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THE PERFORMANCE OF MERGERS AND ACQUISITIONS IN THE SINGAPORE BANKING SECTOR: AN APPLICATION OF TWO-STAGE BANKING MODELS

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Abstract

An event study window analysis of Data Envelopment Analysis (DEA) is employed in this study to investigate the effects of mergers and acquisitions (M&As) on Singapore domestic banking groups' efficiency. The results suggest that the merger has resulted in higher Singapore banking groups' mean overall efficiency post-merger. Despite that, from the scale efficiency perspective, the findings do not support for further consolidation in the Singapore banking sector. We found mixed evidence on the characteristics of efficiency on the acquirers and targets banks, hence, do not fully support the hypothesis of a more (less) efficient bank becoming the acquirer (target). In most cases, the results further confirmed the hypothesis that the acquiring banks' mean overall efficiency improved (deteriorates) post-merger resulting from the merger with a more (less) efficient bank. Tobit regression model is employed to determine factors affecting bank performance. The results suggest that bank profitability has significant positive impact on bank efficiency, whereas poor loan quality has significant negative influence on bank performance.

JEL Classifications: G21; D24
Keywords: Bank Merger; Data Envelopment Analysis; Tobit Model; Singapore

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1. Introduction

In recent decades, the Singapore banking sector has been subject to globalization, deregulation, and liberalization similar to that in industrialized countries such as the EU and the USA. Those changes are linked with M&A processes aimed at increasing bank competitiveness and efficiency. The Singapore banking industry is a considerable component in Asian financial activities, which has not been subjected to substantial research compared to the other countries in the developed world. As efficient banking systems contribute in an extensive way for higher economic growth in any country, studies in this nature are very important for policy makers, industry leaders and many others who are reliant on the banking sector.

The analysis of bank efficiency continues to be important from both a microeconomic and macroeconomic point of views as is documented by its long tradition in the literature[1]. From the microeconomic perspective, the issue of bank efficiency is crucial, given increasing competition and measures to further liberalize the banking system. This renders the issue of increasing the efficiency as one of the main priorities of the regulators towards the sector. From the macroeconomic perspective, the efficiency of the banking sector influences the costs of financial intermediation and the overall stability of the financial markets.

The motivation of this study comes firstly from the fact that despite the importance of the Singapore banking sector to the domestic, regional, and international economy, there are only a few microeconomic studies performed in this area of research. The present study thus addresses an important gap in the literature by providing the most recent evidence on the efficiency of the Singapore banking sector.

Secondly, in order to appraise the effectiveness and success of the mergers and acquisitions (M&As) activities among the domestic incorporated Singapore commercial banks, it is therefore essential to conduct a formal analysis. This study thus attempts to provide empirical evidence on the efficiency changes of Singapore commercial banks arising from M&As over the past decade. Utilizing the non-parametric Data Envelopment Analysis (DEA) methodology, the overall, pure technical and scale efficiencies of all domestic incorporated Singapore commercial banks that were involved in M&As will be investigated. The role of mergers in efficiency changes will be examined by comparing relative efficiency scores before and after the merger program.

[1] For an overview, see Berger *et al.* (1993), Berger and Humphrey (1997).

Finally, the study employs the Tobit regression technique to identify the determinants of the performance of Singapore banks, which as generally accepted in the literature, could overcome the limitations of a standard method of comparing financial parameters that are unable to capture the long-term trends. Furthermore, to the best of our knowledge, the study will be the first to employ a Tobit regression technique to identify the determinants of the efficiency of the Singapore banking sector.

In effect the paper raises four important fundamental questions. 1) Did the M&As result in the improvement of the mean overall efficiency levels of the Singapore banking system post-merger? 2) Did a less efficient bank become the target for acquisition? 3) Did a less (more) efficient target result in the deterioration (acceleration) in the acquirer's mean overall efficiency level post-merger? 4) What determines the relative performance of banks in Singapore?

The paper is structured as follows: the next section gives a brief overview of the Singapore banking system, Section 3 reviews related studies in the main literature with respect to studies on bank efficiency, Section 4 outlines the approaches to the measurement and estimation of efficiency change, Section 5 discusses the results and finally, Section 6 provides some concluding remarks.

2. Brief Overview of the Singapore Banking System

The development of Singapore as a financial centre was the move of deliberate government policy to broaden the country's economic base in the 1970s. With the introduction of Monetary Authority of Singapore (MAS) in 1970, the government has introduced fiscal incentives, removed exchange controls, and encouraged competition to spur the financial sector development. Supported by its sound macroeconomic fundamentals and prudent policies, today, Singapore ranks among the leading international financial centers. At present, Singapore is an established financial centre and is one of the key centers in Asia. Singapore lags only behind London, New York and Tokyo in foreign exchange trading. Growth in the financial services sector has contributed significantly to its economic growth and development, which today accounts for approximately 13% to 15% of its GDP. This is evidenced by the presence of a wide network of financial institutions providing a range of services that facilitate domestic, regional, and international flow of funds for trade and investments.

The Singapore domestic banking sector is closely regulated and largely protected until the later half of the 1990s. The entry of foreign banks was restricted to the wholesale banking markets since 1971. While locally incorporated banks are given permission to expand its branch

networks, foreign incorporated full licensed banks admitted prior to 1971 are subjected to restrictions in terms of opening up new branches and re-locating existing branches. As such, locally incorporated banks are relatively sheltered from foreign competition. The result is a banking industry with many international players but where domestically incorporated commercial banks, control the local banking market.

During the Asian Financial Crisis 1997-1998, its sound economic and financial fundamentals have enabled the sector to weather the crisis relatively well. Despite incurring losses from defaulted loans, which escalated during the crisis, Singapore commercial banks were adequately capitalized and insolvency was not an issue. Nonetheless, the immediate lessons from the financial turmoil for the local financial institutions are the need to create strong incentive for banks to merge, which would form large institutions able to cope with international competition.

Mergers and Acquisitions in the Singapore Banking Sector

A regional financial centre can be defined as a central location, where there is a high concentration of financial institutions and capital markets that allow financial transactions in the region to take place efficiently. Singapore has been a remarkable success as a regional financial centre. In just over three decades, the city-state has become one of the world's leading financial centers. The Singapore government has been actively undertaking financial liberalization and reforms since the 1960s. As a result of its endeavors, Singapore has become a leading financial centre serving the domestic as well as neighboring economies of South East Asia. As a financial centre, Singapore has facilitated greater financial intermediation in the region, contributing to the development of capital markets and cross border trade and business investment.

Singapore was the economy in South East Asia least affected by the Asian financial crisis. Nevertheless, the crisis exposed Singapore's vulnerability to external shocks and financial contagion. Rather than becoming more inward looking, as did some of the crisis affected countries, Singapore hastened financial liberalization in order to create a more resilient financial sector, which could compete in an increasingly globalized environment. The liberalization has involved strengthening domestic banks through consolidation and increasing foreign participation in the financial sector.

Since 1998, when Development Bank of Singapore (DBS) acquired the Post Office Savings Bank (POSB) and Keppel Bank merged with Tat Lee Bank, the Singapore government has been encouraging domestic banks to consolidate to prepare them for stiffer competition from foreign

banks. In fact, for Singapore banks to compete successfully in the new era of globalization, the government intended to eventually merge the domestic financial institutions into two "super banks".
The recent M&As activities among domestic incorporated Singapore banks were:

- On June 12, 2001, Singapore's third largest bank, Overseas-Chinese Banking Corporation (OCBC) announced a S$4.8 billion bid (voluntary general offer) for Keppel Capital Holdings (KCH), which owns Singapore's smallest bank, Keppel Tat Lee Bank.
- On June 29, 2001 Singapore's second largest lender, United Overseas Bank (UOB) made a competing bid for Overseas Union Bank (OUB), Singapore's fourth largest bank, after DBS Holdings Group's unsolicited bid of S$9.4 billion for OUB. UOB's bid succeeded in August 2001 forming Singapore's largest bank in terms of assets.

Table 1
Characteristics of Singapore's Commercial Banks after the M & As in 2001

	DBS	UOB + OUB	OCBC + KEP
Total Assets (S$ billion)	**111.0**	**113.7**	**83.0**
Total Loans (S$ billion)	54.2	61.5	50.4
Total Deposits (S$ billion)	92.8	96.6	71.1
Total Shareholders Fund (S$ billion)	8.4	13.1	8.3
Number of Branches	107	93	74
Number of ATMs	900	426	381

Source: Banks' Annual Reports.
Notes: DBS is Development Bank of Singapore; UOB is United Overseas Bank; OUB is Overseas Union Bank; OCBC is Overseas-Chinese Banking Corporation; and KEP is Keppel Capital Holdings (which owns Keppel Tat Lee Bank).

3. Related Studies

Bank M&As may enable banking firms to benefit from new business opportunities that have been created by changes in the regulatory and technological environment. Berger *et al.* (1999, p. 136) pointed the consequences of M&As, which may lead to changes in efficiency, market power, economies of scale and scope, availability of services to small customers and payment systems efficiency.

Besides improvements in cost and profit efficiencies, M&As could also lead banks to earn higher profits through the banks market in leveraging loans and deposit interest rates. Prager and Hannan (1998) found that bank M&As have resulted in higher banks' concentration, which in turn

leads to significantly lower rates on deposits. Some evidence also suggested that U.S. banks that involved in M&As improved the quality of their outputs in the 1990s in ways that increased costs, but still improved profit productivity by increasing revenues more than costs (Berger and Mester, 2003, p. 88).

The DEA method has been widely applied in the empirical estimation of financial institutions, health care, and education sectors' efficiency worldwide. Furthermore, the technique has increasingly been the preferred method to investigate the impact of M&As on bank efficiency, in particular if the sample size is small (see Table 2). Previous studies undertaken to analyze a small number of M&As includes among others Avkiran (1999), Liu and Tripe (2002), and Sufian (2004).

Table 2
Examples of Small Sample Size in DEA Literature

Researchers (Date)	Sample Size	Inputs *x* Outputs
This study	5	1x2=2 and 2x2 = 4
Liu and Tripe (2002)	7-14	2x2=4 and 2x3=6
Avkiran (1999)	16-19	2x2=4
Oral and Yolalan (1990)	20	5x4=20
Vassiloglou and Giokas (1990)	20	4x4=16
Giokas (1991)	17	3x3=9
Haag and Jaska (1995)	14	3x4=12
Yeh (1996)	7	3x3=9
Sufian (2004)	10	3x2=6

Source: Avkiran (1999) and Liu and Tripe (2002).

Avkiran (1999) employed DEA and financial ratios to a small sample of 16 to 19 Australian banks during the period of 1986-1995, studied the effects of four mergers on efficiency and the benefits to public. He adopted the intermediation approach and two DEA models. He reported that acquiring banks were more efficient than target banks. He also found that acquiring banks do not always maintain their pre-merger efficiency, but that, during the deregulated period, overall efficiency, employees' productivity and return on assets (ROA) improved. There were mixed evidence from the four cases on the extent to which the benefits of efficiency gains from mergers were passed on to the public.

Liu and Tripe (2002) using a small sample of 7 to 14 banks employed accounting ratios and two DEA models to explore the efficiency of 6 bank mergers in New Zealand between 1989 and 1998. They found that the acquiring banks to be generally larger than their targets, although they were not consistently more efficient. They found that five of the six merged banks had efficiency gains based on the financial ratios, while

another only achieved a slight improvement in operating expenses to average total income. Based on the DEA analysis, they found that only some banks were more efficient than the target banks pre-merger. The results suggest that four banks had obvious efficiency gains post-merger. However, they could not decisively conclude on possible benefits of the mergers on public benefits.

Using a small sample size of 10 banks, Sufian (2004) investigates the impact of the recent mega merger program among the domestically incorporated Malaysian commercial banks. He found that Malaysian banks have exhibited an average overall technical efficiency level of 95.9% during the period of study. He found that the inefficiency among Malaysian banks was largely attributed to scale rather than pure technical, suggesting that Malaysian banks were operating at non-optimal scale of operations. He concludes that the merger was particularly successful for the small and medium sized banks, which have benefited most from expansion and via economies of scale.

A note of caution however, encouraging or forcing banks to merge in times of severe banking crisis as a measure to reduce bank failure risk, would not only possibly create a weaker bank, but could also worsen the banking sector crisis. As shown by Shih (2003), merging a weaker bank into a healthier bank in many cases would result in a bank even more likely to fail than both the predecessors' bank. On the other hand, he found that mergers between relatively healthy banks would create banks that are less likely to fail.

Studies on Singapore Bank Efficiency

Despite substantial studies performed concerning the efficiency and productivity of financial institutions in the U.S., Europe and other Asia-Pacific banking industries, the Singapore banking industry has not followed suite partly due to the lack of available data sources and the small sample of banks. Among the notable microeconomic research performed on Singapore bank efficiency was by Chu and Lim (1998), Leong *et al.* (2003), and more recently Randhawa and Lim (2005).

Using DEA with three inputs and two outputs, Chu and Lim (1998) evaluate the relative cost and profit efficiency of a panel of six Singapore listed banks during the period 1992-1996. They found that during the period the six Singapore listed banks have exhibit higher overall efficiency of 95.3% compared to profit efficiency of 82.6%. They also found that large Singapore banks have reported higher efficiency of 99.0% compared to the 92.0% for the small banks. The also suggest that scale inefficiency dominates pure technical inefficiency during the period of study.

Leong *et al.* (2003) examines the efficiency of Singapore banks during the period 1993 to 1999. Following the seminal work by Bauer *et al.* (1997), they employ DEA to a variant of three models i.e. Model A, B and C. They found that the Singapore banking sector exhibit the highest mean efficiency score of 0.533 for Model A, followed by 0.437 for Model C while Model B recorded the lowest efficiency score of 0.332. The results clearly suggest that DEA efficiency scores may vary from different model specifications, which can create problems for policymakers. The results clearly emphasize the importance of robustness checks as well as the need for DEA users to testify for the robustness of the DEA results with alternative specifications and variables.

More recently, Randhawa and Lim (2005) utilize DEA to investigate the locally incorporated banks in Hong Kong and Singapore X-efficiencies during the period 1995 to 1999. They found that during the period the seven domestic incorporated Singapore banks have exhibit an average overall efficiency score of 80.4% under the intermediation approach and 97.2% under the production approach. They suggest that the large Singapore banks have reported higher overall efficiency compared to the small banks under the production approach while on the other hand the small banks have exhibit higher overall efficiency under the intermediation approach. They also suggest that pure technical inefficiency dominates scale inefficiency under both approaches during the period of study.

4. Methodology

The small number of banks is a serious handicap in studying efficiency of the Singapore banking system. The small sample size is among other reasons, which leads us to DEA as the tool of choice for evaluating Singapore banks X-efficiency. Furthermore, DEA is less data demanding as it works fine with small sample size and does not require knowledge of the proper functional form of the frontier, error, and inefficiency structures (Evanoff and Israelvich, 1991, Grifell-Tatje and Lovell, 1997, Bauer *et al.*, 1998). The stochastic models on the other hand, necessitate a large sample size to make reliable estimations.

A non-parametric Data Envelopment Analysis (DEA) is employed with variable return to scale assumption to measure input-oriented technical efficiency of the Singapore banking groups. DEA involves constructing a non-parametric production frontier based on the actual input-output observations in the sample relative to which efficiency of each firm in the sample is measured (Coelli, 1996). The term DEA was first introduced by Charnes, Cooper and Rhodes (1978), (hereafter CCR), to measure the efficiency of each Decision Making Units (DMUs), that is

obtained as a maximum of a ratio of weighted outputs to weighted inputs. This denotes that the more the output produced from given inputs, the more efficient is the production. The weights for the ratio are determined by a restriction that the similar ratios for every DMU have to be less than or equal to unity. This definition of efficiency measure allows multiple outputs and inputs without requiring pre-assigned weights. Multiple inputs and outputs are reduced to single 'virtual' input and single 'virtual' output by optimal weights. The efficiency measure is then a function of multipliers of the 'virtual' input-output combination.

Let us give a short description of the DEA[2]. Assume that there is data on K inputs and M outputs for each N bank. For ith bank these are represented by the vectors x_i and y_i respectively. Let us call the K x N input matrix – X and the M x N output matrix – Y. To measure the efficiency for each bank we calculate a ratio of all inputs, such as $(u'y_i/v'x_i)$ where u is an M x 1 vector of output weights and v is a K x 1 vector of input weights. To select optimal weights we specify the following mathematical programming problem:

$$\min_{u,v} (u'y_i/v'x_i),$$

$$u'y_i/v'x_i \leq 1, \quad j = 1, 2,..., N,$$

$$u,v \geq 0 \qquad (1)$$

The above formulation has a problem of infinite solutions and therefore we impose the constraint $v'x_i = 1$, which leads to:

$$\min_{\mu,\varphi} (\mu'y_i),$$

$$\varphi'x_i = 1$$

$$\mu'y_i - \varphi'x_j \leq 0 \qquad j = 1, 2,..., N,$$

$$\mu,\varphi \geq 0 \qquad (2)$$

where we change notation from u and v to μ and φ, respectively, in order to reflect transformations. Using the duality in linear programming, an equivalent envelopment form of this problem can be derived:

[2] A good reference book on efficiency measures is Thanassoulis (2001), Cooper *et al.* (2000) and Avkiran (2002).

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ &y_i + Y\lambda \geq 0 \\ &\theta x_i - X\lambda \geq 0 \\ &\lambda \geq 0 \end{aligned} \qquad (3)$$

where θ is a scalar representing the value of the efficiency score for the *i*th decision-making unit which will range between 0 and 1. λ is a vector of *N* x 1 constants. The linear programming has to be solved N times, once for each decision-making unit in the sample. In order to calculate efficiency under the assumption of variable returns to scale (VRS), the convexity constraint ($N1'\lambda = 1$) will be added to ensure that an inefficient firm is only compared against firms of similar size, and therefore provides the basis for measuring economies of scale within the DEA concept. The convexity constraint determines how closely the production frontier envelops the observed input-output combinations and is not imposed in the constant returns to scale (CRS) case. The VRS technique therefore forms a convex hull which envelops the data more tightly than the CRS, and thus provides efficiency scores that are greater than or equal to those obtained from the CRS model.

It is also of considerable interest to explain the determinants of technical efficiency scores derived from the DEA models. As defined in Equations (1) and (2) the DEA score falls between the interval 0 and 1 ($0 < h^* \leq 1$) making the dependent variable a limited dependent variable. A commonly held view in previous studies is that the use of Tobit model can handle the characteristics of the distribution of efficiency measures and thus provide results that can guide policies to improve performance. DEA efficiency measures obtained in the first stage are used as dependent variables in the second stage Tobit model. The Tobit model was first introduced in the econometrics literature by Tobin (1958). These models are also known as truncated or censored regression models where expected errors are not equal zero[3]. Therefore, estimation with an Ordinary Least Squares (OLS) regression of h^* would lead to a biased parameter estimate since OLS assumes a normal and homoscedastic distribution of the disturbance and the dependent variable (Maddala, 1983).

In recent years, many DEA applications employ a two-stage procedure involving both DEA and Tobit. Among others, Luoma *et al.* (1996) and Chilingerian (1995) conduct both DEA and Tobit analyses in health sector applications to estimate both inefficiency and the determinants of inefficiencies. Another study by Kirjavainen and Loikkanen (1998)

[3] The model is truncanted if the observation outside a specified range are totally lost and censored if one can at least observed the exogenous variables (Amemiya, 1984).

applies both DEA and Tobit for the Finnish senior secondary schools. On the other hand, Jackson and Fethi (2000) and Grigorian and Manole (2002) apply DEA with Tobit to evaluate technical efficiency of Turkish banks and banks in transition countries respectively.

The standard Tobit model can be defined as follows for observation (bank) i:

$$y_i^* = \beta' x_i + \varepsilon_i$$
$$y_i = y_i^* \text{ if } y_i^* \geq 0 \text{ and}$$
$$y_i = 0, \text{ otherwise} \qquad (3)$$

where $\varepsilon_i \sim N(0, \sigma^2)$ [4], x_i and β are vectors of explanatory variables and unknown parameters, respectively. The y_i^* is a latent variable and y_i is the DEA score.

The likelihood function (L) is maximized to solve β and σ based on 20 observations (banks) of y_i and x_i is

$$L = \prod_{y_i=0}(1-F)\prod_{y_i>0}\frac{1}{(2\Pi\sigma^2)^{1/2}} \times e^{-[1/(2\sigma^2)](y^i-\beta x_i)^2} \qquad (4)$$

where

$$F_i = \int_{-\infty}^{\beta x_i/\sigma}\frac{1}{(2\Pi)^{1/2}}e^{-t^2/2}dt \qquad (5)$$

The first product is over the observations for which the banks are 100 percent efficient (y = 0) and the second product is over the observations for which banks are inefficient (y >0). F_i is the distribution function of the standard normal evaluated at $\beta' x_i / \sigma$.

Inputs and Outputs Definition and the Choice of Variables

The definition or identification of the outputs produced by the institution under study is critical to the measurement of its performance. However, especially in the case of financial institutions, there exists little agreement about what they produce. In the banking theory literature, there are two main approaches competing with each

[4] μ_{it} are unobserved firm-specific effect and ε_{it} are residuals that are independently and normally distributed with mean equals to zero and common variance σ^2.

other in this regard: the production and intermediation approaches (Sealey and Lindley, 1977).

Under the production approach, a financial institution is defined as a producer of services for account holders, that is, they perform transactions on deposit accounts and process documents such as loans. Hence, according to this approach, the number of accounts or its related transactions is the best measures for output, while the number of employees and physical capital is considered as inputs. Previous studies that adopted this approach are among others by Sherman and Gold (1985), Ferrier and Lovell (1990) and Fried *et al.* (1993).

The intermediation approach on the other hand assumes that financial firms act as an intermediary between savers and borrowers and posits total loans and securities as outputs, whereas deposits along with labor and physical capital are defined as inputs. Previous banking efficiency studies research that adopted this approach are among others Charnes *et al.* (1990), Bhattacharyya *et al.* (1997) and Sathye (2001).

For the definition of inputs and outputs, we adopt the intermediation approach proposed by Sealey and Lindley (1977)[5, 6]. It assumes that the bank collects deposits to transform them, using labor and capital, in loans as opposed to the production approach, which views the bank as using labor and capital to produce deposits and loans. According to Berger and Humphrey (1997), the production approach might be more suitable for branch efficiency studies, as at most times bank branches basically process customer documents and bank funding, while investment decisions are mostly not under the control of branches. Furthermore, Sathye (2001) also noted that this approach is more relevant to financial institutions, as it is inclusive of interest expenses,

[5] Humphrey (1985) presents an extended discussion of the alternative approaches of what a bank produces.

[6] Berger and Humphrey (1992) called this approach "the asset approach" (Weill, 2003). In the case of banking industry, where the frontier analyses have been applied most commonly, Berger and Humphrey (1992) distinguish three alternative approaches to the definition of inputs and outputs: 'the asset approach', 'the user cost approach', and 'the value-added approach'. The asset approach assumes that banks collect funds, deposits and purchased funds, and intermediate these funds into loans and other assets. The user cost approach involves classifying financial goods into input and output categories according to their 'user costs' or signs of their derivatives in a bank profit function, which is estimated empirically as in Hancock (1985). The value added approach considers all liability and asset categories to have some output characteristics instead of separating inputs from outputs in a mutually exclusive way. The categories with significant value added, depending on the operating cost allocations, are used as important outputs. Others are considered as unimportant outputs, intermediate products, or inputs, according to the specifics of the category (Berger and Humphrey 1992, p.250).

which often accounts for one-half to two-thirds of total costs depending on the phase of the interest rate cycles.

The aim in the choice of variables for this study is to provide a parsimonious model and to avoid the use of unnecessary variables that may reduce the degree of freedom[7]. All variables are measured in millions of Singapore Dollars. Given the sensitivity of efficiency estimates to the specification of outputs and inputs, we estimate two alternative models. In Model 1, we follow the approach by Avkiran (1999), to include *Total Deposits* (*x1*) as an input vector to produce *Total Loans* (*y1*) and *Interest Income* (*y3*). To recognize that banks in recent years have been increasingly generating income from 'off-balance sheet' business and fee income generally, following Sturm and Williams (2004) among others, *Non-Interest Income* (*y2*) would be incorporated as a proxy to non-traditional activities as output in Model 2. Non-interest income is defined as fee income, investment income and other income, which among others consist of commission, service charges and fees, guarantee fees, net profit from sale of investment securities and foreign exchange profit. Accordingly, in Model 2 and assume that *Interest Income* (*y1*) and *Non-Interest Income* (*y2*) are produced from *Interest Expense* (*x1*) and *Non-Interest Expense* (*x2*).

Table 3
Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
Total Loans (*y1*)	45,348.21	18,845.16	12,713.56	71,021.0
Non-Interest Income (*y2*)	727.26	477.50	73.31	2,153.0
Interest Income (*y3*)	3,201.95	1,153.90	944.39	5,298.0
Total Deposits (*x1*)	56,598.01	30,090.08	12,089.23	113,206.0
Interest Expense (*x2*)	1,674.51	736.21	568.64	3,501.26
Non-Interest Expense (*x3*)	991.64	627.17	169.09	2,446.0

Notes: Model 1 – Outputs = (*y1, y2*), Inputs (*x1*)
Model 2 – Outputs = (*y2, y3*), Inputs (*x2*, *x3*)

Data

For the empirical analysis, *all* domestically incorporated Singapore commercial banks will be incorporated in the study. In the spirit of maintaining homogeneity, only commercial banks that make commercial loans and accept deposits from the public are included in the analysis. Therefore, Investment Banks are excluded from the

[7] For a detailed discussion on the optimal number of inputs and outputs in DEA, see Avkiran (2002).

sample. The annual balance sheet and income statement used to construct the variables for the empirical analysis were taken from published balance sheet information in annual reports of each individual bank. Three banks were omitted from the study, namely, Bank of Singapore, Far Eastern Bank and Industrial and Commercial Bank, which are all wholly owned subsidiaries of the OCBC and UOB groups.

As for the potential determinants in the Tobit regression, the following variables extracted from the published annual report of individual banks from 1998 to 2004 are used. First, we determine the impact of bank size on Singapore banking groups' efficiency, and the impact of efficiency on the Singapore banking groups' profitability. Bank size is measured by the amount of total assets, and bank profitability is measured by net operating income to total assets. Second, there are various bank specific characteristics, which may have an impact on efficiency. Three variables are utilized to explain the Singapore banking groups' efficiency: 1) capitalization is measured by the amount of share and supplementary capital divided by total assets; 2) asset quality is measured by provision over loans, and 3) overhead costs is measured by personnel expense over the number of employees.

Due to the small sample size across 1998-2004, it was decided to reduce the number of variables entering DEA analysis. This enhanced the discrimination between efficient and inefficient DMUs. Nevertheless, the sample size in this study compares favourably with some of the other small sample sizes in the DEA literature (see Table 2). As pointed by Avkiran (1999), CRS is a common assumption in DEA analysis if the sample size is small. The alternative assumption, VRS, compares each unit only against other units of similar size.

Given the recent merger program initiated by Monetary Authority of Singapore (MAS) among the locally incorporated Singapore commercial banks with the aim of strengthening the banking sector to face future challenges, understanding the precise nature of scale efficiency in the industry is critically important both to comprehend the economic rationale behind the industry's movement to consolidation and to prescribe their going forward policy. Study in this nature is also of utmost importance to shed some light on the impact of the merger particularly on the returns to scale of the Singapore banking groups. This provides justification to employ a VRS model for this study.

Assessing the Role of Mergers in Efficiency Gains

It is hypothesized that acquiring banks are more efficient than target banks (Berger and Humphrey, 1992 and Rhoades, 1993). For the merger cases identified in this study, the relative efficiencies of the acquiring

banks and the targets were monitored for a period of three years prior to the merger and that of the merged entity for three years following the merger. In the study population, two mergers that fit into our criteria have taken place:

> *Case 1*: Overseas Chinese Banking Corporation acquisition of Keppel Capital Holdings on June 12, 2001.
>
> *Case 2*: United Overseas Bank acquisition of Overseas Union Bank in August 2001.

5. Empirical Results

In the spirit of Rhoades (1998), we develop a [-3, 3] event window, to investigate the effect of M&As on the Singapore banking groups' efficiency. The choice of the event window is motivated by Rhoades (1998, p. 278), who pointed out that there has been unanimous agreement among the experts that about half of any efficiency gains should be apparent after one year and all gains should be realized within three years after the merger. The whole period, from 1998 to 2004, is divided into three sub-periods; 1998-2000 refers to the pre-merger period, 2001 is considered as the merger year and 2002-2004 represents the post-merger period, when the M&As is expected to have some impact on Singapore banking groups' efficiency. We expect to be able to capture the effects of M&As on the efficiency of Singapore banks during this period. The mean OE of the targets and acquirers during all periods are compared, along with its decomposition of PTE and SE scores. This could help shed some light on the sources of inefficiency of the Singapore banking system in general as well as to differentiate between the target and acquirers' efficiency scores.

Model 1 – Pre-Merger Period

In Table 4, the OE estimates are presented, along with its decomposition into PTE and SE components for Model 1. It is apparent that during the pre-merger period, Singapore banks have exhibit average OE score of 93.82%, suggesting that the Singapore banking system has performed relatively well in its basic function – transforming deposits to loans, with relatively minimal mean input waste of 6.18%. The results imply that during the pre-merger period, Singapore banking groups could have produced the same amount of outputs with only 93.82% of the amount of inputs used. In other words, Singapore banking groups could have reduced its inputs by 6.18% to produce the same amount of outputs produced during the pre-merger period.

The results are in line with Chu and Lim (1998) who found that Singapore banks have exhibit an average overall efficiency of 95.30% during the period of 1992-1996, while Randhawa and Lim (2005) found 19.60% input waste among seven Singapore domestic banks during the period of 1995-1999. The results also compare favorably with Fukuyama (1993) study on Japanese banks (14%) and the 14%-25% averages of Indian commercial banks (Bhattacharyya *et al.*, 1997). The decomposition of OE into its PTE and SE estimates suggest that during the pre-merger period, Singapore banks' inefficiency was solely attributed to scale rather than pure technical.

Model 1 – Post-Merger Period

Despite the initial decline of the mean OE to 88.67% during the merger year from 93.82% pre-merger, from Table 4, it is clear that the merger has resulted in the improvement of Singapore banking groups' mean OE for Model 1 post-merger. The initial decline in the mean OE during the merger year, which was solely attributed to scale inefficiency, could be due to the larger size resulting from the merger. During the post-merger period, it is apparent from Table 4 that Singapore banking groups have exhibit mean OE of 98.77%. Despite exhibiting improvement in its mean OE level relative to the merger year, the only bank to be inefficient during the post-merger period, UOB's mean OE of 96.3% is still lower compared to the 100.0% level during the pre-merger period, while DBS exhibit significant improvement in its efficiency levels, operating at CRS during the post merger period. Decomposition of the OE scores into its PTE and SE components revealed that OUB's inefficiency was attributed solely to scale during the post-merger period.

Table 4
Summary of Mean Efficiency Levels of Singapore Banks (Model 1)

Bank	**Pre-Merger***			**During Merger****			**Post-Merger*****		
	OE	**PTE**	**SE**	**OE**	**PTE**	**SE**	**OE**	**PTE**	**SE**
KEP	98.43	100.0	98.43						
OCBC	95.03	100.0	95.03	100.0	100.0	100.0	100.0	100.0	100.0
OUB	99.73	100.0	99.73						
UOB	100.0	100.0	100.0	88.8	100.0	88.8	96.3	100.0	96.3
DBS	75.93	100.0	75.93	77.2	100.0	77.2	100.0	100.0	100.0
Mean	**93.82**	**100.0**	**93.82**	**88.67**	**100.0**	**88.67**	**98.77**	**100.0**	**98.77**

Notes: * 1998-2000; ** 2001; *** 2002-2004
OE – Overall Efficiency
PTE – Pure Technical Efficiency
SE – Scale Efficiency

Figure 1 (a)
Overall Technical Efficiency DEA Model 1 – 1998-2004

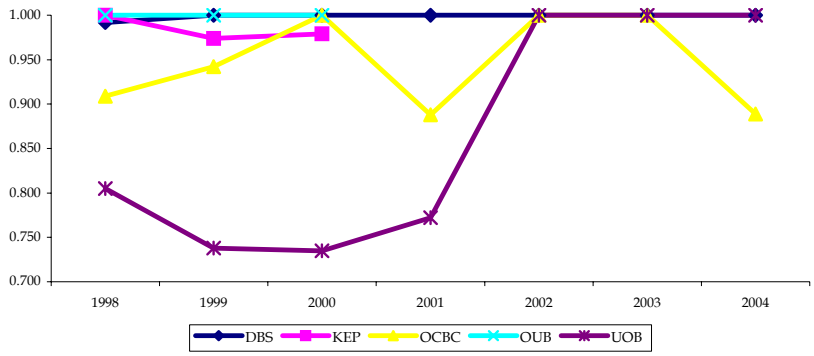


Figure 1 (b)
Pure Technical Efficiency DEA Model 1 – 1998-2004

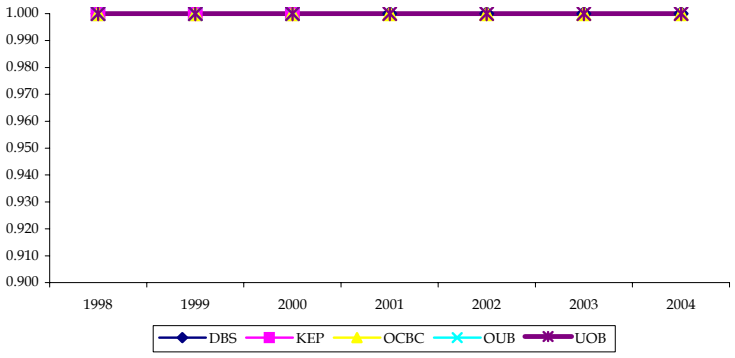
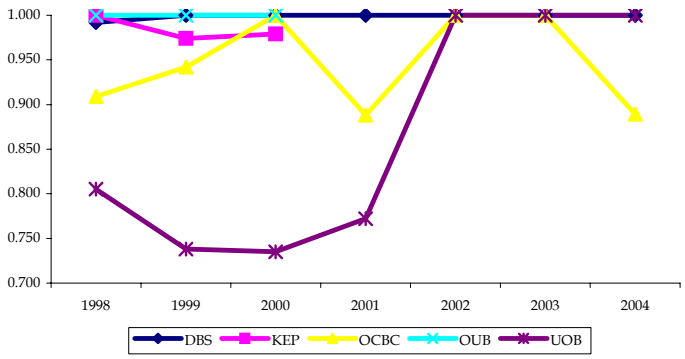


Figure 1 (c)
Scale Efficiency DEA Model 1 – 1998-2004



Model 2 – Pre-Merger Period

In Table 5, the OE estimates are presented, along with its decomposition into PTE and SE for Model 2. It is apparent that during the pre-merger period, Singapore banking groups have exhibit mean OE score of 97.09%, slightly higher compared to 93.82% for Model 1. The decomposition of OE into its PTE and SE estimates suggest that during the pre-merger period, Singapore banks' inefficiency was largely attributed to scale (1.43%) rather than pure technical (0.65%). During the period, the results suggest that all Singapore banking groups were pure technically efficient, with the exception of OUB, which inefficiency was largely attributed to pure technical (3.27%) rather than scale (0.87%). It is also interesting to note that UOB was the only bank identified to be scale efficient during the pre-merger period, while the other Singapore banking groups have exhibit scale inefficiency in the range of 0.87% for OUB to 4.90% in the case of KEP.

Model 2 – Post-Merger Period

Similar to Model 1, it is apparent from Table 5 the merger has resulted in the improvement of Singapore banking groups' mean OE for Model 2, increasing from 97.09% during the pre-merger period to 98.96% post-merger. During the post-merger period, the results suggest that OCBC to be the only bank which was inefficient due solely to scale. It is clear from Table 5 that the largest bank in the sample, DBS, exhibits significant improvement in its mean OE level as the bank has been operating at CRS post-merger. UOB on the other hand has been able to maintain to operate at CRS post-merger.

It is also interesting to note that despite earlier evidence which suggests that the lack of competition may result in lower OE, (see Sathye, 2001 and Walker, 1998), it is apparent from Table 5 that all Singapore banking groups have reported 100% mean PTE score post-merger. Walker (1998) states that the high degree of concentration in the Australian banking, which was dominated by four major banks, may result in the "quiet life" hypothesis to come into play. The "quiet life" hypothesis predicts a reverse causation, that is, as firms enjoy greater market power and concentration, inefficiency follows not because of non-competitive pricing but more so because of a relaxed environment with no incentives to minimize costs. Hence, the findings suggest that during the period of 1998-2004 the source of inefficiency among Singapore domestic incorporated banks is solely attributed to scale.

Is the Acquirer a More Efficient Bank?

We now turn to the assessment of the merging activity and how such a consolidation process has affected the mean OE of the involved banks. First, we analyze the pre-merger performance of the banks concerned. Theoretically, the more efficient banks should acquire the less efficient ones. A more efficient bank is assumed to be well organized, and has a more capable management. The idea is that since there is room for improvement concerning the performance of the less efficient bank, a takeover by a more efficient bank will lead to a transfer of the better management quality to the inefficient bank. This will in turn lead to a more efficient and better performing merged unit. In order to see whether indeed it is the case banks that are more efficient acquire the inefficient ones, we calculate the difference in OE between an acquiring and an acquired bank. This efficiency difference is measured as the mean OE of the acquiring bank, minus the mean OE of the acquired banks for the last observation period before consolidation.

For Model 1, it is clear from Table 4 that during the pre-merger period KEP's (the target) OE level of 98.43% is higher compared to OCBC's (the acquirer) OE of 95.03%. Conversely, from Table 4 it is clear that during the pre-merger period, for Model 1, UOB's TE level of 100.0% is higher compared to its target, OUB's OE of 99.73%. Thus, the results from Model 1 reject the hypothesis that the targets were less efficient relative to the acquirers.

Table 5
Summary of Mean Efficiency Levels of Singapore Banks (Model 2)

Bank	Pre-Merger*			During Merger**			Post-Merger***		
	OE	**PTE**	**SE**	**OE**	**PTE**	**SE**	**OE**	**PTE**	**SE**
KEP	95.1	100.0	95.1						
OCBC	98.6	100.0	98.6	100.0	100.0	100.0	96.87	100.0	96.87
OUB	95.9	96.73	99.13						
UOB	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
DBS	95.87	100.0	100.0	94.2	100.0	94.2	100.0	100.0	100.0
Mean	**97.09**	**99.35**	**98.57**	**98.077**	**100.0**	**98.07**	**98.96**	**100.0**	**98.96**

Notes: * 1998-2000; ** 2001; *** 2002-2004
See Notes to Table 4.

Figure 2 (a)
Overall Technical Efficiency DEA Model 2 – 1998-2004

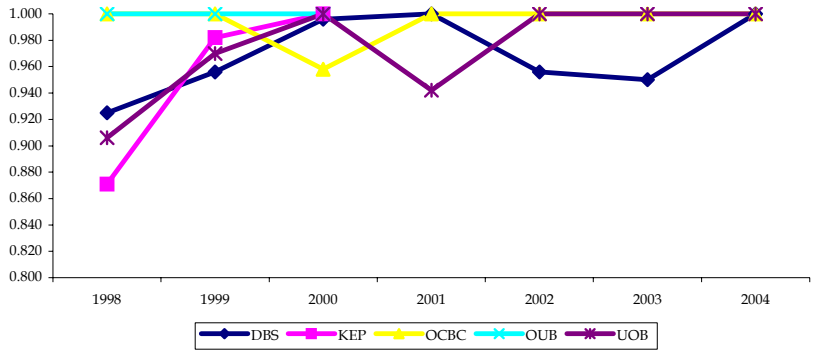


Figure 2 (b)
Pure Technical Efficiency DEA Model 2 – 1998-2004

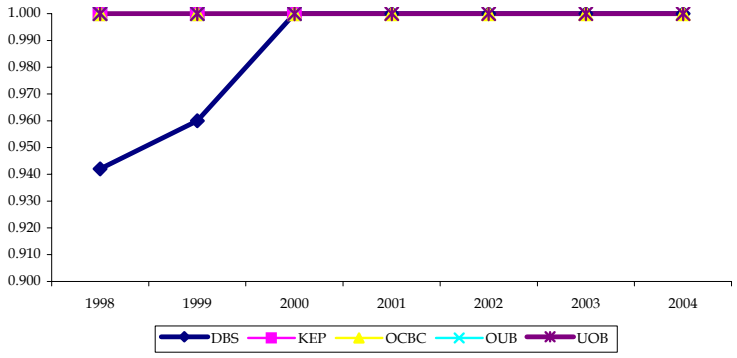
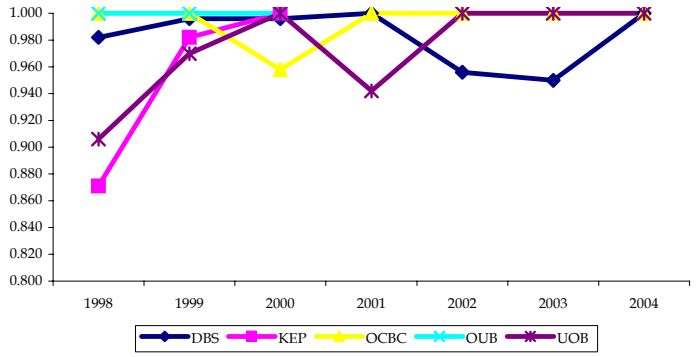


Figure 2 (c)
Scale Efficiency DEA Model 2 – 1998-2004



In contrast to Model 1, the results for Model 2 suggest that KEP's mean OE is lower at 95.10% compared to its acquirer's, OCBC's mean OE level of 98.60%. Similar to Model 1, it is clear from Table 5, the results from Model 2 suggest that during the pre-merger period, UOB's (the acquirer) mean OE of 100.0% is higher compared to its target, OUB's, mean OE of 95.90%. Unlike the results from Model 1, the results from Model 2 support the hypothesis that the acquirers are more efficient than the targets.

Implications of Mergers on Acquiring Banks' Efficiency

Next, we turn the discussion to the ex-post performance of the merged banking groups. Here the issue at hand is whether there exists a positive (negative) relationship between the differences in the efficiency before the merger and the performance of the institutions after the consolidation. In other words, we want to find out whether there has been any transfer of better management quality from the acquiring bank to the one acquired. Conversely, we would also like to find out whether a less efficient target would consequently result in the deterioration of the mean efficiency levels of the acquirers. This is done by computing the difference between the acquirers' mean efficiency levels (OE, PTE and SE) during the post-merger period compared to pre-merger period.

Table 6
Summary of Mean Efficiency Levels of the Acquirers – Model 1

Bank	Pre-Merger*			During Merger**			Post-Merger***		
	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE
OCBC	95.03	100.0	95.03	100.0	100.0	100.0	100.0	100.0	100.0
UOB	100.0	100.0	100.0	88.8	100.0	88.8	96.3	100.0	96.3

Notes: * 1998-2000; ** 2001; *** 2002-2004
See Notes to Table 4.

For Model 1, KEP's (the target) mean OE level of 98.43% is higher compared to OCBC's (the acquirer) mean OE of 95.03% during the pre-merger period. It is apparent from Table 6 that the merger between OCBC and KEP has resulted in the improvement of OCBC's mean OE during the merger and subsequently post-merger, when OCBC has been operating at CRS. Conversely, during the pre-merger period, UOB's OE level of 100.0% is higher for Model 1 compared to its target, OUB's TE of 99.73%. The results suggest that UOB's OE deteriorated to 88.80% during the merger year. Although UOB's mean TE improved to 96.3% during the post-merger period, it is still lower relative to pre-merger, when the bank was operating as a fully efficient bank. Based on the

results for Model 1 we can conclude that a more efficient (inefficient) target resulted in the improvement (deterioration) of the acquirers' mean OE post-merger.

Table 7
Summary of Mean Efficiency Levels of the Acquirers – Model 2

Bank	Pre-Merger*			During Merger**			Post-Merger***		
	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE
OCBC	98.6	100.0	98.6	100.0	100.0	100.0	96.87	100.0	96.87
UOB	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Notes: * 1998-2000; ** 2001; *** 2002-2004
See Notes to Table 4.

In contrast to the results from Model 1, it is apparent from Table 7, the results for Model 2 suggest that KEP's mean OE of 95.10% is lower compared to its acquirer's, OCBC's, mean OE of 98.60%. The results suggest that the merger has resulted in the deterioration of OCBC's mean OE level post-merger to 96.87%. For Model 2, it is clear from Table 7 that during the pre-merger period, UOB's OE of 100.0% is higher compared to its target, OUB's OE of 95.90%. The results suggest that UOB's mean OE level remained stable and that the bank has been operating at CRS during the merger year and has been operating as a fully efficient bank post-merger. Hence, for Model 2, we found mixed evidence on the implications of mergers on acquirers' mean OE post-merger.

Results of Second Stage Tobit Regression

To further investigate the determinants of efficiency over time, Equations for DEA Model 1 and DEA Model 2 were estimated using the censored Tobit model by utilizing DEA score for OE derived from DEA Model 1 and DEA Model 2. Unlike the conventional Ordinary Least Square (OLS) estimation, in the case of limited dependent variables, Tobit models are known to generate consistent estimates of regression coefficients. The results are presented in Table 8. A positive coefficient implies an efficiency increase whereas a negative coefficient reflects the deterioration in efficiency.

Bank size has a negative effect on efficiency but insignificant, indicating that the larger banks have lower efficiency, which could be due to complex organizational structure and moral hazard behavior. On the other hand, profitability has a significant positive relationship with bank efficiency. Banks reporting higher profitability are seen by clients as

preferential and in turn attract the biggest share of deposit as well as the best potential borrowers. The findings correspond with studies by among others Jackson and Fethi (2000).

Now we turn to the analysis of bank characteristics and their influence on efficiency. As can be seen from Table 8, capitalization variable yields a positive affect but insignificant at conventional level in explaining bank performance. Theoretically, better capitalize banks should enjoy a higher level of efficiency. In performing further investigation, we treated loans as homogenous with respect to risk. We were forced to make such an assumption because we could not correct the model for risk without a thorough investigation of the causes of bad loans (Berger and DeYoung, 1997). If a bank has a poor quality loan portfolio, this should entail additional costs associated with monitoring and enforcement of loan repayment. The significant negative coefficient of the provisions over loans variable gives support to the above prediction.

Table 8
Second Stage Tobit Regression of the Efficiency Measures and Bank Characteristics

Explanatory Variables	DEA 1	DEA 2
CONSTANT	0.407 (1.847)	1.159*** (1.235)
Bank Characteristics		
SIZE	-0.037 (-1.289)	-0.001 (-0.971)
PROFITABILITY	0.029*** (3.124)	0.012*** (4.491)
CAPITALIZATION	0.259 (1.338)	0.087 (1.323)
PROVISIONS/LOANS	-0.222 (-0.476)	-0.445*** (-2.452)
OVERHEADS	3.856*** (3.701)	0.566 (1.235)
R^2	0.63	0.62

Notes: $\varphi_{it} = \alpha + \beta_1 SIZE_{it} + \beta_2 PROFITABILITY_{it} + \beta_3 CAPITALISATION_{it} + \beta_4 PROVISION/LOANS_{it} + \beta_5 OVERHEADS_{it} + \varepsilon_{it}$

The dependent variable is bank's efficiency scores derived from DEA Model 1 and DEA Model 2; *SIZE* is a measure of bank's market share calculated as a natural logarithm of total bank assets; *PROFITABILITY* is a measure of bank's profit calculated as the ratio of net operating income to bank total assets; *CAPITALIZATION* is the bank's specific characteristics measured as the ratio of the amount of share and supplementary capital divided by total assets; *PROVISIONS/LOANS* is a measure of bank's assets quality calculated as the ratio of total loan loss provisions divided by total loans; *OVERHEADS* is a measure of overhead costs calculated as personnel expense over numbers of employees. DEA 1 refers to DEA scores generated from Model 1 and DEA 2 refers to DEA scores generated from Model 2.

z-statistics are in parenthesis.

***, **, and * indicate significance at 1, 5 and 10% levels.

The effect of overhead costs on bank efficiency seems counterintuitive at a first glance, where higher overhead costs seem to pay off. Although theoretically consolidation should reduce the amount of back office personnel, the reductions could however be offset by increases in the front office personnel, implying a better customer service. Furthermore, as suggested by Sathye (2001), management that is more professional might require higher remuneration and thus highly significant positive relationship with efficiency measure is natural. The result is also consistent with Claessens *et al.* (2001) who suggest that overstaffing of domestic bank in middle-income countries has always led to deterioration in bank efficiency in comparison to high-income countries.

6. Conclusions

Applying a non-parametric frontier approach, Data Envelopment Analysis (DEA), the paper attempts to investigate the effects of M&As on the efficiency of domestic incorporated Singapore banking groups. The sample period is divided into three sub-periods i.e. pre-merger, during merger and post-merger periods, to compare the differences in Singapore banking groups' mean efficiency levels during all periods. Given the sensitivity of efficiency estimates to the specification of inputs and outputs used, we adopted a variant of the intermediation approach to two models.

For Model 1 the results suggest that Singapore banking groups have exhibit a commendable OE level of 93.82% suggesting minimal input waste of 6.18%. We found that during the merger year, Singapore banking groups' OE level deteriorates slightly to 88.67%, which was solely due to scale inefficiency. Despite that, during the post merger period, Singapore banking groups have exhibit higher mean OE levels compared to the pre-merger period. Similar to the pre-merger period, the results suggest that scale inefficiency dominates pure technical inefficiency in the Singapore banking sector post-merger. Similar to the results from Model 1, the results from Model 2 suggest that Singapore banking groups were relatively efficient in its intermediation role, exhibiting relatively minimal input waste of 2.91% during the pre-merger period. In contrast to the results from Model 1, the results from Model 2 suggest that Singapore banking groups' mean OE levels were higher during the merger year and further improved during the post-merger period.

Although mergers has resulted in a more efficient banking system, as it may appear from the results for Model 1 and Model 2, size has become the biggest source influencing the inefficiency of the Singapore banking system. Henceforth, from the scale efficiency perspective, both the

results do not support for further consolidation in the Singapore banking sector to create two 'super banks'. Based on the results from Model 1 and Model 2, further increase in size would only result in a smaller increase of outputs for every proportionate increase in inputs, resulting from the fact that Singapore banking groups have been operating at constant returns to scale (CRS) and declining returns to scale (DRS) during the post-merger period.

We found mixed evidence on the characteristics of the acquirers and targets' efficiencies. While the results from the merger between KEP and OCBC revealed mixed findings, hence do not fully support for the hypothesis of a less efficient bank becoming a merger target. On the other hand, in the case of OUB and UOB merger, the results suggest that in both models the acquirers have exhibited higher mean OE levels compared to the targets during the pre-merger period.

The results from both models suggest that the merger between KEP and OCBC support the hypothesis that the acquiring bank's mean OE improved (deteriorates) post-merger resulting from the merger with a more (less) efficient bank. On the other hand, in the case of OUB-UOB merger, while the result from Model 1 support the hypothesis that the acquirer's mean OE deteriorates post-merger resulting from the merger with a less efficient target, we do not find the same evidence for Model 2.

The explanation of the efficiency scores using Tobit regressions offers useful economic insights. We interpret the significance of profitability as an indication of the ability to attract the biggest share of deposit as well as the best potential borrowers. The significance of the level of loan quality portfolio proxy by provision of bad loans should entail additional costs associated with monitoring and enforcement of loan repayment, hence negatively related to efficiency. Not surprising, the high complexity of banking environment in Singapore, the overhead cost tends to contribute positively to bank performance which might due to highly skilled personnel with high remuneration packages.

Due to its limitations, the paper could be extended in a variety of ways. Firstly, the scope of this study could be further extended to investigate changes in cost, allocative, and technical efficiencies over time. Secondly, future research into the efficiency of the Singapore banking sector could also consider the production function along with the intermediation function. Finally, the non-parametric frontier analysis adopted in this paper could be combined with the stochastic frontier analysis method of estimating the frontier. This should testify to the robustness of the results against alternative estimation methods. Investigation of changes in the productivity changes over time as a result of technical change or technological progress or regress by

employing the Malmquist Productivity Index (MPI) could yet be another extension to the paper.

Despite these limitations, the findings of this study are expected to contribute significantly to the existing knowledge on the operating performance of the Singapore banking industry. Nevertheless, the study have also provide further insight to bank specific management as well as the policymakers with regard to attaining optimal utilization of capacities, improvement in managerial expertise, efficient allocation of scarce resources and most productive scale of operation of the banks in the industry. This may facilitate directions for sustainable competitiveness of future banking operations in Singapore.

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