Investigating the Effects of Mergers and Acquisitions on Banks' Efficiency: An Event Window Analysis

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Abstract

An event window analysis is employed in this study to investigate the effects of mergers and acquisitions on Singapore banking groups' efficiency. A three-year window is chosen to examine the 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 any efficiency gains (or losses) resulting from the mergers and acquisitions among the groups. The results suggest that the mergers have resulted in a higher mean overall efficiency for Singapore banking groups post-merger. Although mergers have resulted greater efficiency, size is becoming the biggest factor contributing to inefficiency in these groups. Therefore, from the scale efficiency perspective, the results do not support for further consolidation in the Singapore banking sector. The findings support the hypothesis that the acquiring banks' mean overall efficiency improves (deteriorates) resulting from merger with more (less) efficient banks.

Keywords: bank mergers, efficiency, data envelopment analysis, event window analysis, Singapore

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 but for other products as well. Financial activity in Asia, in which Singapore banking holds considerable importance, has not been subjected to the same degree of academic attention as has been devoted to other countries in the developed world. As efficient banking systems make an extensive contribution to higher economic growth in any country, studies of 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

microeconomic and macroeconomic points of view, 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 efficiency as one of the main priorities of the sector's regulators. From the macroeconomic perspective, the efficiency of the banking sector influences the costs of financial intermediation and the overall stability of financial markets.

The motivation for this study comes firstly from the fact that despite the importance of the Singapore banking sector to the domestic, regional, and international economy, only a few microeconomic studies have been performed in this area. The present study thus addresses an important gap in the literature. Secondly, in order to appraise for the effectiveness and success of mergers and acquisitions activity among the domestic incorporated commercial banks in Singapore, it is essential to conduct a formal analysis. This study thus attempts to provide empirical evidence on the efficiency changes of Singapore commercial banks arising from mergers 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 the Singapore banking sector.

This paper addresses the following three fundamental questions. Q1: Did the mergers and acquisitions result in an improvement of the mean overall efficiency levels of the Singapore banking system post-merger? Q2: Did less efficient banks become the targets for acquisition? Q3: Did a less (more) efficient target result in a deterioration (acceleration) in the acquirer's mean overall efficiency level post-merger?

The 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, a 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 approaches to the measurement and estimation of efficiency change. Questions 1, 2 and 3 are answered in Section 5 and finally, Section 6 provides some concluding remarks.

Overview of the Singapore Banking System

The development of Singapore as a financial centre was a deliberate government move to broaden the country's economic base in the 1970s. With the introduction of the Monetary Authority of Singapore (MAS) in 1970, the government has introduced fiscal incentives, removed exchange controls, and encouraged competition to spur financial sector development. Supported by its sound macroeconomic fundamentals and prudent policies, today, Singapore ranks among the leading international financial centres after New York, London, and Tokyo. 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. By the end of 2000, there were 141 commercial banks (full, wholesale, or offshore licenses) in Singapore.

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

The Singapore domestic banking sector is closely regulated and was 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 their 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 that has many international players, but a local banking market which is dominated by domestically incorporated commercial banks.

At present, Singapore is an established financial hub and one of the key centres in Asia. It lags behind only London, New York and Tokyo in foreign exchange trading. Growth in the financial services sector has contributed significantly to Singapore's economic growth and development, which today accounts for approximately 13 to 15% of its GDP. During the Asian Financial Crisis of 1997-1998, sound economic and financial fundamentals enabled the sector to weather the crisis relatively well. Despite incurring losses from defaulted loans, which escalated during the crisis, Singapore's commercial banks were adequately capitalised and insolvency was not an issue. Nonetheless, the immediate lesson from the financial turmoil for the local financial institutions is the need to establish a strong incentive for banks to merge, which would create large institutions to cope with international competition.

Looking ahead, the Singapore banking sector is faced with the challenge of maintaining its competitiveness while at the same time preserving a prudent regime for financial regulation. At a national level, the challenges are deemed as one of the key drivers for Singapore to become a developed nation. In the 2001 World Competitiveness Yearbook published by the Institute for Management Development (IMD), Singapore was ranked as the second most competitive economy in the world for the fifth year running (IMD, 2001).

To remain competitive in the new global economy, Singapore has recognised the need to deregulate closed sectors and shift into a knowledge-based economy. To this end, the MAS has taken steps to open the domestic banking and insurance industries to greater foreign participation. It has also shifted the emphasis of regulation to risk focused supervision. The challenge now is to develop a flexible and integrated risk-focused supervisory framework that is well grounded in prudential principles and yet attuned to evolving global financial trends.

The MAS embarked on a fundamental review of its policies in regulating and developing Singapore's banking sector in late 1997. In February 1998, the MAS unveiled several series of reforms aimed at making Singapore a predominant financial centre in an increasingly competitive global market. In developing the reforms, MAS worked closely with industry players and other government agencies to review the regulatory framework and formulate strategies to stimulate growth and intensify the development of specific industries in the financial services sector over the next five to ten years.

Hitherto, the MAS had launched two reform packages in October 1999 and June 2001. These two packages were aimed at strengthening Singapore's banking system and local banks through liberalisation, which would allow greater access to foreign players, consolidation of local banks, strengthening of corporate governance to enhance greater transparency and restructuring through the shedding of non-core banking businesses.

The first package started with the award of the Qualifying Full Bank (QFB)[2] privileges to four foreign banks – namely, ABN Amro Bank NV, Banque Nationale de Paris, Citibank N.A and Standard Chartered Bank – to increase competition. Eight new Restricted Banking[3] licences and Offshore Banking[4] licences were also issued to foreign banks to promote greater flexibility in their business activities.

In June 2001, the MAS unveiled the second round of the financial reform package. This package introduced free entry to the Singapore Dollar (SG$) wholesale market and intensified retail competition by giving foreign QFBs more business opportunities. Under the blueprint, the three-tier regimes of full, restricted, and offshore banks were crunched into two-tiers by merging the restricted and offshore categories under the "wholesale" licence. This will allow the banks to accept SGD fixed deposits above SG$250,000. It will also remove limits on the amount of SGD lending.

Under revisions to the QFBs licence, foreign banks can open up to 15 locations, of which 10 can be branches and the rest off-site automated teller machines (ATMs). The old licence only allowed up to 10 locations, of which five could be branches. From July 2002, QFBs are also allowed to provide debt services by negotiating with vendors like Nets, Visa or MasterCard for access to their EFTPos network. Consequently, this will enable QFBs to issue debit cards. Finally, the revision also allows a QFB to apply to operate supplementary retirement scheme accounts (known as central provident fund investment accounts).

These two liberalisation programmes could be regarded as significant milestones in the history of Singapore's financial sector and is hoped that these initiatives will enable local banks to grow into sound, well-capitalised institutions.

Mergers and Acquisitions in the Singapore Banking Sector

A regional financial centre can be defined as a central location, where there is a high concentration of financial institutions and capital markets that allow financial transactions in the region to take place efficiently. Singapore has been a remarkable success as a regional financial centre, and 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 other reforms since the 1960s. As a result of its endeavours, Singapore has become a leading financial hub serving the domestic as well as neighbouring economies of South East Asia. In this way, Singapore

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[2] A QFB license permits the bank to carry out the whole range of banking business approved under the Banking Act. All the local commercial banks fit into this category apart from those offshore banks mentioned above.

[3] A bank operating under a Restricted Banking License may engage in the same range of activities as a full bank except that they can only have one main branch and cannot accept Singapore Dollar savings accounts and fixed deposits of less than S$250,000 from non-bank customers. Banks that comes under this category includes UBS, AG, CSFB, and Barclays Bank Plc.

[4] Institutions with an Offshore Banking Privilege have the same opportunities as the full and restricted banks in 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 of S$300 million in total credit facilities to resident non-bank customers in Singapore Dollars. The Commonwealth Bank of Australia, and the Banks of Montreal, New Zealand, and Taiwan belong to this group.

has facilitated greater financial intermediation in the region, contributing to the development of capital markets for 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 countries affected by the crisis, Singapore hastened financial liberalisation in order to create a more resilient financial sector, which could compete in an increasingly globalised environment. The liberalisation 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 Singapore government has been encouraging domestic banks to consolidate to prepare them for stiffer competition from foreign banks. In fact, for Singapore banks to compete successfully in the new era of globalisation, the government intended eventually to 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 1 Characteristics of Singapore's Commercial Banks after the M & As in 2001

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

Source: Banks' Annual Reports.
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).

Related Studies

Bank mergers and acquisitions (M&As) may enable banking firms to benefit from new business opportunities that have been created by changes in the regulatory and technological environment. Efficiency gains can be made by banks using and integrating their combined resources. This can reduce operating costs, or achieve greater revenues, or reduce risk to increase value. Berger *et al.* (1999: 136) pointed that M&As may lead to changes in efficiency, market power, economies of scale and scope, availability of

services to small customers and payments systems efficiency. Besides improvement in cost and profit efficiency, M&As could also lead banks to earn higher profits through the banking market in leveraging loans and deposit interest rates. Prager and Hannan (1998) found that bank M&As have resulted in higher 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 over and above cost increases (Berger and Mester, 2003: 88).

Earlier evidence of cost efficiency associated with mergers and acquisitions in the U.S. banking industry in the 1980s proved to be insignificant. The average cost curve had a relatively flat U-shape with medium sized banks being slightly more cost scale efficient than either large or small banks (Berger and Humphrey, 1992; Rhoades, 1993; DeYoung, 1997). Average costs were usually found to be minimised somewhere in a wide range between about $100 million and $10 billion in assets (Berger *et al*., 1987; Hunter *et al*., 1990; Noulas *et al*., 1990). However, studies in the 1990s have shown mixed results. Berger (2003) noted that it is possible that technological progress would have increased scale economies in the production of financial services as most of the researchers used data on financial institutions in the 1980s.

Studies performed to investigate U.S. bank mergers in the 1990s have arrived at different conclusions. Rhoades (1998) found that there were modest cost efficiency gains for most M&As involving large U.S. banks, on the other hand, Berger (1998) suggests very little improvement in cost efficiency for mergers and acquisitions for both large and small banks. Despite that, mergers and acquisitions in the 1980s and 1990s did result in the improvement in profit efficiency (Akhavein *et al*., 1997; Berger, 1998). Studies that focused on profit have also been able to observe improvement in profitability. Akhavein *et al*., (1997) show M&As help to improve profitability, not by improvement in efficiency, but rather by a change in the output mix in favour of more loans and fewer securities holdings.

Berger and Humphrey (1992) and Rhoades (1993) found evidence that if the acquiring banks are more efficient that acquired banks, there are no efficiency gains from horizontal mergers. Some studies have found that, in a substantial proportion of M&As, more efficient and larger financial institutions tend to take over smaller, less efficient ones (Berger and Humphrey, 1992; Pilloff and Santomero, 1998). A study on European banks by Vander Vennet (1996) also showed that larger banks with higher efficiency and profitability tend to acquire smaller banks, which are less efficient and profitable.

Earlier studies examining the efficiency effects on bank M&As in the U.S. banking sector involved a large number of M&As transactions. However, a growing number of empirical studies have been undertaken to analyse a smaller number of M&As using a non-parametric Data Envelopment Analysis (DEA) method. The DEA method has increasingly been the preferred method to investigate the impact of M&As on banks efficiency, in particular if the sample size is small (see Table 2). Avkiran (1999) stated that it is advisable to work with a sample size substantially larger than the product of number of inputs and number of outputs if the analysis to discriminate effectively between efficient and inefficient decision making units (DMUs). Previous studies undertaken to analyse a small number of M&As include among others Avkiran (1999), Liu and Tripe (2002) and Sufian (2004).

Table 2 Singapore Domestic Commercial Banks

Bank	Abbreviation Used
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

Avkiran (1999) employed DEA and financial ratios to a small sample of 16 to 19 Australian banks during the period 1986-1995, studying 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 was 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 to the public.

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

Despite substantial studies performed in regard to the efficiency and productivity of financial institutions in the U.S., Europe and other Asia-Pacific banking industries, the Singapore banking industry has not followed suit, partly due to the lack of available data sources and the small sample of banks. Among the notable microeconomic research performed on Singapore banks' efficiency was by Chu and Lim (1998), Rezvanian and Mehdian (2002), and Randhawa and Lim (2005).

Using DEA with three inputs and two outputs, Chu and Lim (1998) evaluated 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 exhibited 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. Their findings suggest that scale inefficiency

dominated pure technical inefficiency during the period of study.

Rezvanian and Mehdian (2002) used a parametric and non-parametric approach to examine the production performance and cost structure of a sample of Singapore commercial banks. The results of the parametric methodology suggest that the average cost curve of these banks is U-shaped and there are economies of scale for small and medium-size banks. Further analysis provides evidence of economies of scope for all banks regardless of their size. The non-parametric results indicate that the Singapore banks could have reduced cost by 43% had they been efficient overall. This cost inefficiency seems to be caused equally by allocative and technical inefficiencies.

More recently, Randhawa and Lim (2005) utilised DEA to investigate X-efficiencies in the locally incorporated banks in Hong Kong and Singapore in the period 1995 to 1999. They found that during the study period the seven domestic incorporated Singapore banks had 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. On the other hand, the small banks have exhibited 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.

Methodology

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

The term Data Envelopment Analysis (DEA) was first introduced by Charnes, Cooper and Rhoades (1998), (hereafter CCR), to measure the efficiency of Decision Making Units (DMUs), 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 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 that it delivers the overall technical efficiency (OTE). The CRS assumption is only justifiable when all DMUs are operating at an optimal scale. In practice, however, 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 characterised by variable returns to scale (VRS). The VRS assumption provides the measurement of pure technical efficiency (PTE), which measures technical efficiency devoid of the scale efficiency effects. Any difference between the TE and PTE scores of a particular DMU indicates the existence of scale inefficiency.

$$max \quad {}_0 \, \theta_0 \qquad (1)$$

$$subject \; to \quad \sum_{j=1}^{n} {}_{0j} y_{rj} \geq y_{r0} \qquad (r = 1, \ldots, s)$$

$$\theta_0 x_{i0} \geq \sum_{j=1}^{n} {}_{0j} x_{ij} \qquad (i = 1, \ldots, n)$$

$$\sum_{j=1}^{n} {}_{0j} = 1$$

$${}_{0j} \geq 0 \qquad (j = 1, \ldots, n)$$

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

$$max \quad {}_0 \, \theta_0$$
$$(2)$$

$$subject \; to \quad \sum_{j=1}^{n} {}_{0j} y_{rj} \geq y_{r0} \qquad (r = 1, \ldots, s)$$

$$\theta_0 x_{i0} \geq \sum_{j=1}^{n} {}_{0j} x_{ij} \qquad (i = 1, \ldots, n)$$

$$\sum_{j=1}^{n} {}_{0j} \leq 1$$

$${}_{0j} \geq 0 \qquad (j = 1, \ldots, n)$$

Definitions of Inputs and Outputs Used and 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 banking technology. The banking theory literature is divided between two main approaches 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 related transactions are the best measures of output, while the number of employees and physical capital are considered as inputs. Previous studies that adopted this approach are, among others, 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. It posits total loans and securities as outputs, whereas deposits along with labour and physical capital are defined as inputs. Previous banking efficiency studies 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.[5] 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.[6] All variables are measured in millions of Singapore Dollars (SG$). Given the sensitivity of efficiency estimates to the specification of outputs and inputs, we have estimated two alternative models for the purpose of the study. In Model 1, we model Singapore banks as multi-product firms, producing two outputs by employing one input. Accordingly, *Total Deposits* ($x1$) is used as an input vector to produce *Total Loans* ($y1$) and *Interest Income* ($y2$).

In an analysis of bank 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) and include *Shareholders Equity* ($x2$) as an input variable along with *Interest Income* ($y2$) as an output 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* ($y3$) would be incorporated as a proxy to non-traditional activities as output in Model 2.

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[5] Humphrey (1985) presets an extended discussion of the alternative approaches regarding what a bank produces.
[6] For a detailed discussion on the optimal number of inputs and outputs in DEA, see Avkiran (2002).

Table 3 Examples of Small Sample Size in DEA Literature

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

Data

For the empirical analysis, *all* domestically incorporated Singapore commercial banks will be incorporated (see Table 4). 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 4 Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
Total Loans ($y1$)	45,348.21	18,845.16	12,713.56	71,021.0
Non-Interest Income ($y2$)	727.26	477.50	73.31	2,153.0
Interest Income ($y3$)	3,201.95	1,153.90	944.39	5,298.0
Total Deposits ($x1$)	56,598.01	30,090.08	12,089.23	113,206.0
Shareholders Equity ($x2$)	9,417.43	4,314.58	2,581.63	17,630.0

Note: Model 1 – Outputs = ($y1$, $y3$), Inputs ($x1$), Model 2 – Outputs = ($y3$, $y2$), Inputs ($x2$)

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 groups' efficiency. The choice of the event window is motivated by Rhoades (1998: 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 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 efficiency scores. This could help shed some light on the sources

of inefficiency in the Singapore banking system in general, as well as to differentiate between the efficiency scores of targets and acquirers.

Pre-Merger – Model 1

The overall efficiency estimates are presented in Table 5 along with decomposition into pure technical and scale efficiency estimates for Model 1. It is apparent that, during the pre-merger period, Singapore banks have exhibited 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 have exhibited average overall efficiency of 95.30% during the period of 1992-1996, while Randhawa and Lim (2005) found 19.60% input waste among seven Singapore domestic banks during the period of 1995-1999. The results also compare 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 due to scale (7.14%) rather than pure technical inefficiency (6.31%).

Table 5 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	99.23	100.0	99.23	100.0	100.0	100.0	100.0	100.0	100.0
OCBC	96.23	100.0	96.23						
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

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

Post Merger – Model 1

From Table 5, it is clear that the merger has resulted in the improvement of Singapore banks' overall efficiency for Model 1. During the post-merger period, the results suggest that Singapore banks have exhibited 75.53% (DBS) to 100.0% (OCBC and UOB) overall efficiency levels. During the post-merger period, the results suggest that DBS, which is the largest bank in our sample in terms of total assets, has exhibited the lowest overall efficiency with mean input waste of 24.47%, while OCBC's overall efficiency improved after the merger, and thus has consistently been operating at CRS. Interestingly our results suggest that UOB has exhibited 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 their pure technical and scale efficiency components suggest that DBS, the only bank in our sample which was found to be inefficient, was operating at the wrong scale during the post-merger period.

Pre-Merger – Model 2

In Table 6, the overall efficiency estimates are presented along with pure technical and scale efficiency decomposition for Model 2. It is apparent that during the pre-merger period, Singapore banks have exhibited a mean overall efficiency score of 91.72%, higher than the 88.59% reported for Model 1, suggesting mean input waste of 8.28% (11.41% for Model 1). This implies that banks could have reduced their inputs by 8.28% and still been 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 figures were higher in Model 2 than in Model 1 estimates. It is also interesting to note that different factors have contributed to Singapore banking groups' lower overall efficiency in Model 2 relative to Model 1. From Table 6 it is apparent that while OUB's inefficiency was due to both scale and pure technical efficiency 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 suggest that KEP's pure technical efficiency level remained the same in both models. 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 depicts some other 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 6 that UOB's overall efficiency improvement was attributed to both scale and pure technical efficiencies, which increased by 2.27% and 21.57% respectively. On the other hand, DBS improvement in overall efficiency was solely attributed to higher scale efficiency, as the bank's pure technical efficiency remained stable at 100.0%.

Table 6 Summary of Mean Efficiency Levels of Singapore Banks (Model 2)

Bank	Pre-Merger*			During Merger**			Post-Merger***		
	OE	PTE	SE	OE	PTE	SE	OE	PTE	SE
KEP	78.47	100.0	78.47						
OCBC	90.07	91.43	98.47	100.0	100.0	100.0	96.1	100.0	96.1
OUB	95.27	98.57	96.67						
UOB	100.0	100.0	100.0	75.7	76.2	99.3	99.67	100.0	99.67
DBS	94.77	100.0	94.77	97.4	100.0	97.4	100.0	100.0	100.0
Mean	91.72	98.0	93.68	91.03	92.07	98.90	98.59	100.0	98.59

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

Post Merger – Model 2

From Table 6, it is clear that during the post-merger period, the Singapore banking system has exhibited higher mean overall efficiency (98.59%) than in the pre-merger period (91.72%) and Model 1 post-merger overall efficiency (91.84%). Similar to Model 1, all Singapore banking groups were found to be efficient in pure technical terms during

the post-merger period, and that post-merger inefficiency was solely due to scale. In contrast to Model 1, which suggests that UOB and OCBC are 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 were scale inefficient banks during the post-merger period.

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 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 banks that are more efficient do indeed acquire the less efficient ones, we calculate the difference in overall efficiency between an acquiring and an acquired bank. This efficiency difference is 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 5 that during the pre-merger period the overall efficiency level of KEP (the target), at 99.23%, is higher than that of OCBC (the acquirer), at 96.23%. It is also apparent that during the pre-merger period, KEP's scale efficiency is higher than OCBC's. This could be due to the fact that KEP is smaller in comparison with OCBC. Similarly, from Table 4 it is clear that during the pre-merger period, in Model 1, UOB exhibited a lower overall efficiency level of 76.4% compared to its target, OUB, which showed overall efficiency of 100.0%. Thus, the results from Model 1 reject the hypothesis that the target is a less efficient bank.

Conversely, the results for Model 2 in Table 6 suggest that KEP's overall efficiency level, at 78.47%, is lower than OCBC's, at 90.07%. These 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 have produced the same amount of outputs produced during the pre-merger period. Similarly, for Model 2, it is clear from Table 6 that during the pre-merger period, UOB's overall efficiency of 100.0% is higher than that of its target, OUB, which had 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.

Implications of Mergers on Acquiring Banks' Efficiency
Next, we turn to discuss the ex-post performance of the merged banking groups. Here the issue 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 need to find out whether there has been any transfer of better management quality from the acquiring bank to the one acquired. Conversely, we must also ask 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) in the post-merger period compared to pre-merger period.

Table 7 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	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

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

For Model 1, the overall efficiency level of KEP (the target) is 99.23%, higher than the level of OCBC (the acquirer), which is at 96.23% during the pre-merger period. It is apparent from Table 7 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 7 it is clear that during the pre-merger period, UOB has exhibited lower overall efficiency level of 76.4% for Model 1 compared to its target, OUB, which had overall efficiency of 100.0%. Again, our results suggest that UOB's overall efficiency improved to 88.8% during the merger year and that it subsequently operated as a fully efficient bank post-merger. Based on our results for Model 1 we can conclude that a more efficient target results in the improvement of the acquirers' mean overall efficiency post-merger.

Table 8 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	S E
OCBC	90.1	91.4	98.5	100.0	100.0	100.0	96.1	100.0	96.1
UOB	100.0	100.0	100.0	75.7	76.2	99.3	99.7	99.7	100.0

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

Conversely, our results for Model 2, provided in Table 8, suggest that KEP's overall efficiency (78.47%) is lower than that of OCBC (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 deteriorated to 96.1% from 98.47% pre-merger, resulting from the target's (KEP) lower scale efficiency.

Similar to the merger between KEP and OCBC, for Model 2, Table 7 shows that during the pre-merger period, UOB's overall efficiency of 100.0% was higher than its target OUB's overall efficiency of 95.27%. The results suggest that UOB's overall efficiency level deteriorated drastically to 75.7% during the merger year. Despite an improvement in mean overall efficiency to 99.67% during the post-merger period, our results suggest that UOB's mean overall efficiency is still lower than the pre-merger period of 100.0%. The findings thus support the hypothesis that the acquirer's efficiency will deteriorate post-merger resulting from the acquisition of a less efficient target.

<u>Discussion</u>

Although Singapore banks have become much larger as a result of mergers and acquisitions activity, size alone is not a sufficient condition to guarantee higher efficiency in terms of economies of scale. This is 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 between 1998 and 2004, Singapore banking groups were experiencing the post-merger 'blues'. Bank takeovers, in general, are complex and a certain amount of disruption is to be expected 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 can have a 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 from development and introduction of new technologies in a more progressive bank. Such innovative banks may acquire improved status and benefit from scale operations. Although size alone is not sufficient to guarantee efficiency, it is important to achieve sufficient scale to enable investment 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 was observed that in terms of scale efficiency, larger banks are lagging behind their smaller counterparts. The optimal size for a firm would be a point at which constant returns to scale (CRS) are reached. 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 require 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 mergers and acquisitions activity. There are considerable costs associated with the management of large organisations, and it is important to ensure that these costs do not outweigh the size benefits. The findings above could be reflected in the belief that scope economies, rather than economies of scale, are the main benefits banks derive from merging.

Conclusions

Applying an event window analysis to the non-parametric frontier approach of Data Envelopment Analysis (DEA), the paper has investigated the effects of mergers and acquisitions on the efficiency of domestic incorporated Singapore banking groups. The sample period is divided into three sub-periods – pre-merger, during merger and post-merger – to compare differences in Singapore banking groups' efficiency over these periods. Given the sensitivity of efficiency estimates to the specification of inputs and

outputs used, we have applied a variant of the intermediation approach to two models.

For Model 1, the results show that Singapore banking groups have exhibited a mean overall efficiency level of 88.59%, suggesting mean input waste of 11.41%. We have 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 levels improved since the year of the merger and improved further during the post-merger period. Again, our results suggest that scale inefficiency dominates 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 intermediation roles, 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 groups' efficiency level deteriorated during the merger year, the mean overall efficiency level improved substantially during the post-merger period.

Although mergers have resulted in a more efficient banking system, as apparent from our results from Model 1 and Model 2, size has become the biggest factor contributing to inefficiency in the Singapore banking system. From the scale efficiency perspective, our results do not support for further consolidation in the Singapore banking sector to create two "super banks". The results from both Model 1 and Model 2 suggest that further increases in size would only result in a small increase in 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 have found mixed evidence on the characteristics of the acquirers and targets. 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 acquirers have exhibited higher efficiency levels compared to the targets during the pre-merger period. The results further support the hypothesis that the acquiring banks' mean overall efficiency improves (deteriorates) post-merger resulting from the merger with a more (less) efficient bank.

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