from foreign investors as a result of Vietnam's accession into the WTO stimulated banks to rapidly increase their assets via lending and investments. One may doubt the sustainability of the banking sector as the credit growth will ultimately create a high NPL rate.

7. Conclusion

Using data for Vietnamese banks covering the post-WTO period (2007-2012), we have found that state-owned bank groups are the most efficient and have the smallest technology gap relative to that of industry technology. By contrast, and contrary to the mainstream view, foreign and joint stock banks are the least efficient groups and have the biggest gap relative to the meta-frontier. The impacts from reform measures such as transforming rural to urban banks and allowing industrial groups to become involved in the banking sector have contributed negatively to bank performance. We do not find evidence of SOCBs privatisation on improved banking efficiency, and perhaps more time is needed for its effectiveness to take effect. The participation of foreign investors has improved the efficiency of joint stock banks. Regardless of ownership the results illustrate a negative relation between bank capitalisation and performance as well as a positive impact on profitability. However, the responses of various bank types can be different to the same explanatory factors. For example, the efficiency of state-owned banks is positively related with the loan to asset ratio while a negative relationship is recorded in the case of joint stock banks.

Overall, this paper has contributed to the literature on bank efficiency by introducing a new approach, combining a meta-frontier analysis with a double-bootstrap two-stage DEA method under the assumption that the technology sets of bank groups classified by ownership can be different. This approach has been proven to be applicable for transition and newly emerging market economies, such as Vietnam, where the business environment is not fully competitive

and has a low level of transparency and state-owned and private banks are not equally treated in terms of regulation, guarantee of solvency or accessibility to financial resources that result in a difference of operations and technology sets.

End Notes

[1] Whether to use the input or output orientation depends on firms' objectives (Coelli *et al*., 2005). In the context of the Vietnamese banking sector in the post-WTO period, banks rapidly expanded their services and customer base under the expansionary monetary policy of the SBV to stimulate economic growth (Pincus, 2009). Banks pursued maximising their outputs (loans) rather than minimising inputs (which are labour and other assets). Thus, in this paper, output-oriented models are adopted.

[2] The constant returns to scale assumption is only appropriate when all firms are operating at their optimal scale (Charnes *et al*., 1978). In the banking sector, banks are strongly impacted by regulations imposed by central banks such as those on capital adequacy and loan-loss provisioning. Furthermore, in the case of Vietnam, private banks are discriminated against compared to state-owned banks, causing an unfair and imperfect business environment amongst different bank groups. Consequently, Vietnamese banks may not perform at their optimal scale. Hence, this research chooses the assumption of variable returns to scale when measuring the technical efficiency of banks in the Vietnamese banking system.

[3] In this paper linear programming is used to generate bootstrap efficiency scores from simulated input/output data.

[4] This paper applies revenue shares.

[5] For a comprehensive description of this procedure, see Simar and Wilson (2007).

[6] For a comprehensive understanding of the Vietnamese commitments to the WTO, see *"Working Party on The Accession of Vietnam - Part II-Schedule of Specific Commitments in Services List of Article II MFN Exemptions"*, which can be downloaded from *http://www.wto.org/english/thewto_e/acc_e/a1_vietnam_e.htm*

[7] This finding is in line with Hasan and Marton (2003), Das and Ghosh (2006), Fang *et al*. (2011) but is contrary to that obtained by Grigorian and Manole (2006).

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