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Profit Efficiency and Productivity of Vietnamese Banks: A New Index Approach

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Abstract

In this paper, we measure and analyse profit efficiency and productivity of Vietnamese banks using a newly developed index approach which is based on the directional distance function. Our findings indicate that the average bank operates quite far below the frontier of the best-practice bank, mainly due to allocative inefficiency rather than technical inefficiency, and that Vietnamese banks experience modest productivity growth. The thrust of this growth is technological progress, and to some degree technical efficiency change, whereas scale efficiency change contributes adversely to productivity growth. We also investigate the effects of the capital-adequacy and deposit-taking regulations on profit efficiency, and find no significant influences.

JEL classification numbers: C43, G21
Keywords: Efficiency, Productivity, Directional Distance, Banking industry

1 Introduction

Banking sectors around the world have changed substantially over recent decades through a series of developments, including deregulation, mergers and acquisitions, financial liberalization and other reforms and restructuring programs. A similar evolution can be observed in the Vietnamese banking system, commencing with its transformation from a mono-tier to a two-tier banking system, followed by banking restructuring programs for domestic banks, financial deregulation and, most recently, integration into the global financial system. It is reasonable to expect profit gains from this evolution. In fact, it is

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reported that over 2000–2006 the profit of the Vietnamese banking industry increased by nearly 30% on average. However, this increase in profit does not necessarily mean an improvement in profitability and profit efficiency. It is of interest, therefore, to investigate how the profit efficiency of the banking industry in Vietnam developed during this period. The existing literature in the field has shown that profit efficiency of a bank can be measured by using either a non-parametric approach (mainly the Data Envelopment Analysis – DEA) or a parametric approach (mainly the Stochastic Frontier Analysis – SFA). Recent studies that employ the DEA method to measure profit efficiency include those of Maudos and Pastor (2003), Kirkwood and Nahm (2006), and Ariff and Can (2008), among others. These papers utilized either input- or output-oriented DEA to measure technical and allocative efficiency, and then profit efficiency as the product of these two efficiencies. These studies appear not to have experienced a zero or negative profit problem, so the conventional DEA approach seems to work well. In case the study sample contains non-positive profit figures, a computational adjustment is needed to transform the non-positive profit into a form that can be used in the measurement. The most common adjustment to those studies using the SFA method is to add a large enough constant to every bank's profit in the sample period, to avoid taking the natural log of zero or negative profit (see, e.g., Maudos et al., 2002; Kasman and Yildirim, 2006; Pasiouras et al., 2007; Mamatzakis et al., 2008; Krasnikov et al., 2009).[3] Alternatively, DeYoung and Hasan (1998) set profit efficiency equal to zero for banks with negative profit. However, these ad hoc adjustments could lead to measurement errors. To avoid the imposition of a specific adjustment, Färe et al. (2004) utilized the Nerlovian profit inefficiency indicator which is proposed in the context of the directional distance function to measure technical inefficiency, allocative inefficiency, and profit inefficiency. Although the Nerlovian profit inefficiency measure has a strong theoretical underpinning, it is at odds with the traditional index approach that measures efficiency as a proportion of full efficiency.

The present paper develops a new method utilising the Euclidean distances in the input-output space. In particular, it firstly shows that the Euclidean distances are proportional to profit differences, and then constructs index number formulas measuring technical efficiency, allocative efficiency, and profit efficiency. The newly proposed measure of efficiency has a number of advantages. Firstly, it can deal with the problem of non-positive profit without any need for ad hoc adjustment. Secondly, it provides a measure of profit efficiency which is comparable with the traditional radial efficiency measures. Thirdly, it provides unit-invariant measures, so that efficiency scores are independent of units of measurement. And lastly, it provides a compatible efficiency measure that is readily interpretable as to how much a bank can improve its performance. The paper also introduces an alternative perspective to computing the Malmquist Productivity Index (MPI) and its three components (namely pure technical efficiency change, scale efficiency change, and technological change) based on the directional distance function as opposed to the output or input distance function. The use of the directional distance function and measuring productivity in a ratio form, enabling it to be comparable with the radial measures based on the input or output distance function, makes this study distinct from previous studies. It also contrasts with the approach based

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[3]The use of SFA normally involves a specification of a translog functional form, in which both the dependent (e.g., profit) and explanatory variables are in a log form.

on a directional distance function and a Luenberger Productivity indicator (see, for example, Briec and Kerstens, 2009; Koutsomanoli-Filippaki et al., 2009).

The new approach is then utilized to access the efficiency and productivity of banks in Vietnam during 2000-2006. The present paper further investigates the impact of the regulatory environment on profit performance. The specific regulations of concern are a minimum capital-adequacy constraint and a deposit-taking constraint. The former constraint affects banks' behavior in taking risks to increase profit gain. The latter constraint directly affects banks' decisions regarding mobilizing funds and then in lending, since banks with limited resources cannot offer infinite outputs.

This paper contributes to the literature in terms of both methodological choices and country-specific case studies. In particular, by introducing a new approach to measure profit efficiency and a new derivation to calculate productivity, the study diversifies the methodological choices for applied researchers for measuring profit efficiency and productivity. In addition, by investigating the magnitude and components of profit efficiency of a sample of 56 banks operating in Vietnam during 2000-2006, this is the most inclusive study of bank performance in Vietnam.

The rest of the paper is organized as follows. Section 2 provides an overview of the banking industry in Vietnam. Section 3 presents the proposed new method. Section 4 summaries the selection of variables and inclusion of regulations. Section 5 analyzes the empirical results, and the last section summaries the main themes of the paper.

2 Brief Overview of the Banking Industry in Vietnam

In 1986, Vietnam initiated a comprehensive economic reform package known as *Renovation* in an attempt to improve the country's economic environment. This package consisted of a wide range of reforms such as tax reform, price reform, agricultural reform, state-owned enterprise reform, and banking reform to transform the economy from one that was based on central planning, to one in which market relations would be central. The most notable component of the reform program in terms of the banking sector was its transformation from a 'mono' system, in which the State Bank of Vietnam (SBV) acted as both the central bank and a commercial bank, to a two-tier system. The SBV handed over all commercial banking functions to commercial banks and began to shift its role more towards that of a true central bank. Meanwhile, the system of commercial banks came to comprise state-owned commercial banks (SOCBs), joint-stock commercial banks (JSCBs), and foreign banks (FBs).

Starting in 1999 and 2001, reform programs for JSCBs and SOCBs respectively were adopted to recapitalize banks, replace and reorganize the work of their management boards, improve staff skills, increase transparency to assess the true size of non-performing loans (NPLs) and reduce NPLs, raise profitability, and phase out policy- and noncommercial- 'directed lending' from SOCBs (IMF, 2002). As a result of the reform programs, the industry made much progress via the merger of poor and weak banks among the JSCBs, the phasing out of government-directed lending from the SOCBs, and the decline in NPLs (the last largely attributed to loans growth, as well as some write-offs) (IMF, 2003).

However, the progress of banking reform overall had remained patchy, with a continuing large gap in NPLs calculated using both the Vietnamese Accounting System and (perhaps more importantly given the country's greater integration with the global economy) that of the international accounting standards. Also, the speed of SOCB recapitalization was very slow, while the profitability of Vietnamese banks remained marginal. Therefore, to speed up these banking reforms, the Vietnamese Government announced the 'Banking Sector Reform Roadmap' at the end of 2005. This Roadmap focused especially on accelerating the restructuring of commercial banks and to gradually 'equitize' SOCBs, increase capital capacity and the competitiveness of JSCBs, and apply international prudential standards (especially the so-called Basel framework).

The 2000–2006 period also saw the enlargement of bank branch networks, the removal of many restrictions on foreign banks, and the integration of Vietnam into the global economy. The signing of the Bilateral Trade Agreement with the US in 2000, and Vietnam becoming a member of the World Trade Organization in late 2006, marked the global integration of Vietnam. Furthermore, this period witnessed substantial changes in banking technology, including the application of banking software to computerize transactions, the expansion of automatic teller machine (ATM) networks, the issuing of debit and credit cards, and the development of internet and electronic banking services. Given the significant changes in the Vietnamese banking sector over the period, it is crucial to investigate the level of efficiency over this period.

3 Methodology: a New Index Approach

Traditionally, a radial measure of efficiency uses either input or output distance functions. In particular, the input distance function looks for the largest radial contraction of an input vector used to produce a given output vector, whereas the output distance function looks for the largest radial expansion of an output vector produced from a given input vector. Neither the input nor the output distance function is adequate to measure profit efficiency. In contrast to these common distance functions, the directional distance function measures "the amount that one can translate an input and/or output vector radially from itself to the technology frontier in a pre-assigned direction" (Chambers *et al.*, 1998). Hence, it allows for simultaneous expansion of outputs and contraction of inputs. Based on the directional distance function, Chambers et al. (1998) proposed a measure of profit inefficiency, called the *Nerlovian profit inefficiency indicator*, in difference form rather than in ratio form. In particular, the *Nerlovian profit inefficiency indicator* measures the difference between the maximum and actual profit, normalized by the value of a directional vector. This approach can handle the case of non-positive profit by expressing profit inefficiency in terms of a difference between the maximum profit and actual profit, rather than in ratio form. Thus, this approach is not comparable with traditional radial efficiency measures. The approach proposed in this chapter can overcome this shortcoming and at the same time still handle the case of non-positive profit.

3.1 Graphical Illustration

Consider a simple example of a bank (say k') producing one output, y, using one input, x. In Figure 1, the bank's input-output levels are depicted by vector **z**, and its current operation is technically inefficient as point A is off the frontier that defines the feasible technology set (the shaded area is the feasible set of input-output combinations under the available technology). To be technically efficient, the bank needs to simultaneously reduce input and increase output along the directional vector given by $\mathbf{g} = (-g_x\ g_y)'$, by the movement from the current point, A, to point B where vector AD (that is parallel to **g)** passes through the frontier. Thus, a natural measure of technical inefficiency would be a ratio of the distance between A and B, |AB|, to the total distance from O to A and then B, namely |OA|+|AB|. When point B’ is located along the extension of **z** such that |AB|=|AB’|, the technical inefficiency score can be defined as |AB’|/|OB’|, and hence the technical efficiency score as |OA|/|OB’|.

The parallel lines passing through points A, B, C and D on vector AD are the price lines the bank is facing, whose slope equals the input price, denoted $w^{k'}$, divided by the output price, denoted $p^{k'}$. When the bank is allowed to change the input-output mix in any direction, the maximum profit can then be achieved at a point where the price line is tangent to the feasible set, namely at point Q*. Let C be the point where the price line that is tangent to the frontier crosses vector AD, and let π, π^T, and π^* denote the actual profit at point A, the profit at the technically efficient point B and the optimal profit achievable under the given price vector

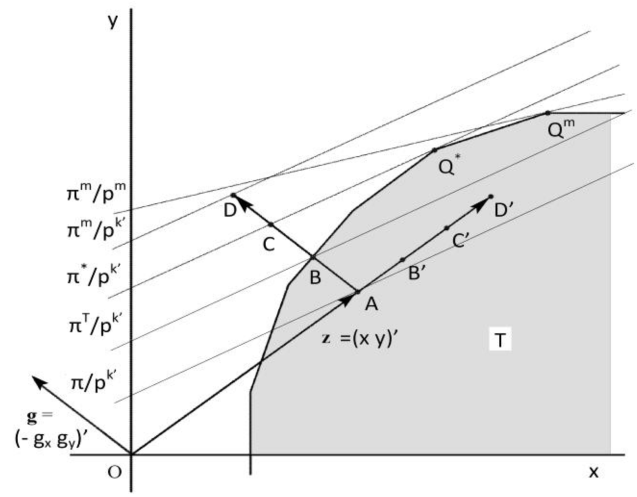

Figure 1: Directional Distance

$(w^{k'}\ p^{k'})$, at point Q* respectively. Then, the ratio between the differences in the profits given by $(\pi^T-\pi)/(\pi^*-\pi)$, equals |AB|/|AC| since the heights of the parallel price lines along the vertical axis represent profit levels normalised by the same constant which is output price, $p^{k'}$. It implies that |AB| is proportional to the additional profit the bank can achieve to become technically efficient, and |AC| is proportional by the same proportion to the additional profit the bank can achieve when it is allowed to change the input-output mix and attain the maximum profit under the given prices. Furthermore, as |AC| equals |AB|+|BC|, |BC| is proportional by the same proportion to $(\pi^*-\pi^T)$, which is the additional profit the bank can achieve over the profit it makes at the technically efficient point when it changes input-output bundle and becomes allocatively efficient on top of being technically efficient. So, analogous to the definition of technical inefficiency, allocative inefficiency can be defined as |BC|/(|OA|+|AB|+|BC|), which is equal to |B’C’|/|OC’| where C’ is located along the extension of **z** such that |AC|=|AC’|. The allocative efficiency index is then defined by |OB'|/|OC'|, and the profit efficiency index by |OA|/|OC'|, which is the product of technical efficiency and allocative efficiency. Note that profits may be negative, but π^* will be always at least as great as π^T which is in turn at least as great as π, hence negative profits will not cause a trouble in the definitions of indices. When π equals π^*, technical efficiency, allocative efficiency and profit efficiency will be all one.

3.2 A New Index Approach

Consider a banking industry where banks produce M outputs using N inputs, that is, input vector $x \in R_+^N$ and output vector $y \in R_+^M$. Let $\mathbf{z} = (x'\ y')' \in R_+^{N+M}$ be the actual input output vector, $\mathbf{g} = (-g_x'\ g_y')' \in R_+^{N+M}$ be the directional vector, and $\mathbf{p} = (-w'\ p')' \in R_{--}^N \times R_{++}^M$ be the vector of negative input prices and positive output prices.

We define the feasible set $T \subseteq R_+^N \times R_+^M$ under the available technology as

$$T = \{(x,y): x \text{ can produce } y\} \tag{1}$$

Then, the directional (technology) distance function is defined by (Luenberger, 1992; Chambers *et al.*, 1998):

$$\beta^* = \vec{D}(\mathbf{z};\mathbf{g},T) = \max_\beta\{\beta: (\mathbf{z} + \beta\mathbf{g}) \in T\} \tag{2}$$

where β^* is the solution to the conditional maximisation problem. Since $\mathbf{z} \in T$, β^* is non-negative.[4] If β^* equals zero, it implies that it is technically impossible to simultaneously contract inputs and expand outputs from the current levels and hence the bank is technically efficient. When β^* is greater than zero, on the other hand, it is implied that there is room for an increase in the profit by producing more outputs using less inputs. The maximum simultaneous reductions in the inputs and increases in the outputs that the bank can make along the directional vector are by $\beta^*\mathbf{g}$, whose equivalence in Figure 1 is AB. Thus the maximum profit achievable at the technically efficient point is given by

$$\pi^T = \mathbf{p}\cdot(\mathbf{z} + \beta^*\mathbf{g}) = \mathbf{p}\cdot\mathbf{z} + \beta^*\mathbf{p}\cdot\mathbf{g} = \pi + \beta^*\delta \tag{3}$$

where π is the actual profit and $\delta = \mathbf{p}\cdot\mathbf{g} = w'g_x + p'g_y$ which is strictly positive given that $\mathbf{g}$ is not a null vector. Rearranging equation (3) for β^* yields

$$\beta^* = (\pi^T - \pi)/\delta. \tag{4}$$

Similarly, the maximum profit the bank can achieve when changes in input-output bundle are allowed is calculated as

$$\pi^* = \mathbf{p}\cdot(\mathbf{z} + \lambda_1\mathbf{g}) = \mathbf{p}\cdot\mathbf{z} + \lambda_1\mathbf{p}\cdot\mathbf{g} = \pi + \lambda_1\delta \tag{5}$$

where λ_1 is non-negative scalar value that makes the first equation in (5) hold. The new input-output vector, $(\mathbf{z} + \lambda_1\mathbf{g})$, may not be feasible under T, but a λ_1 should exist to make

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[4] See Lemma 2.1 of Chambers et al. (1998, p354).

the equation algebraically true. Rearranging (5) for λ_1 gives

$$\lambda_1 = (\pi^* - \pi)/\delta. \tag{6}$$

In Figure 1, |AB| which represents technical inefficiency equals β^* times the length of the directional vector, i.e. $\beta^*|\mathbf{g}|$. This implies that |AC| equals λ_1 times the length of the directional vector, i.e. $\lambda_1|\mathbf{g}|$, and |BC| which represents allocative inefficiency equals $\lambda_1|\mathbf{g}| - \beta^*|\mathbf{g}|$. Comparing equations (3) and (5) reveals that $\lambda_1 \geq \beta^*$ because $\pi^* \geq \pi^T$ and $\delta > 0$. Thus, $\lambda_1|\mathbf{g}| - \beta^*|\mathbf{g}| \geq 0$.

We are now ready to define our technical efficiency (TE), allocative efficiency (AE), and profit efficiency (PE) scores as:

$$TE = 1 - \beta^*|\mathbf{g}|/(|\mathbf{z}|+\beta^*|\mathbf{g}|) = |\mathbf{z}|/(|\mathbf{z}|+\beta^*|\mathbf{g}|), \tag{7}$$

$$AE = 1 - (\lambda_1|\mathbf{g}| - \beta^*|\mathbf{g}|)/(|\mathbf{z}|+\lambda_1|\mathbf{g}|) = (|\mathbf{z}|+\beta^*|\mathbf{g}|)/(|\mathbf{z}|+\lambda_1|\mathbf{g}|), \text{ and} \tag{8}$$

$$PE = |\mathbf{z}|/(|\mathbf{z}|+\lambda_1|\mathbf{g}|). \tag{9}$$

Note that PE=TE×AE. The lengths of the vectors, $|\mathbf{z}|$ and $|\mathbf{g}|$, are measured as Euclidean distances, $\sqrt{\mathbf{z}\cdot\mathbf{z}}$ and $\sqrt{\mathbf{g}\cdot\mathbf{g}}$, respectively.

As alluded at the beginning of this section when we used notations $w^{k'}$ and $p^{k'}$ for the input and output prices faced by bank k', individual banks face different input and output prices. The difference between output price and input price represents banking margin, and hence it may well reflect bank's business skills as well as its reputation and credit rating. Thus, we next look at banks' such skills, namely, their efficiency in securing the most favourable input-output price ratios. In Figure 1, the maximum profit a bank can achieve when price negotiation skills are allowed for is denoted by π^m and the most favourable output price by p^m. The most favourable price line is tangent to the feasible set at point Q^m. Its slope is w^m/p^m and it cuts through the vertical axis at π^m/p^m, where w^m is the input price so that the price ratio w^m/p^m is the most favourable. To make π^m comparable with the other profit levels, we normalise it by the actual output price, $p^{k'}$. The price line with the same slope as the actual price line, $w^{k'}/p^{k'}$, and the intercept $\pi^m/p^{k'}$ will represent the normalised profit at point Q^m. In Figure 1, the line is drawn through point D.

Let λ_2 be a non-negative scalar that makes the following equation true,

$$\pi^m = \mathbf{p}\cdot(\mathbf{z} + \lambda_2\mathbf{g}) = \mathbf{p}\cdot\mathbf{z} + \lambda_2\mathbf{p}\cdot\mathbf{g} = \pi + \lambda_2\delta. \tag{10}$$

Thus,

$$\lambda_2 = (\pi^m - \pi)/\delta, \tag{11}$$

which is greater than or equal to λ_1. We define the efficiency of securing the most favourable input-output prices as follows and refer to it by price efficiency (PRE).[5]

$$PRE = (|z|+\lambda_1|g|)/(|z|+\lambda_2|g|) \tag{12}$$

We also analyse the change in productivity over each pair of consecutive years using a modified version of the Malmquist productivity index. Our Malmquist productivity index builds on the Malmquist productivity index of Caves et al. (1982), which is based on

[5]We note that this term is occasionally used to refer to allocative efficiency in the literature.

radial input or output distances, and it measures profit-oriented productivity based on directional distances. As we intend to decompose a change in productivity into pure technical efficiency change, scale efficiency change, and technology change, we measure distances of an input-output vector against both the constant returns to scale (CRS) and the variable returns to scale (VRS) frontiers. Then, the difference between the distance to the CRS frontier and the distance to the VRS frontier will represent scale inefficiency.
Define the distances as

$$\alpha_t^s = \vec{D}(\mathbf{z}_t;\mathbf{g}_t, T_{CRS}^s) = \max_\alpha\{\alpha: (\mathbf{z}_t + \alpha\mathbf{g}_t) \in T_{CRS}^s\}, \text{ and} \tag{13}$$

$$\beta_t^s = \vec{D}(\mathbf{z}_t;\mathbf{g}_t, T_{VRS}^s) = \max_\beta\{\beta: (\mathbf{z}_t + \beta\mathbf{g}_t) \in T_{VRS}^s\} \text{ for t = 0,1 and s = 0,1} \tag{14}$$

where t and s are either base period (0) or comparison period (1), $\mathbf{z}_t = (x_t' \ y_t')'$ is the input-output vector in period t, $\mathbf{g}_t$ is the directional vector in period t, T_{CRS}^s is the CRS feasible technology set in period s, and T_{VRS}^s is the VRS feasible technology set in period s. Then, the Malmquist productivity index between two periods is defined as the geometric mean of two productivity indices – one based on period 0's and the other based on period 1's technology:

$$M^{0,1} = \left[\frac{M^0(z_1)}{M^0(z_0)} \cdot \frac{M^1(z_1)}{M^1(z_0)}\right]^{1/2} \tag{15}$$

where $M^s(\mathbf{z}_t) = |\mathbf{z}_t|/[|\mathbf{z}_t| + \alpha_t^s|\mathbf{g}_t|]$, for t=0,1 and s=0,1. Note that each $M^s(\mathbf{z}_t)$ can be decomposed into $1/[1+\bar{\beta}_t^s]$ and $[1+\bar{\beta}_t^s]/[1+\bar{\alpha}_t^s]$, where $\bar{\alpha}_t^s = \alpha_t^s|\mathbf{g}_t|/|\mathbf{z}_t|$ and $\bar{\beta}_t^s = \beta_t^s|\mathbf{g}_t|/|\mathbf{z}_t|$, representing technical efficiency and scale efficiency of $\mathbf{z}_t$ respectively. When these are substituted into (15), the profit-oriented Malmquist productivity index can be rewritten as follows.

$$M^{0,1} = \left[\frac{(1+\bar{\beta}_1^0)/(1+\bar{\alpha}_1^0)}{(1+\bar{\beta}_0^0)/(1+\bar{\alpha}_0^0)} \cdot \frac{(1+\bar{\beta}_1^1)/(1+\bar{\alpha}_1^1)}{(1+\bar{\beta}_0^1)/(1+\bar{\alpha}_0^1)}\right]^{1/2} \left[\frac{1/(1+\bar{\beta}_1^1)}{1/(1+\bar{\beta}_0^0)}\right] \left[\frac{1/(1+\bar{\beta}_1^0)}{1/(1+\bar{\beta}_1^1)} \cdot \frac{1/(1+\bar{\beta}_0^0)}{1/(1+\bar{\beta}_0^1)}\right]^{1/2} \tag{16}$$

The terms in the three sets of brackets on the right-hand side of the equation are scale efficiency change (SEFFCH), pure technical efficiency change (TEFFCH), and technological change (TECHCH), respectively. The SEFFCH in the first set of brackets is the geometric mean of two scale efficiency ratios, one based on period 0's and the other based on period 1's technology. The TEFFCH in the second set of brackets measures how much closer (or farther) the input-output vector has moved to the corresponding period's VRS technology frontier. The TECHCH in the last set of brackets is the geometric mean of two measures of the shift in the frontier, one along the input-output vector in period 0 and the other along the input-output vector in period 1. This definition of productivity index is in a ratio form and thus is in line with the earlier definitions of efficiency measures. It contrasts with the Luenberger productivity indicator defined in terms of differences by Chambers et al. (1996).
Following Färe et al. (2004), the DEA method is used to construct frontiers defining technology sets and to measure distances to the frontiers. For the DEA models of the present paper, we assume that the underlying technology is characterised by VRS. Further,

to account for the potential tradeoff between risk and profit, equity capital is included as a fixed input. Other considerations include two important regulatory constraints faced by the banks operating in Vietnam that the equity capital of a domestic bank should be at least a certain proportion of its total risk-weighted asset (capital-adequacy constraint) and that the total amount of deposits by Vietnamese nationals with a foreign bank cannot exceed a set multiple of its equity capital (deposit constraint). We will estimate the models with and without the capital-adequacy and deposit constraints to analyse the effects of those constraints.

Specifically, the maximal short-run *unregulated* profit that is attainable by a decision making unit (DMU), k', facing input and output prices, $w^{k'}$ and $p^{k'}$ respectively, is estimated by solving the following linear programming (LP) problem:

$$
\begin{aligned}
\pi^* = \max_{y,x,v} \{p^{k'} \cdot y - w^{k'} \cdot x:& \\
&\sum_{k=1}^{K} v_k y_m^k \ \geq y_m \qquad m = 1, \ldots, M \\
&\sum_{k=1}^{K} v_k x_n^k \ \leq x_n \qquad n = 1, \ldots, N \\
&\sum_{k=1}^{K} v_k e^k \ \leq e^{k'} \\
&\sum_{k=1}^{K} v_k \ = 1 \\
&x \geq 0_N,\ y \geq 0_M, \text{ and } v_k \geq 0 \text{ for } k = 1, \ldots, K\}
\end{aligned} \tag{17}
$$

where K is the total number of DMUs, v_k are the intensity variables, y_m is the m^{th} element of the output vector y, x_n is the n^{th} element of variable input vector x, and e is equity capital.

The maximal short-run *regulated* profit for the same DMU is computed by adding the following two additional constraints:

(i) capital-adequacy constraint: $e^{k'} / \sum_{r=1}^{R} \omega_r A_r^{k'} \ \geq \mu_e$ if k' is not a foreign bank; and

(ii) deposit constraint: $x_3^{VN} / e^{k'} \leq \mu_d$ if k' is a foreign bank, (18)

where A_r and ω_r are risk-assigned assets and their risk weights respectively, x_3^{VN} is the total deposit with bank k' by Vietnamese nationals, and μ_e and μ_d are constants set by the regulator.

The directional distance to the VRS frontier of the input-output vector of DMU k' is measured by

$$
\begin{aligned}
\beta^* = \max_{\beta}\{\beta:& \\
&\sum_{k=1}^{K} v_k y_m^k \ \geq \ y_m^{k'} + \beta g_{ym} \qquad m = 1, \ldots, M \\
&\sum_{k=1}^{K} v_k x_n^k \ \leq \ x_n^{k'} - \beta g_{xn} \qquad n = 1, \ldots, N
\end{aligned}
$$

$$\sum_{k=1}^{K} v_k e^k \le e^{k'}$$

$$\sum_{k=1}^{K} v_k = 1,$$

$$\beta \ge 0 \text{ and } v_k \ge 0 \text{ for } k = 1, .., K\} \tag{19}$$

where g_{xn} and g_{ym} are the n^{th} and the m^{th} elements of g_x and g_y respectively. Distances to the CRS frontier can be measured when the VRS constraint, $\sum_{k=1}^{K} v_k = 1$, is excluded.

The Malmquist productivity index defined by (16) requires computation of the distance of an input-output vector in one period against the frontier in the other period, like the computation of $\vec{D}(\mathbf{z}_t;\mathbf{g}_t, T^s)$ where $t \neq s$. In such cases, some efficient DMU's input-output vector may become infeasible under the other period's technology. The LP problems in those cases are modified as follows.

$$\beta^* = \max_\beta\{-\beta:$$

$$\sum_{k=1}^{K} v_k y_m^k \ge y_m^{k'} - \beta g_{ym} \qquad m = 1, \ldots, M$$

$$\sum_{k=1}^{K} v_k x_n^k \le x_n^{k'} + \beta g_{xn} \qquad n = 1, \ldots, N$$

$$\sum_{k=1}^{K} v_k e^k \le e^{k'}$$

$$\sum_{k=1}^{K} v_k = 1,$$

$$\beta \ge 0 \text{ and } v_k \ge 0 \text{ for } k = 1, .., K\} \tag{20}$$

To measure distances against a CRS frontier, the VRS constraint, $\sum_{k=1}^{K} v_k = 1$, is excluded. Note that the solution to the above LP problem for an infeasible DMU in the original LP problem, (19), is negative, and hence the technical efficiency measure $|\mathbf{z}|/(|\mathbf{z}|+\beta|\mathbf{g}|)$ is greater than one, implying that the DMU is "super efficient" under the reference technology.

4 Data

We adopt the *intermediation approach* and define the outputs as customer loans (y_1), other earning assets (y_2), and the actual value of off-balance-sheet items (y_3), and the inputs as full-time equivalent number of employees (x_1), fixed assets (x_2), customer deposits, and other borrowed funds (x_3), plus equity capital (e) as a fixed input. All input and output values are deflated with the consumer price index (CPI).[6]

The price of y_1, denoted p_1, is derived as the amount of interest income from customer loans divided by the amount of customer loans. The price of y_2, denoted p_2, is derived similarly as the amount of other interest and investment income divided by the amount of other earning assets. Necessary information to derive the price for off-balance-sheet items (y_3), denoted p_3, is not available for all banks.

Table 1: Data Summary – Average per Bank over Whole Sample Period

	SOCBs		**JSCBs**		**FBs**		**ALL banks**	
	Mean	*Std*	*Mean*	*Std*	*Mean*	*Std*	*Mean*	*Std*
y_1	46,700	35,300	1,337.2	1,914.1	1,313.6	1,129.5	5,382.2	16,700
y_2	16,200	16,000	726.9	1,548.6	1,020.9	1,072.3	2,217.4	6,561.9
y_3	5,087.2	4,615.9	341.4	636.3	346.6	294.3	767.1	1,983.9
$x_1^{\&}$	10,841	9,248	362	500	137	86	1,213	4,086
x_2	980.8	738.4	47.3	71.7	18.1	12.5	119.7	351.1
x_3	67,800	42,500	2,204.3	3,552.9	2,158.5	1,908.2	8,044.3	22,700
$p_1^{\#}$	0.1065	0.0455	0.1053	0.0279	0.0673	0.0274	0.0912	0.0349
$p_2^{\#}$	0.1159	0.0857	0.0709	0.0828	0.0528	0.0619	0.0681	0.0777
$p_3^{\#}$	0.0873	0.0186	0.0873	0.0184	0.0873	0.0184	0.0873	0.0184
$w_1^{\wedge}$	32.87	10.47	29.07	10.12	106.28	15.29	58.36	39.16
$w_2^{\#}$	0.5947	0.2796	0.6586	0.8415	2.5789	4.2218	1.3730	2.8135
$w_3^{\#}$	0.0766	0.0320	0.0616	0.0214	0.0348	0.0161	0.0529	0.0254
e	3,695.0	2,190.7	215.4	281.1	308.2	95.8	560.9	1,196.0
π	1,285.8	1,441.7	48.9	76.6	35.0	30.8	154.1	556.9

Source: Authors' calculation based on dataset collected from the SBV.

All variables are measured in billion dong (VND) (Average VND/US$ exchange rate during the sample period was around 15,000 VNDs per US$.), except those indicated; $^{\#}$ measured in VND/VND; $^{\wedge}$ measured in million VND per employee; and $^{\&}$ measured in the number of staff.

Hence, we compute p_3 as non-interest income divided by the value of off-balance-sheet items for the banks where separate series are available. Then, the average of those p_3 values in each year is used as the price of y_3 for all banks in that year assuming that p_3 is identical for all banks in each year. Similarly, as the number of full-time equivalent employees was not available for all individual banks in Vietnam, we assume that the unit price of labor (w_1) is the same for all banks in the same ownership category, but varies

[6]It should be noted that the correlation coefficient between CPI and GDP deflator in Vietnam during the studied period was almost equal to one. Thus, the use of either variable to deflate the nominal values of data should result in no significant differences in the results.

from year to year. This assumption is based on the fact that banks in the same ownership category normally offer quite similar salary level. Furthermore, in developing countries like Vietnam, foreign banks usually pay employees more than their domestic rivals do. The common unit price of labor for group j (j=1, 2 and 3, corresponding to the groups of SOCBs, JSCBs and FBs) in each year is calculated as: $\overline{w_1^j} = \frac{1}{I^j}\sum_{i=1}^{I^j}\frac{PerExp_i}{x_{1i}}$, where *PerExp* is personnel expenses and I^j is the number of banks which had information on the number of employees, in group *j*. The price of x_2, denoted w_2, is derived as other non-interest expenses divided by the total value of fixed assets, while the price of x_3, denoted w_3, is derived as interest expenses paid for deposits and other borrowed funds divided by the total amount of customer deposits and other borrowed funds.

Table 1 provides a summary of the data. It shows average per-bank figures over the whole seven-year period for all banks and sub-groups of banks. Dominance of the big five SOCBs is evident from the figures. Their average balances of customer loans and deposits are more than 30 times of the other banks' average balances. In fact, the group of SOCBs holds 77% of all customer loans and 75% of all customer deposits and borrowed funds. While the SOCBs stand apart in terms of scales, the differences in output and input compositions between JSCBs and FBs are not that substantial. As for the unit prices, SOCBs again enjoy the highest prices of outputs, while the FBs pay the highest prices for labor and fixed-asset inputs. The reason for the latter is that foreign banks normally pay higher salaries to employees than do domestic banks. They also tend to pay more for premises resulting in a higher unit price for fixed assets. Although the SOCBs enjoy high output prices and low input prices in general, their unit price of borrowed funds is higher than the prices paid by other banks. This can be explained by the SOCBs' large share of deposits by individuals. Interest rates paid to individual customers are normally much higher than those paid to corporate and institutional customers. Because of government guarantees and support, SOCBs often mobilize a larger proportion of deposits from individuals compared with other banks. Thus, SOCBs face higher interest expenses than do private banks.

It is also of our interest to examine the effect of prudential regulations on efficiency of Vietnamese banks. In particular, we are concerned with the effect of the minimum capital-asset requirement and of the deposit-taking restriction on the performance of the Vietnamese banking sector. The capital-adequacy regulation is applied to all banks except foreign banks, whereas the deposit regulation is applied only to foreign banks. The capital-adequacy regulation currently adopted by the Vietnamese regulator is the minimum ratio of equity capital to risk weighted assets. A bank is regarded as adequately capitalised if the ratio is at least 8%, which is equivalent to μ_e in (18). Total risk-weighted assets in (18) is computed as

$$\text{Risk-weighted assets} = \omega_1 y_1 + \omega_2 y_2 + \omega_3 y_3 c + \omega_4 x_2 + \omega_5 OA \tag{21}$$

where ω_i are risk weights, c is the conversion ratio for off-balance-sheet items, and OA is other assets which is explained below. Risk weights for the variables defined in the present paper are estimated as a weighted average of the risk weights for the sub-assets included in each variable. The risk weight for Customer Loans (y_1) is 55% reflecting various degrees of risk associated with loans with different types of securities, ranging from 0% for loans secured by deposits with the bank itself to 100% for loans secured by a third-party property. Other Earning Assets (y_2) carries a risk weight of 25% representing balances with other financial institutions and securities. Off-balance-sheet Items (y_3) is converted to a value equivalent to balance-sheet items by multiplying by the conversion ratio of 0.5 before the risk weight of 50% is applied. Fixed Assets (x_2) carries a risk weight of 100%. There are other assets (OA) that are not included in any of the output variables or Fixed Assets, while they should be included in the measure of risk-weighted assets for capital-adequacy. Those assets include balance with the central bank, cash and equivalent, and non-performing loans. OA carries a risk weight of 60%.

Note that the capital-adequacy constraint is imposed in the profit-maximisation problem, (17), as

$$\omega_1 y_1 + \omega_2 y_2 + \omega_3 y_3 c + \omega_4 x_2 \leq (e^{k'}/\mu_e) - \omega_5 OA^{k'} \tag{22}$$

while it is imposed for the directional distance function, (19), as

$$\beta(\omega_1 g_{y1}+\omega_2 g_{y2}+\omega_3 g_{y3}c-\omega_4 g_{x2}) \leq (e^{k'}/\mu_e)-(\omega_1 y_1^{k'}+\omega_2 y_2^{k'}+\omega_3 y_3^{k'}c+\omega_4 x_2^{k'}+\omega_5 OA^{k'}) \tag{23}$$

Also note that when the bank in question, k’, violates the capital-adequacy regulation the LP problem for the directional distance usually does not have a feasible set, but the LP problem for maximum profit may have one. The former is the case because the right-hand side of (23) becomes negative while the term in parentheses on the left-hand side is usually positive. On the other hand, the violation does not automatically make the profit-maximisation problem infeasible because an optimum input-output vector can still be found such that the constraint (22) is satisfied.

The restriction of deposit taking only applies to foreign bank branches. The maximum amount of deposits any foreign bank can take from Vietnamese nationals (natural or legal persons) as a percentage of equity capital varies overtime and differs for different groups of foreign banks. Table 2 shows the limits applied to the deposit constraint for the three groups of foreign banks in each year.

Table 2: Limits of Deposits Taken by Foreign Banks from Vietnamese Nationals (μ_d)

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
US Banks	25.00	29.375	105.83	217.50	514.58	770.41	1114.58
European Banks	25.00	25.00	25.00	31.25	387.50	708.33	750.00
Other FBs	25.00	25.00	25.00	31.25	50.00	50.00	50.00

(% of equity capital)

The deposit constraint is imposed as

$$x_3 \leq \mu_d^{k'} e^{k'} / r^{VN,k'} \tag{24}$$

where $\mu_d^{k'}$ is the deposit limit applied to bank k’, $r^{VN,k'}$ is deposit by Vietnamese nationals with bank k’ divided by total deposits with the bank, $x_3^{VN,k'}/x_3^{k'}$, which is assumed to be fixed during the optimisation process. Note that the above constraint is not applicable to the estimation of distance because contracting x_3 by βg_{x3} would make the left-hand side term of the inequality in (24) even smaller than x_3. So, the deposit constraint is imposed only in the profit maximisation problem.

Finally, the directional vector, $\mathbf{g} = (-g_x' \ g_y')'$, is defined as the actual input-output vector, $(-x' \ y')'$. Although there are other alternatives, such as a unit vector or average of inputs and outputs over banks, this approach has an important advantage over others. That is, it enables valid interpretation of allocative efficiency measures.

5 Empirical Findings

5.1. Estimates of Efficiency

Directional distance and maximum profit under a given price vector have been computed for each of the 56 banks in each year by solving the LP problems defined by (17) and (19) respectively, with and without the capital-adequacy and the deposit constraints.[7] In each year, the feasible technology set is defined as the polyhedron enveloping the input-output vectors observed in the current and the years preceding it. Feasible technology sets based on this approach, which is not new in the literature,[8] would more closely resemble the reality where a once-used technology is generally available in the following years unless there exist restrictions preventing it.

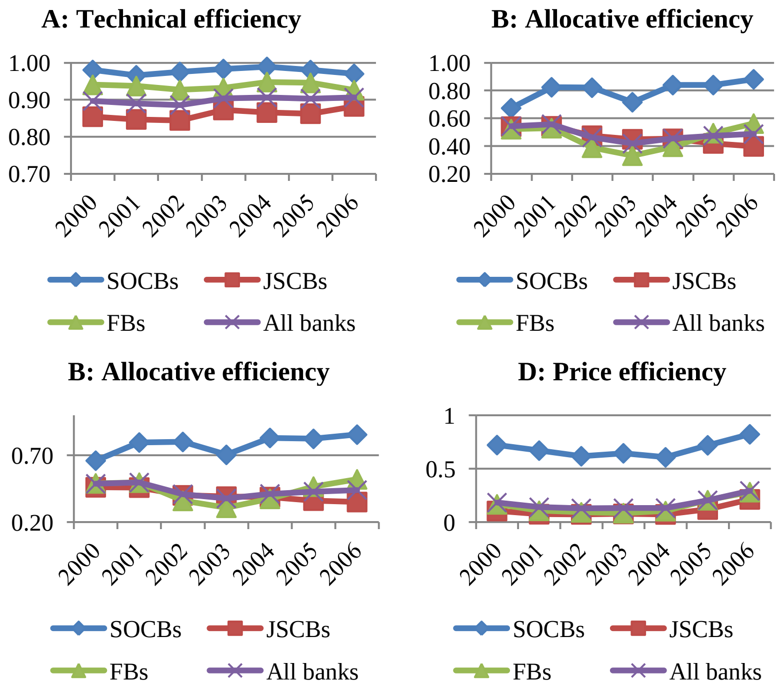

Figure 2: Average Efficiency Scores

The graphs in Figure 2 show geometric average technical efficiency (TE), allocative efficiency (AE), profit efficiency (PE), and price efficiency (PRE) scores for all and

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[7] The econometrics software program *Shazam V10* (Whistler et al., 2004) has been used for the computation. A few instances of "computer cycling" were encountered during the computation, but they could be easily overcome by changing the units of measurement. Note that a change of unit of measurement does not affect the distance or maximum profit, but it only enables LP solutions.
[8] See, for example, Park and Weber (2006), and Tulkens and Vanden Eeckaut (1995).

subgroups of banks in each year, with the capital-adequacy constraint and the deposit constraint imposed on domestic banks and foreign banks respectively. There are 19 cases out of the 273 (39 domestic banks times 7 years) LP problems for directional distance where the bank in question violates the capital-adequacy regulation with the ratio of equity capital to risk-weighted assets falling below 8%. Of the 19 violations, 13 have been committed by SOBs, implying that the penalty fines imposed by the regulator have not been heavy enough to deter big banks from violating the regulation. Directional distances for those 19 cases have been set to zero, implying that the banks involved are technically efficient.[9] Further, in 4 cases out of those 19 cases, actual profit is higher than the maximum profit attainable under given prices. The banks in those cases are assumed to be allocatively efficient.

Average TE scores lie within a relatively narrow range of 0.84 and 1.0, while the AE scores range between 0.33 and 0.88, implying that the main source of the difference in profit efficiency is the difference in allocative efficiency. The low level of allocative efficiency in general might arise because banks produce too much of one type of loan and too little of another. This likely happens to domestic banks because they normally make a poor assessment of credit risk and do not utilize the benefit of diversification. Meanwhile, foreign banks, even though they possess better skills of risk assessment and management, focus too much on wholesale banking and ignore the retail banking market, and thus do not diversify their loan portfolios. Furthermore, domestic banks appear to employ too much labor relative to capital, leading to increased non-wage expenses such as capital equipment and working space. These factors cause the actual relative prices of banks to differ from the shadow relative prices at which banks can maximize profits.

The big five SOCBs not only enjoy a lion’s share of both credit and lending markets (Table 1), but they make their huge profits most efficiently, both technically and allocatively. This may be due to various factors. First, SOCBs are owned by the state, and are thus the first banking choice for state-owned enterprises, especially large and pivotal enterprises (e.g., gas and petroleum, electricity, export and import, and coal enterprises). SOCBs are also protected and guaranteed by the government, so that they have a good reputation (for safety at least) with domestic depositors. These advantages bring SOCBs a large market share in terms of deposits and lending, then market power in the setting of prices, especially prices of banking outputs. Second, SOCBs are larger banks in terms of total assets. It is found in the literature that larger banks are more efficient than smaller banks (Laeven, 1999; Berger et al., 2009). Third, SOCBs have a relatively long history and broader market base via their nationwide branching networks, factors which in turn bring them various benefits. For instance, increased savings from the wide network increase the amount of funds available for lending and investment. In addition, the presence of a wide range of branches makes it easier for individuals and small businesses to access credit and other financial services (Gottschang, 2001). However, even though they are the most profit efficient in the Vietnamese banking sector, some SOCBs still operate below the profit frontier of the best practice banks. The reason for the deficiency is the lack of a strong profit orientation in the SOCBs at two levels. At the national level, the SBV remains heavily involved in the day-to-day management of SOCBs. The SBV

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[9]In fact, the directional distances for those cases are zero except only for four cases when the capital-adequacy constraint is excluded. Even for those four cases, the maximum value is only 0.06.

Governor is responsible for the appointment of Advisory Boards, top management positions and the Chairperson at SOCBs. At the local level, the branches of SOCBs come under the close management of the SBV's branches in all provinces.

The main reason for low profit efficiency scores for FBs is that they have been restricted by a number of regulations. One of the most restrictive is that they have not been permitted to open transaction points or offices outside their current branch offices. Consequently, most foreign bank branches have only one or two offices in either of the two biggest cities—Hanoi (the capital city) and Ho Chi Minh City. They therefore have a limited customer base and limited type of clientele they can serve. Moreover, like FBs in other countries, those in Vietnam have also faced numerous other barriers including differences in language, culture, currency, country-specific market features, bias against foreign institutions, and other explicit or implicit barriers. Together the disadvantages imposed on them seem to surpass their advantages (e.g., long experience in banking internationally, good lending practices, good risk management skills, and capital support from their parent banks), leading to a low level of efficiency.

JSCBs are found to be the least profit efficient banks in the Vietnamese banking sector. This result can be explained by a number of factors. First, compared to SOCBs, they have a shorter history, just around 15 years on average. When they were founded, they were small in both size (measured by equity capital and total assets) and network (measured by the number of branches). They have evolved in the past several years because of the Restructuring Plan. The number of branches in JSCBs has increased significantly since 2005. Thus they operated with a narrow transaction network and then a limited customer base for quite a long time. Second, compared to FBs which, as earlier mentioned, have good lending practices and management skills, many JSCBs have lacked experience and have had low skills in implementing transactions and serving customers. Third, unlike SOCBs and FBs, JSCBs have no explicit support. SOCBs are protected by the Vietnamese government, and FBs are supported by their parent banks. These reasons explain why the profit efficiency scores of JSCBs are not as high as those of FBs and especially of SOCBs.

Concerning the evolution of efficiency, as illustrated in Figure 2, the TE scores of the average bank are relatively high and almost unchanged, with the mean scores in 2000 and 2006 being 0.8967 and 0.9061 respectively. Meanwhile, AE and PE of the average banks are relatively low and seem to decrease in the first half of the studied period and then increase in the second half. The movements of average TE, AE, and PE appear to have the same pattern as those of SOCBs, confirming the dominant role of SOCBs in the Vietnamese banking sector. Moreover, AE and PE appear to follow the same pattern, suggesting that AE dominates TE in shaping PE.

With regard to the type of ownership, PE of JSCBs decreases continuously over the period analysed, from the peak of 0.4612 in 2000 to the trough of 0.3509 in 2006. This finding indicates that JSCBs move further and further away from the optimal bundle of inputs and outputs at which profit can be maximized, and that the restructuring plan, which started in 1999, did not have a positive effect on the performance of these banks in optimizing their input-output mix. This is understandable in the sense that the restructuring program focused on organizational issues rather than operational issues. It might take banks a few more years to adjust, adopt, get used to, and operate smoothly under the new structure. The reduction in PE of JSCBs could be attributed to their failure to manage their diverse activities (e.g., offering a wider range of products, investing in technology, and enlarging branching network), hence spending more and earning less (the increase in revenues being not as great as the increase in costs), leading to lower profitability.

In contrast, PE of FBs evidenced a downward trend during the first half of the sample period and then an upward trend in the second half (2003–2006). This evolution brought an increase of 3% in PE of FBs across the 7-year period. The increase in PE of FBs in the second half of the estimation period might be consistent with the view that when they experience less regulatory control, engage in varied activities, and diversify products and services, FBs manage to translate these factors into a higher level of PE.

For SOCBs, a major improvement in PE (of about 13%) occurs between 2000 and 2001, and the level then remains stable for 2002. In a similar pattern to the FBs, PE of SOCBs also reach their lowest in 2003 before tending upwards toward the end of the period. Overall, SOCBs achieve an improvement in PE of nearly 20%. This significant outcome could be considered a positive effect of the restructuring programs carried out on these banks since 2001. The low level of PE in 2003 for SOCBs could be explained by the fact that in this year, facing the rapid pace of credit growth (which likely led to a high ratio of non-performing loans), SOCBs were more cautious in granting loans, thus reducing pressure on mobilizing funds, and then marginal interest rates tended to decrease slightly, leading to lower profitability. Examining the data set, the study observes that SOCBs faced the lowest marginal rate (lending interest rate minus deposit interest rate) over the 7-year period in 2003, leading to a low rate of profit growth, and then the lowest PE level.

As mentioned in Section 3, we also calculated price efficiency (PRE) scores to compare banks' abilities to secure the most profitable price ratios. In each year, each bank's profit-maximisation problem, (17), has been solved with each of the actual 56 price vectors faced by all banks in that year. Then, the maximum profit achievable among the 56 price vectors is regarded as π^m for the bank in question in the corresponding year. Once λ_2 is obtained, PRE is computed using (12). Panel D of Figure 2 shows PRE scores. The full sample mean PRE is very low, just around 0.17, implying that the observed input and output price level of the average bank in Vietnam is substantially far behind the most favorable price level. Furthermore, PRE of SOCBs is found to be much higher than that of JSCBs and FBs. This implies that private banks may suffer higher costs in providing the same financial services as state-owned banks, or gain lower revenues from providing the same quality and variety of services. This result suggests the existence of a market power advantage for SOCBs in the setting of prices, even in the context of increased competitive pressure. This could be reflected by differences in business between foreign banks and domestic banks. Most of the foreign banks have focused on wholesale banking whereas domestic banks have developed retail banking. Importantly, over the 7-year period, PRE of all groups increased by around 10%, suggesting that there has been an improvement in banks' credibility in the setting of prices.

The efficiency scores estimated without imposing the capital-adequacy and deposit constraints are not separately tabulated to save space. Imposing the capital-adequacy constraint does not have effect on the technical efficiency of domestic banks in most cases, and even for the few cases where that has effect the largest difference is only 0.008. This implies that in most cases the directional vector faces a facet of the technical frontier other than the one that is formed by the capital-adequacy constraint. Imposing the capital-adequacy constraint causes some changes in the allocative efficiency scores of domestic banks, with the mean absolute change being 0.025.[10]

The effects of the two constraints on allocative efficiency and profit efficiency are statistically insignificant. The Kolmogorov-Smirnov (KS) statistic for the null hypothesis that the AE scores for domestic banks with and without the capital-adequacy constraint are from the same distribution is 0.033 with a modified p-value of 0.998. Consequently, the effect of the constraint on PE is also insignificant with the KS statistic 0.037 and its modified p-value 0.991. The KS statistics on the deposit constraint are 0.126 and 0.118 for AE and PE respectively. Their modified p-values are 0.251 and 0.327, respectively, and hence relatively more significant than the statistics for the capital-adequacy constraint. However, the null hypothesis still cannot be rejected at a usual level of significance.

5.2 Estimates of Productivity

The Malmquist productivity index defined by (16) has been computed for each bank in each year. In computing the directional distances, both the capital-adequacy and deposit constraints are excluded in constructing the frontiers. The reason is because such constraints would lead to biased measures of scale efficiency for those cases where the directional vector cuts through the hyperplane formed by the regulatory constraints. In such cases, scale inefficiency would be represented by the distance to the CRS frontier from the frontier formed by the regulatory constraint instead of the VRS frontier formed by the input-output constraints. The productivity change (PROD) is decomposed into technical efficiency change (TEFFCH), technological change (TECHCH), and scale efficiency change (SEFFCH). The overall mean estimates for these changes are reported in Table 3.

Table 3: Overall mean productivity change

	TEFFCH	**SEFFCH**	**TECHCH**	**PROD**
All banks	1.0016	0.9850	1.0300	1.0161
SOCBs	0.9982	0.9148	1.1010	1.0053
JSCBs	1.0050	0.9907	1.0099	1.0056
FBs	0.9974	0.9943	1.0427	1.0341

Overall, the banking industry in Vietnam experiences modest productivity progress with an average rate of 1.61% per annum. The main contributor to this growth is technological progress of 3% per year. Meanwhile, improvement in technical efficiency is tiny, just 0.16% on average, but deterioration in scale efficiency is about 1.5% per year. Technological progress is large enough to offset a decline in scale efficiency, leading to a moderate improvement in productivity.

At the bank category level, the results indicate that foreign banks have a higher rate of productivity growth than the two groups of domestic banks. The driver for their achievement is an improvement in technology, of about 4.3% per annum. Besides, they experience a mild contraction in scale efficiency (−0.57%) and an insubstantial decrease in technical efficiency (−0.26%). The plausible explanation for the high growth rate of productivity in foreign banks lies in their business model. Unlike domestic banks, they

[10]Note that imposing an additional constraint cannot decrease TE but it may decrease AE.

focus on corporate and wholesale banking rather than retail banking. Thus, they can adjust their production plans and operational scale better and more quickly than others when facing changes in the banking environment. The other likely explanation is that most foreign banks have more advanced technology platforms than SOCBs and especially JSCBs. Clearly, they have been the leaders in the introduction of credit cards, debit cards, ATMs, factoring, forfeiting, and other modern financial services. With these advantages, the penetration of foreign banks into the Vietnamese market has promoted productivity gains of the whole banking system.

In contrast to FBs, JSCBs undergo a tiny rate of productivity growth, just 0.56% on average. This growth is made up of gentle rates of technological progress and technical efficiency improvement (0.99% and 0.5% respectively), which are just sufficient to trade off a decrease in scale efficiency of 0.93% each year. Similarly, SOCBs also experience poor productivity growth, 0.53% each year on average. However, the driver to this growth is relatively different from that of JSCBs. SOCBs enjoy impressive technological progress (10.1% each year on average), but also suffer from a large contraction in scale efficiency (8.5% annually).

The main reason for the low rate of productivity growth in JSCBs is their primitive technology applications. Even though it appears that technology has been upgraded recently in some large JSCBs, the common technology application at JSCBs is the application of core-banking software which is used to computerize information and payment transactions. SOCBs have a much more substantial technology infrastructure than JSCBs because they are subsidized by the government to develop ATM networks, non-physical banking (i.e. internet banking, phone banking, and SMS banking), and international card products. However, SOCBs exhibit only modest productivity growth. The possible explanation is that they operate far beyond the optimal scale size, leading to a large decrease in scale efficiency from year to year.

6 Conclusions

We have introduced a new approach to constructing technical efficiency, allocative efficiency, and profit efficiency indices using directional distances. Unlike the available indicator approaches that are based on differences, the new indices are based on ratios between distances, hence making interpretations more sensible. We have also decomposed the Malmquist productivity index into scale efficiency change, pure technical efficiency change, and technological change in a way that is fully consistent with the new ratio-type efficiency indices. In doing so, we have explicitly shown how to handle infeasible linear-programming problems when the directional distance of an input-out vector is measured against the technology frontier in another period.

The new methods have been then applied to an analysis of the Vietnamese banking sector. The findings show that the average bank operated quite far below the frontier of the best-practice bank. The main source of this low profit efficiency was allocative inefficiency rather than technical inefficiency, suggesting that banks were particularly poor at choosing input and output combinations to maximize profits. Price efficiency was found to be significantly low, indicating that the actual price vectors of banks in Vietnam were very different from the most favorable price vector. The implication is that the majority of banks in Vietnam have more room to negotiate borrowing and lending interest rates more favorably to maximize their profit. Moreover, the price efficiency scores of

SOCBs were much higher than those of JSCBs and FBs. This suggests that market power might exist in pricing bank products in Vietnam, and that SOCBs have the power to set price ratios in such a way that their profitability is maximized, whereas other banks do not. We further found that SOCBs were more profit efficient than FBs and domestic private banks. This result can be explained by the fact that SOCBs benefit from being guaranteed and supported by the government, and having nationwide branch networks as well as a huge customer base. The result can also be supported by the preceding argument that market power might exist for state-owned banks in pricing bank outputs. Furthermore, the effects of the two regulatory constraints are found to be insignificant both in a size and statistical sense.

Regarding productivity analysis, the Vietnamese banking industry experienced modest productivity growth, which is mainly due to technological progress, and to some degree technical efficiency change, whereas scale efficiency change contributed adversely to productivity growth. The most successful group, in terms of productivity improvement, appears to be the group of foreign banks. Their technical efficiency and the growth rate of technology are better than any other groups except SOCBs, resulting in the highest improvement in overall productivity, including SOCBs, over the sample period.

Policy implications of the findings are that i) Policies that would result in the expansion of the size of SOCBs would lead to significant decrease in their productivity due to deteriorating scale efficiency; ii) To promote productivity growth, domestic banks need to manage their scale of operation effectively and further upgrade their information technology platform, whereas foreign banks need to enlarge their scale size by opening new offices and transaction points; and (iii) As the capital-adequacy constraint does not lead to a significant change in efficiency, it should be more strictly applied to enhance the soundness and stability of the financial system.

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