

# Consolidation and banks' efficiency in a highly regulated banking market: an event study window analysis approach

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## Abstract

This study investigates the effects of mergers and acquisitions on Singapore's 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 known as Data Envelopment Analysis (DEA) is employed to measure any efficiency gains (losses) resulting from the mergers and acquisitions among the domestically incorporated banking groups. To guide the definition of inputs and outputs into two alternative models, we used a variant of the intermediation approach. 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 the mergers have resulted in a more efficient Singaporean banking system, we find size to be the biggest factor influencing the inefficiency of Singapore's banking system. Hence, from the scale efficiency perspective, both our models do not support further consolidation in Singapore's banking sector. We do not find evidence of more efficient acquirers compared to the targets, as our findings from both models suggest that the targets are more efficient relative to the acquirers. Our results further support the hypothesis that the acquiring banks' mean overall efficiency improves as a result from a merger with a more efficient bank.

*JEL classification:* G21, D24

*Keywords:* Bank merger, data envelopment analysis, Singapore

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## 1. Introduction

Examining banking performance has been a common practice among banking and finance researchers for a number of years. The main reason for the continued interest in this area of research is the ever-changing banking business environment throughout the world. Many countries that have adopted financial deregulation policies are now experiencing competitive banking practices. Singapore is no exception and is becoming a competitive and important market for both financial

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and other products. Although Singapore banking is a considerable component in Asian financial activities, it has not been subjected to substantial research compared to that of other countries in the developed world. Since efficient banking systems contribute extensively to higher economic growth in any country, studies of this nature are very important for policymakers, 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 a macroeconomic point of view, as documented by its long tradition in the literature<sup>1</sup>. From the microeconomic perspective, the issue of banks' efficiency is crucial, given the increasing competition and measures to further liberalize the banking system. In fact, efficiency is 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 for this study stems mainly 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 done in this area. The present study thus addresses an important gap in the literature. Secondly, in order to appraise the effectiveness and success of the merger and acquisition activities among the domestically incorporated Singapore commercial banks, it is essential to conduct a formal analysis. This study thus attempts to provide empirical evidence on the efficiency changes of Singapore's commercial banks arising from mergers and acquisitions over the past decade. Utilizing the non-parametric Data Envelopment Analysis (DEA) methodology, the overall, pure technical, and scale efficiency of all domestically incorporated Singapore commercial banks that were involved in mergers and acquisitions will be investigated. The role of mergers in efficiency changes will be probed by comparing relative efficiency scores before and after the merger program. To the best of our knowledge, this will be the first study in the literature to examine this important issue within the context of the Singaporean banking sector.

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

The paper is structured as follows: The next section gives a brief overview of Singapore's banking system. Section three reviews related studies on bank efficiency. Section four outlines the approaches to the measurement and estimation of efficiency change. Section five discusses the results and finally, section six provides some concluding remarks.

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<sup>1</sup>For an overview, see Berger et al. [1993] and Berger and Humphrey [1997].

## **2. Brief overview of the Singapore banking system**

The development of Singapore as a financial center resulted from a deliberate government policy to broaden the country's economic base in the 1970s. With the establishment of the Monetary Authority of Singapore (MAS) in 1970, the government introduced fiscal incentives, removed exchange controls, and encouraged competition to spur the development of the financial sector. Supported by its sound macroeconomic fundamentals and prudent policies, Singapore today ranks among the leading international financial centers not only in Asia, but in the whole world as well. Singapore lags only behind London, New York and Tokyo in foreign exchange trading. Growth in the financial services sector, which currently accounts for approximately 13 to 15 percent of its GDP, has contributed significantly to its economic growth and development. This is evidenced by the presence of an extensive network of financial institutions providing a wide range of services that facilitate domestic, regional and international flow of funds for trade and investments.

Singapore's domestic banking sector had been closely regulated and largely protected until the latter half of the 1990s. The entry of foreign banks had been restricted to the wholesale banking markets since 1971. While locally incorporated banks were given permission to expand their branch networks, foreign, incorporated, fully-licensed banks admitted prior to 1971 were subjected to restrictions in terms of opening up new branches and re-locating existing branches. As such, locally incorporated banks were relatively sheltered from foreign competition. The result is a banking industry with many international players but where domestically incorporated commercial banks dominate the local banking market.

During the 1997-1998 Asian financial crisis, the sound economic and financial fundamentals of the sector has enabled it to weather the crisis relatively well. Despite incurring losses from defaulted loans, which escalated during the crisis, Singapore's commercial banks were adequately capitalized and insolvency was not an issue. Nonetheless, the financial turmoil brought to the fore the need to create strong incentive for banks to merge, which would create large institutions to cope with international competition.

### *2.1 Mergers and acquisitions in the Singaporean banking sector*

A regional financial center 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. As a regional financial center, Singapore has achieved a remarkable success as one of the world's leading centers in just over three decades. The Singaporean government has been actively undertaking financial liberalization and reforms since the 1960s. As a result of its endeavors, Singapore has become a leading financial center serving the domestic as well as neighboring economies of Southeast Asia, facilitating greater financial

intermediation in the region, and contributing to the development of capital markets and to cross-border trade and business investment.

Among the economies in Southeast Asia, Singapore was the 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 the Development Bank of Singapore (DBS) acquired the Post Office Savings Bank (POSB), and Keppel Bank merged with Tat Lee Bank, the Singaporean 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 globalization, the government intended to eventually merge the domestic financial institutions into two "super banks".

The recent merger and acquisition (M&A) activities among domestically incorporated Singapore banks are:

- On June 12, 2001, Singapore's third largest bank, the 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, the 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, thereby forming Singapore's largest bank in terms of assets.

### **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: 136] studied the consequences of mergers and acquisitions, pointing out that these may lead to changes in efficiency, market power, economies of scale and scope, availability of services to small customers and payments systems.

Besides improving cost and profit efficiency, mergers and acquisitions could also raise banks' profits by expanding the banks' market for loans and deposits. Prager and Hannan [1998] found that banks mergers and acquisitions have resulted

in higher bank concentration, which in turn led to significantly lower rates on deposits. Some evidence also suggested that US banks that participated in M&A's improved the quality of their outputs in the 1990s in ways that increased costs yet still improved profit productivity by increasing revenues more than costs (Berger and Mester [2003: 88]).

**Table 1. Characteristics of Singapore's commercial banks after the M&A's in 2001**

	<i>DBS</i>	<i>UOB + OUB</i>	<i>OCBC + KEP</i>
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	107.0	93.0	74.0
Number of ATMS	900.0	426.0	381.0

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

A note of caution is in order, 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 with a healthier bank would in many cases result in a bank even more likely to fail than either of the predecessor banks. On the other hand, he found that mergers between relatively healthy banks would create banks that are less likely to fail.

### *3.1 Studies on Singaporean banks' efficiency*

Using DEA with three inputs and two outputs, Chu and Lim [1998] evaluated the relative cost and profit efficiency of a panel of six banks in Singapore during the period 1992-1996. They found that the six Singaporean banks exhibited higher overall efficiency of 95.3 percent compared to a profit efficiency of 82.6 percent during the said period. They also found that large banks reported higher efficiency of 99.0 percent compared to 92.0 percent for the small banks. The results also suggested that scale inefficiency dominated over pure technical inefficiency during the period of study.

More recently, Randhawa and Lim [2005] utilized DEA to investigate the efficiency levels of the locally incorporated banks in Hong Kong and Singapore

during the period 1995 to 1999. They found that the seven domestic Singaporean banks exhibited an average overall efficiency score of 80.4 percent under the intermediation approach and 97.2 percent under the production approach. Furthermore, they reported that the large Singaporean banks scored higher in overall efficiency compared to the small banks under the production approach while the small banks exhibited higher overall efficiency under the intermediation approach. It was revealed that pure technical inefficiency dominated over scale inefficiency under both approaches during the period of study.

#### **4. Methodology**

The small number of banks proved to be a serious handicap in studying the efficiency of Singapore's banking system. The small sample size is one of the reasons for the DEA as our tool of choice for evaluating Singapore banks' X-efficiency. Furthermore, DEA is less demanding as it works well with a 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, need a large sample size to make reliable estimations.

The method known as Data Envelopment Analysis or DEA was first introduced by Charnes, Cooper and Rhodes [1978] (hereafter CCR) to measure the efficiency of each decision-making units (DMUS), which 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 the production. The weights for the ratio are determined by a restriction that similar ratios for every DMU have to be less than or equal to unity. This measure of efficiency allows multiple outputs and inputs without requiring pre-assigned weights. These multiple inputs and outputs are reduced to a single "virtual" input and a single "virtual" output by optimal weights. The efficiency measure is then a function of the 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); the resulting measure is the overall technical efficiency (OTE). The CRS assumption is only justifiable when all DMUS are operating at an optimal scale. However, in practice, firms or DMUS 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 characterized by variable returns to scale (VRS). The VRS assumption provides the measurement of pure technical efficiency (PTE), which is the measurement of technical efficiency

(TE) devoid of the scale efficiency effects. Any disparity between the TE and PTE scores of a particular DMU indicates the existence of scale inefficiency.

$$\begin{aligned}
 & \max \lambda_0 \theta_0 && (1) \\
 & \text{subject to } \sum_{j=1}^n \lambda_{0j} y_{rj} \geq y_{r0} && (r = 1, \dots, s) \\
 & \theta_0 x_{i0} \geq \sum_{j=1}^n \lambda_{0j} x_{ij} && (i = 1, \dots, n) \\
 & \sum_{j=1}^n \lambda_{0j} = 1 \\
 & \lambda_{0j} \geq 0 && (j = 1, \dots, n)
 \end{aligned}$$

The first constraint states that the output of the reference unit must be at least at the same level as the output of DMU 0. The second constraint requires 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 the 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 the 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

$$\begin{aligned}
 & \max \lambda_0 \theta_0 && (2) \\
 & \text{subject to } \sum_{j=1}^n \lambda_{0j} y_{rj} \geq y_{r0} && (r = 1, \dots, s) \\
 & \theta_0 x_{i0} \geq \sum_{j=1}^n \lambda_{0j} x_{ij} && (i = 1, \dots, n) \\
 & \sum_{j=1}^n \lambda_{0j} \leq 1 \\
 & \lambda_{0j} \geq 0 && (j = 1, \dots, n)
 \end{aligned}$$

#### *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. To determine what constitutes inputs and outputs of banks, one should first decide on the nature of the banking technology. In the banking theory literature, there are two main contending approaches in this regard, namely, 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 measure for output, while the number of employees and the physical capital are considered as inputs. Among previous studies that adopted this approach are those 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 treats total loans and securities as outputs, whereas deposits along with labor and physical capital are defined as inputs. Previous banking efficiency studies that adopted this approach are by Charnes et al. [1990], Bhattacharyya et al. [1997] and Sathye [2001], among others.

For the purposes 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 input and output<sup>2</sup>. According to Berger and Humphrey [1997], the production approach might be more suitable for branch efficiency studies since at most times bank branches basically process customer documents and bank funding; investment decisions are mostly not under their control. Furthermore, Sathye [2001] has noted that this approach is more relevant to financial institutions, as it is inclusive of interest expenses, which often account 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<sup>3</sup>. 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 model commercial banks as

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<sup>2</sup>Offshore banks have the same opportunities as the full and restricted banks in terms of business transacted in their Asian currency units (ACUS), but their scope of business in the Singapore dollar retail market is slightly more limited. In the domestic banking market, offshore banks cannot accept any interest-bearing deposits from persons other than approved financial institutions, nor can they open more than one branch. In addition, offshore banks may extend a maximum credit of S\$300 million in total credit facilities to resident non-bank customers in Singapore dollars. The Commonwealth Bank of Australia, the Bank of Montreal, the Bank of New Zealand, and Taiwan belong to this group.

<sup>3</sup>Humphrey [1985] presents an extended discussion of the alternative approaches over what a bank produces.

multi-product firms, producing an output by employing two inputs. Accordingly, total deposits ( $x_1$ ) and interest expense ( $x_2$ ) will be used as input variables and total loans ( $y_1$ ) will be considered as an output. In Model 2, we follow the approach by Avkiran [1999] where total deposits ( $x_1$ ) is treated as an input vector that produces total loans ( $y_1$ ) and interest income ( $y_3$ ).

#### 4.2 Data

Our empirical analysis will cover only the domestically incorporated commercial banks in Singapore (see Table 3). To maintain homogeneity, only commercial banks that make commercial loans and accept deposits from the public are included in our sample; therefore, investment banks are excluded. Data for the analysis were based on the annual balance sheets and income statements published in the banks' in annual reports. Three banks were omitted from our study, namely, the Bank of Singapore, the Far Eastern Bank, and the Industrial and Commercial Bank, which are all wholly-owned subsidiaries of the OCBC and UOB groups.

**Table 2. Descriptive statistics**

<i>Variable</i>	<i>Mean</i>	<i>Std. Dev.</i>	<i>Minimum</i>	<i>Maximum</i>
Total loans ( $y_1$ )	45,348.21	18,845.16	12,713.56	71,021.00
Interest income ( $y_2$ )	3,201.95	1,153.90	944.39	5,298.00
Total deposits ( $x_1$ )	56,598.01	30,090.08	12,089.23	113,206.00
Interest expense ( $x_2$ )	1,674.51	736.21	568.64	3,501.26

Note:

Model 1 – Outputs = ( $y_1$ ), Inputs ( $x_1$ ,  $x_2$ )

Model 2 – Outputs = ( $y_1$ ,  $y_2$ ), Inputs ( $x_1$ )

**Table 3. Singapore domestic commercial banks**

<i>Bank</i>	<i>Abbreviation used</i>
DBS Group Holdings Ltd	DBS
Keppel Capital Holdings Ltd	KEP
Oversea-Chinese Banking Corporation Ltd	OCB
Overseas Union Bank Ltd	OUB
United Overseas Bank Ltd	UOB

## 5. Empirical results

Following Rhoades [1998], we developed a  $[-3, 3]$  event window to investigate the effect of mergers and acquisitions on Singapore's banking group's efficiency. As pointed out by Rhoades [1998: 278], 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 (i.e., 1998-2004) is divided into three sub-periods: 1998-2000 refers to the pre-merger period, 2001 is considered the merger year, and 2002-2004 represents the post-merger period, during which we expect to be able to capture the effects of mergers and acquisitions on the efficiency of Singaporean banks. The mean overall efficiency scores of the targets and acquirers during all periods are compared, along with their decomposition into pure technical and scale efficient components. This could help shed some light on the sources of inefficiency of the Singapore banking system in general.

### 5.1 Pre-merger – model 1

In Table 4, the overall efficiency estimates based on Model 1 are presented, along with their decomposition into pure technical and scale efficiency estimates. During the pre-merger period, Singapore banks exhibited average overall efficiency scores of between 84.7 percent for UOB to 99.3 percent for KEP, suggesting that the Singaporean banking system has performed relatively well in its basic function, i.e., in transforming deposits to loans, with a relatively minimal input waste of 8.30 percent. The result implies that during the pre-merger period, the banking groups could have produced the same amount of outputs with only 91.68 percent of the amount of inputs used. In other words, the banks could have reduced their inputs by 8.32 percent and still produced the same amount of outputs produced during the pre-merger period.

Our results are in line with those of Chu and Lim [1998] who found that Singaporean banks exhibited an average overall efficiency of 95.30 percent during the period 1992-1996, and the findings of Randhawa and Lim [2005] who found 19.60 percent input waste among seven Singaporean domestic banks during the period 1995-1999. Our results also compare favorably with Fukuyama's [1993] study on Japanese banks (14 percent) and the 14-25 percent 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, the Singaporean banks' inefficiency was largely attributed to scale (5.44 percent) rather than pure technical efficiency factors (3.08 percent).

### 5.2 Post-merger – model 1

Despite the initial decline of the mean overall efficiency to 90.8 percent during the merger year from 91.68 percent pre-merger, it is clear that based on Model 1 the

the merger has resulted in the improvement of the Singaporean banking groups' overall efficiency. (See Table 4.) The initial decline in the mean overall efficiency 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, data from Table 4 show that the banking groups scored a mean overall efficiency of 94.93 percent. Interestingly, all banking groups in our study registered higher mean overall efficiency post-merger. Notably, DBS, which is the largest bank in our sample in terms of total assets, showed the lowest overall efficiency, with mean input waste of 8.40 percent, while OCBC significantly improved its efficiency levels, operating at CRS during the post-merger period. Decomposition of the overall efficiency scores into their pure technical and scale efficiency revealed interesting findings. While DBS' inefficiency during the post-merger period was solely attributed to scale, OUB's inefficiency was attributed solely to purely technical reasons.

**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	99.30	100.00	99.30	-	-	-	-	-	-
OCBC	86.50	96.30	89.60	100.00	100.0	100.0	100.00	100.00	100.00
OUB	97.20	100.00	97.20	-	-	-	-	-	-
UOB	84.70	88.30	96.00	100.00	100.0	100.0	93.20	93.20	100.00
DBS	90.70	100.00	90.70	72.40	100.0	72.4	91.60	100.00	91.60
Mean	91.68	96.92	94.56	90.80	100.0	90.8	94.93	97.73	97.20

\* 1998-2000; \*\* 2001; \*\*\* 2002-2004

OE – Overall Efficiency

PTE – Pure Technical Efficiency

SE – Scale Efficiency

### 5.3 Pre-merger – model 2

In Table 5, the overall efficiency estimates based on Model 2 are presented, along with their decomposition into pure technical and scale efficiency. Results show that during the pre-merger period, the study's banking groups scored 88.59 percent mean overall efficiency, with mean input waste of 11.41 percent. The decomposition of overall efficiency during the pre-merger period shows that the banks' inefficiency was largely attributed to scale (7.14 percent) rather than technical efficiency (6.31 percent). All our banking groups fared high on pure technical efficiency, with the exception of UOB. The largest bank in our sample, DBS, exhibited the lowest mean scale efficiency of 71.1 percent, while the smallest bank, KEP garnered the highest mean scale efficiency of 99.23 percent during the pre-merger period. Our

results corroborated the earlier findings by Berger et al. [1993], among others, that larger banks report higher levels of technical or X-efficiency than do their smaller counterparts.

A possible explanation for this inefficiency observed in large banks could be the large depositor base resulting from government protection, the high capital reserve requirement by the MAS, and overly conservative loan growth strategies. As pointed out by Randhawa and Lim [2005], the small Singaporean banks—due to their smaller depositor base and thus lesser deposits to transform into loans—have attained higher efficiency levels compared to their larger counterparts. Although Singapore banks survived the 1997/98 Asian financial crisis relatively unscathed, the banks may have undertaken overly conservative and cautious loan growth strategies as they attempted to rehabilitate their balance sheets from the rising volume of non-performing loans. This has resulted in low interest income and, in turn, scale efficiency (output-related) during the latter part of the studies.

**Table 5. Summary of mean efficiency levels of Singapore banks (Model 2)**

<i>Bank</i>	<i>Pre-Merger*</i>			<i>During Merger**</i>			<i>Post-Merger***</i>		
	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE
KEP	99.23	100.0	99.23						
OCBC	96.23	100.0	96.23	100.0	100.0	100.0	100.0	100.0	100.0
OUB	100.0	100.0	100.0						
UOB	76.4	78.43	97.73	88.8	100.0	88.8	100.0	100.0	100.0
DBS	71.1	100.0	71.1	88.2	100.0	88.2	75.53	100.0	75.53
Mean	88.59	93.69	92.86	91.82	100.0	92.33	91.84	100.0	91.84

\* 1998-2000; \*\* 2001; \*\*\* 2002-2004

OE – Overall Efficiency

PTE – Pure Technical Efficiency

SE – Scale Efficiency

#### *5.4 Post-merger – model 2*

Using Model 2, it is clear that the merger has resulted in the improvement of the Singaporean banking groups' mean overall efficiency, increasing from 88.59 percent during the pre-merger period to 91.84 percent post-merger. During the latter period, the banks registered 75.53 percent (DBS) to 100.0 percent (OCBC and UOB) overall efficiency levels. Both before and after the merger, the figures show that DBS, which is the largest bank in our sample in terms of total assets, exhibited the lowest overall efficiency, with mean input waste of 24.47 percent, while OCBC's overall efficiency improved after the merger and has consistently been operating at CRS. It is also interesting to note that UOB showed 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 percent overall efficiency level. Decomposition of the overall efficiency scores into its pure technical and scale efficiency components suggests 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.

It is also interesting to note that despite earlier evidence which suggests that the lack of competition may result in lower technical efficiency (see Sathye [2001] and Walker [1998]), it is clear from Table 5 that all Singaporean banking groups reported 100 percent mean pure technical efficiency score post-merger. Walker [1998] has posited that the high degree of concentration in Australian banking, which was dominated by four major banks, could reflect in the "quiet life" hypothesis coming 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. Indeed, our findings suggest that during the period 1998-2004, the source of inefficiency among Singapore's domestically incorporated banks was solely attributable to scale inefficiency.

### *5.5 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 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. To see whether it is indeed the case that the more efficient banks acquire the inefficient ones, we calculated the difference in overall efficiency between an acquiring and an acquired bank. From the overall efficiency of the acquiring bank, we deducted the mean overall efficiency 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) overall efficiency level of 99.3 percent was higher compared to OCBC's (the acquirer) overall efficiency of 86.5 percent. Similarly, for Model 1, UOB exhibited lower overall efficiency level of 84.7 percent compared to its target, OUB with overall efficiency of 97.2 percent. Thus, our results from Model 1 reject the hypothesis that the targets are less efficient relative to the acquirers.

Similar to Model 1, our results for Model 2 show that KEP's mean overall efficiency was higher at 99.23 percent compared to its acquirer's (OCBC) mean overall efficiency level of 96.23 percent. Likewise, UOB's mean overall efficiency of

76.4 percent is lower compared to its target, OUB's, mean overall efficiency of 100.0 percent. Again, our results from Model 2 reject the hypothesis that the acquirers are more efficient than the targets.

## 6. Implications of mergers on acquiring banks' efficiency

Lastly, we 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 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 those in the pre-merger period.

**Table 6. Summary of mean efficiency levels of the acquirers post-merger – Model 1**

Bank	Pre-Merger*			During Merger**			Post-Merger***		
	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE
OCBC	86.5	96.3	89.6	100.0	100.0	100.0	100.0	100.0	100.0
UOB	84.7	88.3	96.0	100.0	100.0	100.0	93.2	93.2	100.0

\* 1998-2000; \*\* 2001; \*\*\* 2002-2004

OE – Overall Efficiency

PTE – Pure Technical Efficiency

SE – Scale Efficiency

Using Model 1, KEP's (the target) mean overall efficiency level of 99.3 percent is higher compared to OCBC's (the acquirer) mean overall efficiency of 86.5 percent during the pre-merger period. It is apparent from Table 6 above that the merger between OCBC and KEP has resulted in the improvement of OCBC's mean overall efficiency during the merger and subsequently post-merger, when OCBC has been operating at CRS. Similarly, it is clear from Table 6 that during the pre-merger period, UOB exhibited lower overall efficiency level of 84.7 percent for Model 1 compared to its target, OUB, whose overall efficiency stood at 97.2 percent. Again, our results suggest that UOB's overall efficiency improved to 93.2 percent post-merger. Based on our results for Model 1, we can conclude that a more efficient target resulted in the improvement of the acquirers' mean overall efficiency post-merger.

Similarly, in our results for Model 2 in Table 7, KEP's mean overall efficiency of 99.23 percent is higher compared to its acquirer's (OCBC) mean overall efficiency of 96.23 percent. Since the merger, OCBC has been operating as a fully efficient bank. Likewise, UOB's pre-merger overall efficiency of 76.4 percent is lower compared to its target's, OUB's, overall efficiency of 100.0 percent. The results show that UOB's mean overall efficiency level improved to 76.4 percent during the merger year and has been operating at 100.0 percent efficiency level post-merger. Similar to our findings for Model 1, our results from Model 2 again support the hypothesis that the acquirer's efficiency tended to improve after merging with a more efficient target.

**Table 7. Summary of mean efficiency levels of the acquirers post-merger – Model 2**

Bank	Pre-Merger*			During Merger**			Post-Merger***		
	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE
OCBC	96.2	100.0	96.2	100.0	100.0	100.0	100.0	100.0	100.0
UOB	76.4	78.4	97.7	88.8	100.0	88.8	100.0	100.0	100.0

\* 1998-2000; \*\* 2001; \*\*\* 2002-2004

OE – Overall Efficiency

PTE – Pure Technical Efficiency

SE – Scale Efficiency

## 7. Conclusions

Applying a non-parametric frontier approach called the Data Envelopment Analysis, the paper attempted to investigate the effects of merger and acquisitions on the efficiency of domestically incorporated banking groups in Singapore. The sample period was divided into three sub-periods—pre-merger, during merger and post-merger—in order to compare the difference in the banking group's mean efficiency levels during all three 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.

Based on Model 1 results, Singapore banking groups exhibited a commendable overall efficiency level of 91.68 percent suggesting minimal input waste of 8.32 percent. We found that during the merger year, the banking groups' overall efficiency level deteriorated slightly to 90.80 percent, which was solely due to scale inefficiency. Despite that, the banking groups' post-merger mean overall efficiency levels were higher compared to the pre-merger period levels. Similar to the pre-merger period, scale inefficiencies dominated over pure technical inefficiency in the banking sector post-merger. Likewise, our results from Model 2 suggested that

Singapore's banking groups were relatively efficient in their intermediation role, exhibiting relatively minimal input waste of 11.41 percent during the pre-merger period. In contrast to the results from Model 1, our Model 2 results showed the banking groups' mean overall efficiency levels were higher during the merger year and improved further during the post-merger period.

Although mergers have resulted in a more efficient banking system, as would appear from our findings for Model 1 and Model 2, size appears to be the biggest factor contributing to the inefficiency of Singapore's banking system. From the perspective of scale efficiency, our results do not support further consolidation in the Singaporean banking sector to create two "super banks". As borne out by our results from Model 1 and Model 2, any 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's banking groups have been operating at declining returns to scale (DRS) during the post-merger period.

Our results from both models do not support the hypothesis that a less efficient bank serves as a merger target, since both the targets are found to be more efficient compared to the acquirers during the pre-merger period. On the other hand, our results support the hypothesis that the acquiring banks' mean overall efficiency improves during the post-merger period as a result of a merger with more efficient target banks.

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## When is entry the the wisest strategy for a firm?

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### Abstract

This paper examines the role of the sunk-costs in production short-run profit maximization. It also analyzes the entry of a potential entrant in the market. Wright (1978) also analyzes the sunk-costs in production short-run profit maximization. The paper analyzes the importance of the sunk-costs in production short-run profit maximization by using numerical examples of learning-by-doing.

JEL classification: E22, D21, L20

Keywords: entry decision

### 1. Introduction

As the famous saying goes, "practice makes perfect". Indeed, through hands-on experience, we gain proficiency. More time on the job usually leads to lower production costs, the so-called learning-by-doing, a strategy taken by a firm of repeating experience of the costed outputs.

There are many interesting works on learning-by-doing. The empirical test descriptive evidence in this paper starts with the work of Wright (1936) who demonstrates that the fixed costs of producing an airplane declines with the accumulated number of airplanes produced. Rapping (1965) and Dabau (1997) find that cumulative industry output yields stronger returns than cumulative firm output in 1924) examines some aspects of market learning curves based on transportation data for 37 chemical products. For each of the 37 products, the raw data on output and capacity are used to construct a large set of learning curves, namely, firm cumulative industry output, cumulative industry capacity, and output of industry output, average scale of plant, and rate of new plant construction. The results show that cumulative industry output yields the strongest learning curves. Dabau and Qi (1994) examine learning-by-doing by using time-series and cross-sectional data for various examples of learning-by-doing plants over a 1-year period. Their findings show that new entrants, in fact, learn that were born again before exiting the market. Their panel data have 13 entries for countries of the Organization for Economic Co-operation

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