The Efficiency Effects of Bank Mergers and Acquisitions: A Non-Stochastic Window Event Analysis Approach

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Abstract

An event window studies is employed in this study to investigate the effects of mergers and acquisitions on Singapore domestic banking groups’ efficiency. A three-year window is chosen to examine the relative overall, pure technical and scale efficiency scores, ex-ante and ex-post. The non-parametric frontier approach, Data Envelopment Analysis (DEA), is employed to detect for any efficiency gains (loss) resulting from the mergers and acquisitions among the domestic incorporated Singapore
banking groups. We employed a variant of the intermediation approach to two models. The results from both models suggest that the merger has resulted in higher mean overall efficiency of Singapore banking groups post-merger relative to pre-merger. Although mergers has resulted in a more efficient Singapore banking sector, we found that size has become the biggest factor resulting in the inefficiency of the Singapore banking groups, henceforth, from the scale efficiency perspective, both our models do not support for further consolidation in the Singapore banking sector. Our results further support the hypothesis that, the acquiring banks mean overall efficiency improved (deteriorates) post-merger resulting from the merger with a more (less) efficient bank.

**JEL Classification:** G21; D24  
**Keywords:** Bank Merger, Event Window Analysis, Data Envelopment Analysis, Singapore

1. **Introduction**

Examining banking performance has been a common practice among banking and finance researchers for a number of years. The main reason for continued interest in this area of research is the ever-changing banking business environment throughout the world. Many countries that adopted financial deregulation policies are now experiencing competitive banking practices. Singapore is no exception and is becoming a competitive and important market not only for financial products and for other products. Singapore banking 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 banks 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 banks efficiency is crucial,
given increasing competition and measures to further liberalise the banking system. This renders the issue of increasing the efficiency as one of the main priority 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. Secondly, in order to appraise the effectiveness and success of the merger and acquisitions 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 merger and acquisitions over the past decade. Utilising the non-parametric Data Envelopment Analysis (DEA) methodology, the overall, pure technical and scale efficiency estimates of all domestic incorporated Singapore commercial banks that were involved in mergers and acquisitions will be investigated. The role of mergers in efficiency changes will be probe by comparing the relative efficiency scores of the acquirers and targets ex-post and ex-ante. To the best of our knowledge, this will be the first study in the literature to examine this important issue within the context of Singaporean banking sector.

The paper raises three important fundamental questions. Q1: Did the merger and acquisitions result in the improvement of the mean overall efficiency levels of the Singapore banking system post-merger? Q2: Did a less efficient bank become the target for acquisition? Q3: Did a less (more) efficient target result in the deterioration (acceleration) in the acquirer’s mean overall efficiency level post-merger?

This paper has been designed to answer each of these questions in the order they have been presented. After a brief overview of the Singapore banking system in Section 2, survey of the literature devoted
to mergers and banks efficiency as well as earlier works on Singapore banks efficiency is presented in Section 3. Section 4 outlines the approaches to the measurement and estimation of efficiency change. Questions Q1, Q2 and Q3 are answered in Section 5 and finally, Section 6 provide 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 centres. At present, Singapore is an established financial centre and is one of the key centres 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, dominates the local banking market.

**Table 1** Singapore’s Commercial Banks Assets and Liabilities, 1998-2004

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets (S$ billion)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash in hand</td>
<td>1.0</td>
<td>2.6</td>
<td>1.5</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Balances with MAS</td>
<td>5.4</td>
<td>7.5</td>
<td>5.7</td>
<td>7.0</td>
<td>6.5</td>
<td>6.6</td>
<td>6.8</td>
</tr>
<tr>
<td>Amounts due from banks</td>
<td>105.2</td>
<td>109.7</td>
<td>116.5</td>
<td>114.3</td>
<td>96.8</td>
<td>97.5</td>
<td>113.9</td>
</tr>
<tr>
<td>Investments</td>
<td>35.2</td>
<td>40.3</td>
<td>45.5</td>
<td>70.8</td>
<td>61.5</td>
<td>64.1</td>
<td>68.2</td>
</tr>
<tr>
<td>Loans and advances to non-bank customers</td>
<td>151.6</td>
<td>147.2</td>
<td>154.0</td>
<td>162.9</td>
<td>161.3</td>
<td>171.4</td>
<td>179.1</td>
</tr>
<tr>
<td>Fixed and other assets</td>
<td>10.1</td>
<td>13.7</td>
<td>12.5</td>
<td>17.4</td>
<td>25.8</td>
<td>21.4</td>
<td>28.6</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td>308.8</td>
<td>321.0</td>
<td>335.8</td>
<td>373.7</td>
<td>353.1</td>
<td>362.5</td>
<td>398.2</td>
</tr>
</tbody>
</table>

| **Liabilities (S$ billion)** | | | | | | | |
| Paid up capital and reserves | 23.3 | 25.3 | 24.5 | 36.9 | 30.6 | 32.7 | 35.9 |
| Deposits of non-bank customers | 162.3 | 174.5 | 171.3 | 182.6 | 180.1 | 194.2 | 206.2 |
| Amounts due to banks | 104.1 | 98.2 | 118.0 | 118.3 | 106.1 | 103.6 | 115.0 |
| **Total Liabilities** | 308.8 | 321.0 | 335.8 | 373.7 | 353.1 | 362.5 | 398.2 |

*Source: Monetary Authority of Singapore*

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 centres. The Singapore government has been actively undertaking financial liberalisation and reforms since the 1960s. As a result of its endeavours, Singapore has become a leading financial centre serving the domestic as well as neighbouring 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 to 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 liberalisation in order to create a more resilient financial sector, which could compete in an increasingly globalise environment. The liberalisation has involved strengthening domestic banks through consolidation and increasing foreign participation in the financial sector.

During the Asian Financial Crisis 1997-1998, its sound economic and financial fundamental has 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 capitalised and insolvency was not an issue. Nonetheless, the immediate lessons from the financial turmoil for the local financial institutions are the need for the creation of strong incentive for banks to merge, which would create large institutions to cope with international competition.

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 Singaporean banks to compete successfully in the new era of globalisation, the government intended to eventually merge the domestic financial institutions into two “super banks”.

The recent merger and acquisition activities among domestic incorporated Singapore banks are:

- 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 2 Characteristics of Singapore’s Commercial Banks after the M & As in 2001

<table>
<thead>
<tr>
<th></th>
<th>DBS</th>
<th>UOB + OUB</th>
<th>OCBC + KEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Assets (S$ billion)</td>
<td>111.0</td>
<td>113.7</td>
<td>83.0</td>
</tr>
<tr>
<td>Total Loans (S$ billion)</td>
<td>54.2</td>
<td>61.5</td>
<td>50.4</td>
</tr>
<tr>
<td>Total Deposits (S$ billion)</td>
<td>92.8</td>
<td>96.6</td>
<td>71.1</td>
</tr>
<tr>
<td>Total Shareholders Fund (S$ billion)</td>
<td>8.4</td>
<td>13.1</td>
<td>8.3</td>
</tr>
<tr>
<td>Number of Branches</td>
<td>107</td>
<td>93</td>
<td>74</td>
</tr>
<tr>
<td>Number of ATMs</td>
<td>900</td>
<td>426</td>
<td>381</td>
</tr>
</tbody>
</table>

*Note:* 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).

*Source:* Banks Annual Reports

3. Related Studies

Bank mergers and acquisitions 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 mergers and acquisitions, which may lead to changes in efficiency, market power, economies of scale and scope, availability of services to small customers and payments systems efficiency.

Besides improvements in cost and profit efficiencies, mergers and acquisitions 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 banks mergers and acquisitions 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 than costs (Berger and Mester, 2003, p. 88).

The DEA method has increasingly been the preferred method to investigate the impacts of mergers and acquisitions on banks efficiency, in particular if the sample size is small (see Table 3). Previous studies undertaken to analyse a small number of M&As includes among others Avkiran (1999), Liu and Tripe (2002) and Sufian (2004).

**Table 3 Examples of Small Sample Size in DEA Literature**

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

*Source: 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 predecessor banks. On the other hand, he found that mergers between relatively healthy banks would create banks that are less likely to fail.
**Studies on Singapore Banks Efficiency**

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.

More recently, Randhawa and Lim (2005) utilise 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 exhibited 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 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 term Data Envelopment Analysis (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.

The CCR model presupposes that there is no significant relationship between the scale of operations and efficiency by assuming constant returns to scale (CRS), and it delivers the overall technical efficiency (OTE). The CRS assumption is only justifiable when all DMUs are operating at an optimal scale. However, firms or DMUs in practice might face either economies or diseconomies of scale. Thus, if one makes the CRS assumption when not all DMUs are operating at the optimal scale, the computed measures of technical efficiency will be contaminated with scale efficiencies.

Banker et al. (1984) extended the CCR model by relaxing the CRS assumption. The resulting “BCC” model was used to assess the efficiency of DMUs characterised by variable returns to scale (VRS). The VRS assumption provides the measurement of pure technical efficiency (PTE), which is the measurement of technical efficiency devoid of the scale efficiency effects. If there appears to be a difference between the TE and PTE scores of a particular DMU, then it indicates the existence of scale inefficiency.

\[
\begin{align*}
\max \lambda_0 \theta_0 \\
\text{subject to } \sum_{j=1}^{n} \lambda_{0j} y_{ij} & \geq y_{r0} & (r = 1, \ldots, s) \\
\theta_0 x_{i0} & \geq \sum_{j=1}^{n} \lambda_{0j} x_{ij} & (i = 1, \ldots, n) \\
\sum_{j=1}^{n} \lambda_{0j} & \leq 1 \\
\lambda_{0j} & \geq 0 & (j = 1, \ldots, n)
\end{align*}
\]
The first constraint states that output of the reference unit must be at least at the same level as the output of DMU 0. The second constraint tells that the efficiency corrected input usage of DMU 0 must be greater than or the same as the input use of the reference unit. Since the correction factor is same for all types of inputs, the reduction in observed inputs is proportional. The third constraint ensures convexity and thus introduces variable returns to scale. If convexity requirement is dropped, the frontier technology changes from VRS to CRS. The efficiency scores always have smaller or equal values in the case of CRS. Efficiency can also be measured into output direction in the case of VRS.

Although the scale efficiency measure will provide information concerning the degree of inefficiency resulting from the failure to operate with CRS, it does not provide information as to whether a DMU is operating in an area of increasing returns to scale (IRS) or decreasing returns to scale (DRS). Hence, in order to establish whether scale inefficient DMUs exhibit IRS or DRS, the technical efficiency problem (1) is solved under the assumption of variable returns to scale (VRS) to provide

\[
\begin{align*}
\max & \quad \lambda_0 \theta_0 \\
\text{subject to} & \quad \sum_{j=1}^{n} \lambda_{0j} y_{rj} \geq y_{r0} \\
& \quad \theta_0 x_{i0} \geq \sum_{j=1}^{n} \lambda_{0j} x_{ij} \\
& \quad \sum_{j=1}^{n} \lambda_{0j} \leq 1 \\
& \quad \lambda_{0j} \geq 0
\end{align*}
\]

Because the number of participants in the Singapore banking system is small, the scope to undertake this study using standard econometric methods is somewhat limited. Amongst the strengths of
the DEA is that, DEA is less data demanding as it works fine with small sample size. The small sample size is among other reasons, which leads us to DEA as the tool of choice for evaluating Singapore banks’ X-(in) efficiency. Furthermore, DEA does not require a preconceived structure or specific functional form to be imposed on the data in identifying and determining the efficient frontier, error and inefficiency structures of the DMUs\(^1\) (Evanoff and Israelvich, 1991, Grifell-Tatje and Lovell, 1997, Bauer et al., 1998). Hababou (2002) adds that it is better to adopt the DEA technique when it has been shown that a commonly agreed functional form relating inputs to outputs is difficult to prove or find. Such specific functional form is truly difficult to show for financial services entities. Avkiran (1999) acknowledges the edge of the DEA by stating that this technique allows the researchers to choose any kind of input and output of managerial interest, regardless of different measurement units. There is no need for standardisation\(^2\).

Three useful features of DEA are first, each DMU is assigned a single efficiency score, hence allowing ranking amongst the DMUs in the sample. Second, it highlights the areas of improvement for each single DMU. For example, since a DMU is compared to a set of efficient DMUs with similar input-output configurations, the DMU in question is able to identify whether it has used input excessively or its output has been under-produced. Finally, there is possibility of making inferences on the DMUs general profile. We should aware that the technique used here is a comparison between the production performances of each DMU to a set of efficient DMUs. The set of efficient DMUs is called the reference set. The owners of the DMUs may be interested to know which DMU frequently appears in this set. A DMU that appears more than others in this set is called

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1 Hababou (2002) and Avkiran (1999) provide a relatively thorough discussion of the merits and limits of the DEA.

2 An additional advantage according to Canhoto and Dermine (2003) is that the DEA technique is preferred to parametric methods is when the sample size is small.
the global leader. Clearly, this information gives huge benefits to the DMU owner, especially in positioning its entity in the market.

The main weakness of the DEA is that it assumes data are free from measurement errors. Furthermore, since efficiency is measured in a relative way, its analysis is confined to the sample set used. This means that an efficient DMU found in the analysis cannot be compared with other DMUs outside of the sample. The reason is simple. Each sample, separated, let us say, by year, represents a single frontier, which is constructed on the assumption of same technology. Therefore, comparing the efficiency measures of a DMU across time cannot be interpreted as technical progress but rather has to be taken as changes in efficiency (Canhoto and Dermine, 2003).

DEA can be used to derive measures of scale efficiency by using the variable returns to scale (VRS), or the BCC model, alongside the constant returns to scale (CRS), or the CCR model. Coelli et al. (1998) noted that the BCC model have been most commonly used since the beginning of the 1990s. A DEA model can be constructed either to minimise inputs or to maximise outputs. An input orientation aims at reducing the input amounts as much as possible while keeping at least the present output levels, while an output orientation aims at maximising output levels without increasing use of inputs (Cooper et al., 2000). The focus on costs in banking and the fact that outputs are inclined to be demand determined means that input-oriented models are most commonly used (Kumbhakar and Lozano Vivas, 2005).

The standard approach to measuring scale effects using DEA is to run models on both a constant returns to scale (CRS) and variable returns to scale (VRS) basis. Scale efficiency is then found by dividing the efficiency score from the CRS model by the efficiency score from the VRS model. Because the data points are enveloped more tightly under the VRS model, the VRS efficiency scores will be higher and the scale efficiency measures will therefore be in the range 0 to 1.

A useful feature of VRS models as compared to the CRS models is that it reports whether a decision-making unit (DMUs) is operating at increasing, constant or decreasing returns to scale. Constant returns
to scale will apply when CRS and VRS efficiency frontiers are tangential with each other; in other words, when the slope of the efficiency frontier is equal to the ratio of inputs to outputs (Cooper et al., 2000). Increasing returns to scale must apply below that level, as the slope of the efficient frontier, which reflects the marginal rate of transformation of inputs to outputs) will be greater than the average rate of conversion. Likewise, decreasing returns to scale must apply above the zone in which constant returns to scale apply. DMUs not on the efficient frontier must first be projected onto the efficient frontier before their returns to scale status can be assessed.

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.

4.1 Inputs and Outputs Definition and the Choice of Variables

The definition and measurement of inputs and outputs in the banking function remains a contentious issue among researchers. Banks are typically multi-input and multi-output firms. As a result, defining what constitutes “input” and “output” is fraught with difficulties, since many of the financial services are jointly produced and prices are typically assigned to a bundle of financial services. Additionally, banks may not be homogeneous with respect to the types of outputs actually produced. To determine what constitutes inputs and outputs of banks, one should first decide on the nature of banking technology. In the banking theory literature, there are two
main approaches competing with each 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 labour 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 purpose of this study, a variation of the intermediation approach or asset approach originally developed by Sealey and Lindley (1977) will be adopted in the definition of inputs and outputs used [2]. 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.

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 [3]. All variables are measured in millions of Singapore Dollars. Given the sensitivity of efficiency estimates to the specification of outputs and inputs, we have estimated two alternative models. In Model 1, we model Singapore banks as multi-product firms, producing two outputs by employing one input. Accordingly, Total Deposits ($x_1$), which include deposits from customers and other banks, is used as an input vector to produce
**Total Loans** \((y_1)\) which include loans to customers and other and **Interest Income** \((y_3)\) will be used as the output vectors.

Studies using deposits as an input claimed that this is because they are paid for in part by interest payments and also the funds raised provide the institution with the funds for investments. Alternatively, studies which adopting deposits as an output claimed that deposits are outputs as they are associated with a substantial amount of liquidity, safekeeping and payment functions and will be returned to the depositors upon request. This paper defines deposits as an input as, in Singapore, banks put more emphasis on the input rather than output characteristics of deposits. In the commercial banks, deposits are the major source of funds and provide loanable funds.

Banks also operate in a regulatory environment that requires them to maintain minimum amounts of equity capital. In an analysis of banks profit efficiency, Fare *et al.* (2004) found that using bank equity capital as a quasi-fixed input is sufficient to account for both risk based capital requirements and the risk-return trade-off that bank owners face. Hence, in Model 2, we follow the work of Fare *et al.* (2004) to include **Shareholders Equity** \((x_2)\) as an input variable

To recognise that banks in recent years have been increasingly generating income from ‘off-balance sheet’ business and fee income generally, following Drake and Hall (2003) and Isik and Hassan (2003) among others, **Non-Interest Income** \((y_2)\) along with **Interest Income** \((y_3)\) would be incorporated as a proxy to non-traditional activities as output in Model 2.

**Table 4** Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Loans ((y_1))</td>
<td>45,348.21</td>
<td>18,845.16</td>
<td>12,713.56</td>
<td>71,021.0</td>
</tr>
<tr>
<td>Non-Interest Income ((y_2))</td>
<td>727.26</td>
<td>477.50</td>
<td>73.31</td>
<td>2,153.0</td>
</tr>
<tr>
<td>Interest Income ((y_3))</td>
<td>3,201.95</td>
<td>1,153.90</td>
<td>944.39</td>
<td>5,298.0</td>
</tr>
<tr>
<td>Total Deposits ((x_1))</td>
<td>56,598.01</td>
<td>30,090.08</td>
<td>12,089.23</td>
<td>113,206.0</td>
</tr>
<tr>
<td>Shareholders Equity ((x_2))</td>
<td>9,417.43</td>
<td>4,314.58</td>
<td>2,581.63</td>
<td>17,630.0</td>
</tr>
</tbody>
</table>

*Note:* Model 1 - Outputs = \((y_1, y_3)\), Inputs \((x_1)\)
Model 2 - Outputs = \((y_3, y_2)\), Inputs \((x_2)\)
4.2 Data

As we are looking at relative efficiency, it is important that the DMUs should be sufficiently similar, so that comparisons are meaningful. This is particularly the case with DEA, where Dyson et al. (2001) have developed what they describe as a series of homogeneity assumptions. The first of these is that the DMUs the performance is which is being compared should be undertaking similar activities and producing comparable products and services so that a common set of outputs can be defined. The second homogeneity assumption is that a similar range of resources is available to all the units and they operate in a similar environment.

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 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 our 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.

Table 5 Singapore Domestic Commercial Banks

<table>
<thead>
<tr>
<th>Bank</th>
<th>Abbreviation Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBS Group Holdings Ltd</td>
<td>DBS</td>
</tr>
<tr>
<td>Keppel Capital Holdings Ltd</td>
<td>KEP</td>
</tr>
<tr>
<td>Oversea-Chinese Banking Corporation Ltd</td>
<td>OCB</td>
</tr>
<tr>
<td>Overseas Union Bank Ltd</td>
<td>OUB</td>
</tr>
<tr>
<td>United Overseas Bank Ltd</td>
<td>UOB</td>
</tr>
</tbody>
</table>

Sample selection is based on similarity of bank activities and/or availability of data. For the purpose of the study, we have also limit our scope only to examine banks that have not been involved in any mergers prior to year 2001, due to overlapping issues. Hence, the
merger between Keppel Bank and Tat Lee Bank, which later merged with OCBC bank, was excluded from the sample. As mentioned earlier, the sample selection is also based on similarity of bank activities. We have only considered mergers between commercial banks. Hence, the merger between DBS Bank Ltd. and Post Office Savings Bank (POSB) was excluded from the sample. The final sample considered in this study is therefore the mergers between OCBC Bank and Keppel Tat Lee Bank and UOB Bank and OUB Bank.

5. Empirical Results

In the spirit of Rhoades (1998), we develop a [-3, 3] event window, to investigate the effect of mergers and acquisitions on the Singapore banking group’s 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 realised within three years after the merger. The whole period, (i.e. 1998-2004) 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 merger and acquisitions is expected to have some impact on the efficiency of the Singapore banking groups. We expect to be able to capture the effects of mergers and acquisitions on the efficiency of Singapore banks during this period. The mean overall efficiency of the targets and acquirers during all periods are compared, along with its decomposition of pure technical and scale efficiencies 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 [4].

5.1 Efficiency Results in General

The efficiency results derived from Model 1 is reported in Table 6. It is clear from Table 6 that the Singapore banking sector has exhibit mean overall efficiency of 88.6% during the pre-merger period, before
increasing to 91.8% during the merger and post-merger periods. The decomposition of overall efficiency into its pure technical and scale efficiency components revealed that the improvement in Singapore banking groups’ overall efficiency during the merger and post-merger years was mainly attributed to the improvement in pure technical efficiency. During all periods, the results from Model 1 revealed that scale inefficiency dominates pure technical inefficiency in the Singapore banking groups implying that although the Singapore banking groups were efficient in controlling their costs they were however have been operating at the wrong scale of operations.

Table 7 reports the efficiency results derived from Model 2. Unlike the results from Model 1 the results from Model 2 suggest that, the Singapore banks overall efficiency declined during the merger year, before increasing strongly during the post-merger period. The decomposition of overall efficiency into its pure technical and scale efficiency components results suggest that the deterioration of the Singapore banking groups overall efficiency during the merger year was mainly attributed to the decline in pure technical efficiency, while scale efficiency seems to have improved during the merger year. Likewise, the Singapore banking groups’ increase in overall efficiency during the post-merger period was mainly the result of improvement in pure technical efficiency, which outweighs the decline in scale efficiency.

Results of the DEA Model 1 reveal that OUB was the only bank that performed efficiently during the pre-merger period, while OCBC was found to be the only bank that was efficient during the merger year. Meanwhile, during the post-merger years, OCBC and UOB were found to be operating efficiently. Consistently poor performer relative to its peer was DBS, which exhibit mean overall efficiency scores ranging from 71.1% to 88.2%. 
Table 6 Summary of Mean Efficiency Levels of Singapore Banks (Model 1)

<table>
<thead>
<tr>
<th>Bank</th>
<th>Pre-Merger*</th>
<th>During Merger**</th>
<th>Post-Merger***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OE</td>
<td>PTE</td>
<td>SE</td>
</tr>
<tr>
<td>KEP</td>
<td>99.23</td>
<td>100.0</td>
<td>99.23</td>
</tr>
<tr>
<td>OCBC</td>
<td>96.23</td>
<td>100.0</td>
<td>96.23</td>
</tr>
<tr>
<td>OUB</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>UOB</td>
<td>76.4</td>
<td>78.43</td>
<td>97.73</td>
</tr>
<tr>
<td>DBS</td>
<td>71.1</td>
<td>100.0</td>
<td>71.1</td>
</tr>
<tr>
<td>Mean</td>
<td>88.59</td>
<td>93.69</td>
<td>92.86</td>
</tr>
</tbody>
</table>

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

The DEA Model 2, where the input/output variables were changed, yielded higher efficiency scores except for during the merger year. The mean overall efficiency scores ranged from 78.5% in the case of KEP to 100.0% in the case of UOB. In contrast to Model 1, where OUB was found to be the only bank that performed efficiently, In Model 2, UOB seems to be the only bank that performed efficiently during the pre-merger years. On the other hand, OUB was found to be inefficient in Model 2 during the pre-merger years. During the merger year, OCBC remained as the only bank to operate efficiently. However, the results from Model 2 seem to suggest that while DBS has exhibited higher mean overall efficiency score during the merger year, UOB has exhibited lower mean overall efficiency score relative to Model 1. It is also interesting to note that in contrast to Model 1, which suggests that DBS was the only inefficient bank during the post-merger period, the opposite was true for Model 2. It is clear from Table 7 that DBS was the only bank to operate efficiently during the post-merger period, while both banks that were involved in mergers, namely OCBC and UOB, were found to be inefficient.
The results clearly suggest that DEA analysis is sensitive to the choice of variables. Nevertheless, this is also the strength of the technique as it provides management specific information on where to start improving the efficiency of DMUs under scrutiny (Avkiran, 1999). It allows efficiency measurement from various perspectives depending on the decision-making requirements. For example, if management is interested in the contribution of staff to a particular set of outputs, staff numbers become an input variable.

### 5.2 Pre-Merger — Model 1

In Table 6 below, it is apparent that, during the pre-merger period, Singapore banks have exhibit average overall efficiency scores of between 71.1% for DBS to 100.0% for OUB, 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 11.41%. Similar studies by Chu and Lim (1998) found that Singapore banks exhibit an average overall efficiency of 95.30% during the period of 1992-1996, while Lim and Randhawa (2005) found 19.60% input waste among seven Singapore domestic banks during the period of 1995-1999. Our results also compare

<table>
<thead>
<tr>
<th>Bank</th>
<th>Pre-Merger*</th>
<th>During Merger**</th>
<th>Post-Merger***</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEU</td>
<td>78.47</td>
<td>100.0</td>
<td>78.47</td>
</tr>
<tr>
<td>OCBC</td>
<td>90.07</td>
<td>91.43</td>
<td>98.47</td>
</tr>
<tr>
<td>UOB</td>
<td>95.27</td>
<td>98.57</td>
<td>96.67</td>
</tr>
<tr>
<td>UOB</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>UOB</td>
<td>99.77</td>
<td>97.4</td>
<td>99.67</td>
</tr>
<tr>
<td>DBS</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Mean</td>
<td>91.72</td>
<td>98.0</td>
<td>93.68</td>
</tr>
</tbody>
</table>

*OE – Overall Efficiency*

**PTE – Pure Technical Efficiency**

***SE – Scale Efficiency***

The results clearly suggest that DEA analysis is sensitive to the choice of variables. Nevertheless, this is also the strength of the technique as it provides management specific information on where to start improving the efficiency of DMUs under scrutiny (Avkiran, 1999). It allows efficiency measurement from various perspectives depending on the decision-making requirements. For example, if management is interested in the contribution of staff to a particular set of outputs, staff numbers become an input variable.
favourably with Fukuyama (1993) study on Japanese banks (14%) and the 14-25% averages of Indian commercial banks (Bhattacharyya et al., 1997). The decomposition of overall efficiency into its pure technical and scale efficiency estimates suggest that, during the pre-merger period, Singapore banks inefficiency was largely attributed to scale (7.14%) rather than pure technical efficiency (6.31%).

5.3 Post Merger — Model 1

From Table 6 above, it is clear that the merger has resulted in the improvement of Singapore banks overall efficiency for Model 1. During the post-merger period, we find that Singapore banks have exhibit 75.53% (DBS) to 100.0% (OCBC and UOB) overall efficiency levels. During the post-merger period, our results suggests that, DBS, which is the largest bank in our sample in terms of total assets, exhibit the lowest overall efficiency with mean input waste of 24.47%, while OCBC’s overall efficiency improved after the merger, thus has consistently been operating at CRS. Interestingly our results suggest that UOB has exhibit significant improvement in its overall efficiency levels, operating at CRS during the post-merger period compared to the pre-merger period when the bank was operating at 76.40% overall efficiency levels. Decomposition of the overall efficiency scores into its pure technical and scale efficiency components suggest that, the only bank in our sample which was found to be inefficient, DBS, was operating at a wrong scale during the post-merger period.

5.4 Pre-Merger — Model 2

In Table 7 below, it is apparent that, during the pre-merger period, Singapore banks have exhibit higher mean overall efficiency score of 91.72% compared to 88.59% reported for Model 1, suggesting mean input waste of 8.28% (11.41% for Model 1). This imply that banks could have reduced their inputs by 8.28% and still be able to produce the observed levels of output, without any adjustment in input, output volumes, or the branching network.
Three banks, namely, KEP, OCBC and OUB have exhibited lower overall efficiency scores in Model 2 compared to Model 1, while UOB and DBS overall efficiency were higher in Model 2 compared to Model 1 estimates. It is also interesting to note that, different factors have contributed to Singapore banking group’s lower overall efficiency in Model 2 relative to Model 1. From Table 7 it is apparent that, while OUB’s inefficiency was attributed to both scale and pure technical in Model 2, OCBC on the other hand, exhibited higher scale efficiency of 98.47% in Model 2 compared to 96.23% in Model 1, however, its pure technical efficiency level declined to 91.43% in Model 1 compared to 100.0% in Model 1. Our results from Model 2 suggest that KEP’s pure technical efficiency level remained the same in both model. However the bank’s scale efficiency deteriorates significantly from 99.23% in Model 1 to 78.47% in Model 2. The results from Model 2 also depict interesting findings. While UOB and DBS were ranked as the least efficient banks in Model 1, both banks were the most efficient banks in Model 2, suggesting the sensitivity of input output modelling in DEA. It is also apparent from Table 7 that UOB’s overall efficiency improvement was attributed to both scale and pure technical, which increased by 2.27% and 21.57% respectively. On the other hand, DBS improvement in overall efficiency was solely due to higher scale efficiency, as the bank’s pure technical efficiency remained stable at 100.0%.

5.5 Post Merger — Model 2

From Table 7 above, it is clear that, during the post-merger period, the Singapore banking system have exhibited higher mean overall efficiency of 98.59%, compared to the pre-merger period mean overall efficiency of 91.72% and Model 1 post-merger overall efficiency of 91.84%. Similar to Model 1, all Singapore banking groups were found to be pure technically efficient during the post-merger period and that the inefficiency was solely attributed to scale. In contrast to Model 1, which suggests UOB and OCBC as the fully efficient banking groups, the results from Model 2 identify DBS as
the only efficient bank during the post-merger period. The results from Model 2 suggest that UOB and OCBC as being scale inefficient banks during the post-merger period.

5.6 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 overall efficiency of the involved banks. First, we analyse 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 organised 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 that banks that are more efficient acquire the inefficient ones, we calculate the difference in overall efficiency between an acquiring and an acquired bank. The differences in efficiency are measured as the overall efficiency of the acquiring bank, minus the mean overall efficiency of the acquired banks for the last observation period before consolidation.

For Model 1, it is clear from Table 6 that during the pre-merger period KEP (the target) overall efficiency level of 99.23% is higher compared to OCBC (the acquirer) overall efficiency of 96.23%. It is also apparent that during the pre-merger period, KEP’s scale efficiency is higher compared to OCBC’s, which could be due to the fact that KEP’s size is smaller compared to OCBC. Similarly, from Table 6 it is clear that during the pre-merger period, in Model 1, UOB exhibit lower overall efficiency level of 76.4% compared to its target, OUB overall efficiency of 100.0%. Thus, our results from Model 1 reject the hypothesis that the target is a less efficient bank.

Conversely, it is apparent from Table 7 our results for Model 2 suggest that KEP’s overall efficiency is lower at 78.47% compared
to OCBC’s overall efficiency level of 90.07%. The results imply that during the pre-merger period, KEP could have produced the same amount of outputs with only 78.47% of the amount of inputs used. In other words, the bank could have reduced its inputs by 21.53% and still could have produced the same amount of outputs produced during the pre-merger period. Similarly, for Model 2, it is clear from Table 7 that during the pre-merger period, UOB’s overall efficiency of 100.0% is higher compared to its target, OUB’s overall efficiency of 95.27%. In contrast to Model 1, our results from Model 2 support the hypothesis that the acquirers are more efficient than the targets.

**5.7 Implications of Mergers on Acquiring Banks’ Efficiency**

Next, we turn discuss the ex-post performance of the merged banking groups. Here the issue at hand is whether there exists a positive (negative) relationship between the difference 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 (overall, pure technical and scale) during the post-merger period compared to pre-merger period.
For Model 1, KEP (the target) overall efficiency level of 99.23% is higher compared to OCBC (the acquirer) overall efficiency of 96.23% during the pre-merger period. It is apparent from Table 8 above that, the merger between OCBC and KEP has resulted in the improvement of OCBC mean overall efficiency during the merger and subsequently post-merger, when OCBC has been operating at CRS. Similarly, from Table 8 it is clear that during the pre-merger period, UOB exhibit lower overall efficiency level of 76.4% for Model 1 compared to its target, OUB overall efficiency of 100.0%. Again, our results suggest that UOB’s overall efficiency improved to 88.8% during the merger year and subsequently operating as a fully efficient bank post-merger. Based on our results for Model 1 we could conclude that, a more efficient target resulted in the improvement of the acquirers’ mean overall efficiency post-merger.

Table 8  Summary of Mean Efficiency Levels of the Acquirers Post-Merger – Model 1

<table>
<thead>
<tr>
<th>Bank</th>
<th>Pre-Merger*</th>
<th>During Merger**</th>
<th>Post-Merger***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OE</td>
<td>PTE</td>
<td>SE</td>
</tr>
<tr>
<td>OCBC</td>
<td>96.2</td>
<td>100.0</td>
<td>96.2</td>
</tr>
<tr>
<td>UOB</td>
<td>76.4</td>
<td>78.4</td>
<td>97.7</td>
</tr>
</tbody>
</table>

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

Table 9  Summary of Mean Efficiency Levels of the Acquirers Post-Merger – Model 2

<table>
<thead>
<tr>
<th>Bank</th>
<th>Pre-Merger*</th>
<th>During Merger**</th>
<th>Post-Merger***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OE</td>
<td>PTE</td>
<td>SE</td>
</tr>
<tr>
<td>OCBC</td>
<td>90.1</td>
<td>91.4</td>
<td>98.5</td>
</tr>
<tr>
<td>UOB</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* 1998-2000; ** 2001; *** 2002-2004
OE – Overall Efficiency
PTE – Pure Technical Efficiency
SE – Scale Efficiency
Conversely, from Table 9, our results for Model 2 suggest that KEP’s overall efficiency is lower at 78.47% compared to OCBC’s overall efficiency level of 90.07%. The implication is that, although the acquirer’s (OCBC) mean overall efficiency improved to 96.1% post-merger, compared to 90.07% during the pre-merger period, its scale efficiency deteriorates to 96.1% from 98.47% during the pre-merger period, resulting from the target’s (KEP) lower scale efficiency.

Similar to the merger between KEP and OCBC, for Model 2, it is clear from Table 9 that during the pre-merger period, UOB’s overall efficiency of 100.0% is higher compared to its target, OUB’s overall efficiency of 95.27%. The results suggest that, UOB’s overall efficiency level deteriorate drastically to 75.7% during the merger year. Despite its mean overall efficiency improved to 99.67% during the post-merger period, our results suggest that UOB’s mean overall efficiency is still lower compared to the pre-merger period of 100.0%. The findings thus support the hypothesis that the acquirer’s efficiency to deteriorate post-merger resulting from the acquisition of a less efficient target.

5.8 Discussions

Although Singapore banks have become much bigger resulting from the merger and acquisitions activities, size alone is not a sufficient condition to guarantee higher efficiency in terms of economies of scale. This is in consistent with prior studies that found medium sized banks to be slightly more scale efficient than large banks (Mester, 1987, Humphrey, 1990, Berger, et al., 1993). Our findings suggest that, during the period of 1998-2004, Singapore banking groups were experiencing the post-merger “blues”. Bank takeovers, in general, are complex and a certain amount of disruption is not to be unexpected in the short-term. Problems are likely to occur as a consequence of having to integrate different systems. Moreover, takeovers usually result in staff layoffs and bank branch closures and could have negative impact on staff morale. The bank’s business may need to be refocused before overall confidence returns. The issue of human capital is crucial in the early stages after a takeover has taken
place and incidental redundancies may lead to inferior service delivery and the exit of customers.

On the other hand, over the long-term, improvements might arise arising from a more progressive bank developing and introducing new technologies. Such innovative banks may acquire improved status and benefit from scale operations. Although size alone is not sufficient to guarantee efficiency, nonetheless being a large bank is an important aspect to achieving sufficient scale to be able to invest in the identification and development of cutting-edge technology and management systems. This certainly applies where there has been significant progress in enhancing the network of delivery channels, including optimising the number of branches within the bank’s network. Local full licence banks now offer a very broad range of services through the Internet, as do the foreign full licence banks. Moreover, some of the foreign banks have been authorised to extend their branch networks beyond their 1990 basis, thereby allowing them to have a presence in areas, such as new towns and business parks, which have become developed over the last thirty years.

Nevertheless, during the period of our study, it is observed that, in terms of scale efficiency, larger banks are lagging behind its smaller counterparts. The optimal size for a firm would be at a point where it reaches a constant return to scale (CRS). To recap, a DMU operating under increasing returns to scale (IRS) needs to expand its operations, while a DMU, which is operating at decreasing returns to scale (DRS) would on the contrary lead to downsizing. Perhaps the reason why larger banks are underperforming in comparison to their smaller peers could be that their size has become more of a burden than an advantage arising from the merger and acquisitions activities. There are considerable costs associated with the management of a large organisation and making sure that these costs do not outweigh the size benefits is of great importance. The findings above could be a reflection to the belief that scope economies, rather than economies of scale, are often seen as the main benefit banks derive by merging.
6. Conclusions and Suggestions for Future Research

The banking consolidation wave in the 1990s, characterised by relatively large scaled M&As, might give the impression that the so-called ‘optimum size’ of banking institutions is getting larger (as in the ‘big is beautiful’ principle). The process could well resulted in the disappearance of the small and/or medium sized banking institutions as the consolidation process advances.

Theoretically, a larger size could lead to economies of scale and economies of scope. With respect to the former, a larger scale would permit better absorption of fixed costs. In fact, the importance of technology investment in the banking cost function reinforces this concept. This is particularly true when the need for software is growing. More precisely, given a certain size, a bank operates with economies of scale when the average cost per unit decreases as output grows. Conversely, up to a certain size, diseconomies of scale occur when operating costs increase more proportionately than the production volume. Size could also be a source of scope economies when it is possible to generate cost savings from delivering multiple goods and services jointly through the same organisation rather than through different specialised providers.

Applying an event window analysis to a non-parametric frontier approach, Data Envelopment Analysis (DEA), the paper attempts to investigate the effects of merger and acquisitions 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 difference in Singapore banking group’s efficiency 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 our results suggest that, Singapore banking groups have exhibit mean overall efficiency level of 88.59% suggesting input waste of 11.41%. We found that, during the pre-merger period, scale inefficiency dominates pure technical inefficiency. Interestingly, the results from Model 1 suggest that, despite merger complications,
Singapore banking groups mean overall efficiency level improved since the year of the merger and improved further during the post-merger period. Again, our results suggest that scale inefficiency dominate pure technical inefficiency in the Singapore banking sector post-merger.

Similar to the results from Model 1, our results from Model 2 suggest that Singapore banking groups were relatively efficient in its intermediation role, exhibiting minimal input waste of 8.28% during the pre-merger period. Consistent with our results from Model 1, the results from Model 2 suggest that although Singapore banking group’s efficiency level deteriorates during the merger year, the mean overall efficiency level improved substantially during the post-merger period.

Although mergers has resulted in a more efficient banking system, as it may appear from our results from Model 1 and Model 2, size has become the biggest factor resulting in the inefficiency of the Singapore banking system. Henceforth, from the scale efficiency perspective, both our results do not support for further consolidation in the Singaporean banking sector to create two ‘super banks’. Our results from Model 1 and Model 2 suggest that, 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 declining returns to scale (DRS) during the post-merger period.

We found mixed evidence on the characteristics of the acquirers and targets. While the results from Model 1 do not support the hypothesis of a less efficient bank becoming a merger target, as both the targets are found to be more efficient compared to the acquirers, on the other hand our results from Model 2 suggest that, both the acquirer exhibit higher efficiency levels compared to the target during the pre-merger period. Our results further support the hypothesis that, the acquiring banks mean overall efficiency improved (deteriorates) post-merger resulting from the merger with a more (less) efficient bank.

The results on scale efficiency of the Singapore banking groups
is consistent with similar studies on U.S. banks by among others Miller and Noulas (1996), whom found that larger banks are more likely to operate at decreasing returns to scale, while the smaller banks are more likely to operate under increasing returns to scale. The results thus imply that for the banks that were found to be operating at increasing returns to scale, they may raise their productivity and subsequently efficiency by increasing their scale of operations. On the other hand, the larger banks which were found to be operating at decreasing returns to scale may need to more efficiently control for their existing resources and inputs to grab a competitive edge and take care of their already existing rising average costs.

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, it is suggested that further analysis into the investigation of Singapore banks efficiency to consider risk exposure factors. As to establish overall banks performance, risk exposure factors should be taken into consideration along with the productive efficiency measures. This is particularly true, as the best banks may not necessarily be the most efficient producer of loans, but also one, which balances high efficiency with low risk assumptions. Finally, future research into the efficiency of Singapore banks could also consider the production function along with the intermediation function.

Despite these limitations, the findings of this study are expected to contribute significantly to the existing knowledge on the operative 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 utilisation 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 also facilitate directions for sustainable competitiveness of future banking operations in Singapore.
Endnotes

[3] For a detailed discussion on the optimal number of inputs and outputs in DEA, see Avkiran (2002).
[4] Here, the pre- and post merger period refers to the mergers between OCBC Bank – Keppel Tat Lee Bank and UOB Bank – OUB Bank only. As both mergers took place in year 2001, the years 1998-2000 is thus considered to be the pre-merger year, while years 2002-2004 is considered as the post-merger year.

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References


