Banks' Efficiency and Share Prices in an Emerging Market: A DEA Window Analysis Approach

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Abstract

This paper attempts to investigate the long-term trend in efficiency change of listed Malaysian commercial banks during the period of 1994-2003. Utilising the non-parametric Data Envelopment Analysis (DEA) window analysis technique, our results suggest that during the period of study, listed Malaysian commercial banks have exhibited an average overall efficiency of 92.4% and that the inefficiencies were largely attributed to pure technical (input related) rather than scale (output related). During the period of study, listed large Malaysian commercial banks were found to have outperformed their small and very large counterparts. We further employed a panel regression analysis to test the relationship between share performance and banks efficiency. The results suggest that share price performance of banks with higher X-efficiency scores tend to outperform the share performance of banks with lower X-efficiency scores.

Introduction

Many developing countries that adopted financial deregulation policies are currently experiencing competitive banking practices. As an emerging market, the Malaysian banking sector is becoming a competitive and important market particularly for financial products. Faced with mounting competition, examination of banks efficiencies has therefore become an increasingly important issue in developing economies and emerging markets for public and policy makers (Bhattacharyya *et al*., 1997, and Yeh, 1996).

The Malaysian banking sector is a considerable component in the overall Asian banking and financial activities. Despite that, the sector has not been subjected to substantial research compared to countries in the developed world. As efficient banking systems contribute extensively in mobilising resources for higher economic growth in any country, the studies in this nature is very important for policy makers, industry leaders and market players.

On the other hand, studies on the stock market have found that stock prices do incorporate relevant publicly known information (Ball and Kothari, 1994) and efficient stock market would have taken the efficiency measures into consideration in the price discovery process particularly in the banking industry. All things being equal, cost efficient banks should be able to raise capital at a lower cost whereas cost inefficient banks may be more prone to risk taking than more cost efficient banks (Kane and Kaufman, 1993, Gorton and Rosen, 1995 and Kwan and Eisenbeis, 1996)[1]. Cost efficient banks, ceteris paribus, should be more profitable and therefore generate higher shareholders returns[2]. Thus, it is expected that higher cost efficiency will be reflected in better share performance.

This paper attempts to combine these two literatures to explain and understand the relationship between estimated banks' efficiencies and its share prices. Specifically, working within the Malaysian domestic banking arena, we investigate the influence of X-efficiencies derived from the DEA window analysis technique on the share prices of Malaysian commercial banks that are listed on the Kuala Lumpur Stock Exchange (KLSE).

The study is motivated by the fact that although there are a few studies that investigate the efficiency of listed commercial banks, to our knowledge, all of the studies have concentrated on the developed markets and we could find only limited study that examined listed commercial banks efficiency in the literature on the emerging markets. This study would thus attempts to fill a demanding gap and to contribute further to the literature while providing the most recent evidence within the context of emerging market.

To date there have been only a handful of banks efficiency studies utilising the DEA window approach and most of the studies have been concentrated on the developed countries. Furthermore, to the best of our knowledge, this would be the first study that employs a DEA window analysis to investigate listed commercial banks efficiency and to further test the relationship between the efficiency scores obtained from a DEA window analysis and to link it with the share performances in the marketplace.

The study also has important public policy implications, particularly with respect to the principal aim of the Malaysia Financial Sector Master Plan (FSMP), a long-term development plan charting the future direction of the financial services industry in Malaysia to achieve a more competitive, resilient and efficient financial system. The study could thus help the regulatory authorities in determining the future course of action to be pursued to further strengthen the Malaysian banking sector in particular the domestically incorporated commercial banks to meet the challenges of foreign banks entry from 2007 onwards[b].

Whilst the study has important public policy implications, the importance of this study would not only be limited to regulators and policymakers but to investments analysts, industry consultants and shareholders alike. As banks with higher efficiency scores tend to post higher profits (see Beccali *et al*., 2006), it could be argued that the listed banks performance may in the future reflect its ability to pay higher dividends as dividends are expected to be paid out of net profits (Chu and Lim, 1998). Additionally, the exercise will also provide insights into explaining whether banks with higher efficiency scores would result in greater shareholders wealth, measured by higher banks' share returns. If a statistical link between bank's efficiency and its share performance can be established, it would provide an alternative explanation to the behaviour of share prices in the marketplace.

This paper makes several contributions regarding both data and methodology. In terms of methodology, we present a potentially useful tool in the framework in examining the behaviour of share prices in the marketplace. Given the fact that emerging stock markets are frequently

subjected to turbulence i.e. Asian Financial Crisis, 1997-1998, Russian bond default and Long Term Capital Management (LTCM) crisis in 1998, investigations into the relationship between banks' efficiency scores and its share price reaction could be particularly difficult. This paper suggests a potential way to stabilise the excessive volatility in the emerging stock market when investigating the relationship of banks' efficiency and its share prices in the marketplace.

In terms of data, we are not aware of any other studies in the literature that have investigated the Malaysian banking sector using a relatively long time period, enough to shed some light on the efficiency trends in the Malaysian banking sector over-time. Nevertheless, given the small sample size of the Malaysian banking sector, we believe that it is more appropriate to perform banks efficiency studies using the DEA window analysis, which could provide a greater degree of freedom to the sample.

Our results suggest that during the period of study, Malaysian listed banks have exhibited an average overall efficiency of 92.4% and that the inefficiencies were largely attributed to pure technical (input related) rather than scale (output related). During the period of study, listed large Malaysian commercial banks were found to have outperformed their small and very large counterparts.

We further employed panel regression analysis by combining the capital market research in accounting and banks efficiency literature to test the relationship between share performance and banks efficiency. The results appear to suggest that share prices of banks with higher X-efficiency scores tend to outperform the share performance of banks with lower X-efficiency scores, which suggest that X-efficiency to some extent reflects banks share performance in the marketplace.

The paper is organised as follows: the next section gives an overview of the Malaysian banking system, Section 3 reviews related studies in the main literature with respect to the study of bank efficiency, Section 4 outlines the approaches to the measurement and estimation of efficiency change, Section 5 discusses X-efficiencies of Malaysian banks, Section 6 discusses the efficiency and Malaysian banks' share returns and finally Section 7 provides some concluding remarks.

Overview of The Malaysian Banking Industry

In Malaysia, as in other developing economies, the banking system plays an important role in the economy by channelling funds from those who have excess funds to those who have productive needs for those funds. Unlike in other developed nations, where financial markets, as well as the banking system, work in unison to channel those funds, in developing countries, however, financial markets are undersized and sometimes completely absent. It falls on the banks to bridge the gap between savers and borrowers and to perform all tasks associated with the profitable and secure channelling of funds.

Since the end of the 1980s, full scale and far reaching financial liberalisation has been promoted in Malaysia to create a competitive market environment, thereby improving the managerial efficiency of banks. It was expected that a competitive market environment would provide financial institutions with incentive to minimise management costs based on technically optimal choices. On the other hand, sound management of financial institutions are equally important, as efficient management of financial systems is to support economic development. Examples in industrialised countries have shown that while a financial liberalisation policy improves managerial efficiency, however without prudent regulations and supervision it will adversely affect the managerial robustness of financial institutions.

Towards the end of the nineties, globalisation is revolutionising the world financial industry and expands worldwide network of financial markets and activities. Financial innovation has continued to be unabated, institutions are rationalising and consolidating, transactions and services are rapidly going electronic and online. Not only is Malaysia facing a changing competitive landscape in Asia, rapid technological advances and fundamental shifts in the nature of competition among financial institutions pose both opportunities and challenges for its central bank.

Two episodes of economic turbulence, the economic downturn of 1985-1986 and the financial crisis of 1997-1998 during the past decade, has resulted in commercial banks in Malaysia to suffer from high rates of non-performing loans arising from over exposure to the property sector in the early 1980s and imprudent exposure to share-based financing (BNM, 1999). The commercial banks again suffered from surging levels of non-performing loans and significant erosion of capital due to large provisions made against bad debts and interest-in-suspense resulting from the financial crisis in 1997-1998, which amounted close to 40% compared to only about 17% in 1985-1986 (Ito and Hashimoto, 2002).

The Asian financial crisis of 1997 has not only caused serious damage to the Malaysian banking sector which has historically been characterised by its large number of small institutions but also has exposed the vulnerabilities of the small banking institutions to exogenous shocks[c]. During this period, most banking institutions were more concentrated in preserving the quality of their balance sheets and coping with the erosion of capital, instead of generating new loans. The pullback effect as such has resulted in the disruption to the once smooth functioning intermediation process by the banking system in Malaysia.

Despite having entered the financial crisis in 1997 from a position of strength, the severity of the crisis had weakened the health of the banking sector, as reflected by the deterioration in the capitalisation and asset quality. In recognising this problem and anticipating further adverse implications of the crisis on the banking system, the Malaysian central bank, Bank Negara Malaysia (BNM) has taken a four-pronged pre-emptive measure, to strengthen the resilience of the banking sector. This involved a merger program, the setting up of an asset management company (Pengurusan Danaharta Nasional Berhad), a special purpose vehicle to recapitalise the banking institutions (Danamodal Nasional Berhad) and the Corporate Debt Restructuring Committee (CDRC).

Although the Malaysian central bank has always encouraged banks to merge in order to achieve economies of scale and higher level of efficiency, only a few mergers among the banking institutions have taken place. The urgency to consolidate the banking sector was apparent during the Asian financial crisis that struck the region in 1997-1998, which has exposed the vulnerabilities of the small banking institutions and the need for these institutions to maintain a high level of capital. Furthermore, given the fact that much of the required financing in Malaysia was intermediated through the banking system, the risk associated with cyclical downturn in the economy would therefore be much concentrated in the banking system.

In order to minimise the potential impact of systemic risks on the banking sector as a whole, following the deepening of the financial crisis, the Government took stronger measures to promote (force) merging of banking institutions. Subsequently, ten banking groups were formed intended to avoid the turmoil in the financial markets due to the drastic reduction of financial institutions. The ten banking groups or anchor banks are: Malayan Banking Berhad, RHB Bank Berhad, Public Bank Berhad, Bumiputra-Commerce Bank Berhad, Multi-Purpose Bank Berhad, Hong Leong Bank Berhad, Affin Bank Berhad, Arab-Malaysian Bank Berhad, Southern Bank Berhad and EON Bank Berhad. Each bank had minimum shareholders' funds of Ringgit Malaysia (RM) 2 billion and asset base of at least RM 25 billion. Together, the 10 commercial banks controlled about 80 percent of the market for deposits and loans. With the exception of Multi-Purpose Bank Berhad, all other banking groups are currently listed on the local bourse, the Kuala Lumpur Stock Exchange (KLSE).

The merger programme for domestic banking institutions, initiated in 1999 was finally concluded in 2001. The ten anchor banks emerged having complied with all the requirements of anchor bank status, such as minimum capitalisation, total asset size, and other prudential requirements. The focus of the domestic banking groups entered the next stage that is to complete the business integration processes and rationalisation exercises, e.g., branch, workforce, etc.

Table 1:
Malaysian Banks Mergers and Acquisitions

Anchor Banks	Banks Acquired	Finance Companies Acquired	Merchant Banks Acquired	Anchor's 30 June '00 Total Assets RMb	Post-Merger Total Assets RMb	% of Systems Assets
Maybank	The Pacific Bank Phileo Allied Bank	Mayban Finance* Kewangan Bersatu Sime Finance*	Aseambankers Malaysia*	127	150	24.0
Bumiputra-Commerce Bank	N.A.	Bumiputra-Commerce Finance*	Commerce International Merchant Bankers*	63	67	10.7
RHB Bank	N.A.	Interfinance Delta Finance	RHB Sakura Merchant Bankers*	51	56	9.0
Public Bank	Hock Hua Bank	Public Finance* Advance Finance	Sime Merchant Bankers	43	50	8.0
Arab-Malaysian Bank[1]	N.A.	Arab-Malaysian Finance*	Arab-Malaysian Merchant Bank*	11	39	6.2
Hong Leong Bank	Wah Tat Bank	Hong Leong Finance* Credit Corporation		29	35	5.6
Multi-Purpose Bank	International Bank Malaysia Sabah Bank	Sabah Finance Bolton Finance	Bumiputra Merchant Bankers Amanah Merchant Bank	9	14	2.2
Affin Bank[2]	BSN Commercial Bank	Affin Finance* BSN Finance	Perwira Affin Merchant Bankers* BSN Merchant Bank	15	30	4.8
Southern Bank	Ban Hin Lee Bank	Perdana Finance Cempaka Finance United Merchant Finance	Perdana Merchant Bankers	24	25	4.0
EON Bank	Oriental Bank	EON Finance* City Finance Perkasa Finance	Malaysia International Merchant Bankers	14	25	4.0

* – Originally part of the anchor bank's wider group
Source: **Bank Negara Malaysia**

Banks Efficiency Studies Utilising Dea

Although studies investigating banks efficiency by DEA are voluminous, there are only a few papers, which have utilised the DEA window analysis approach to banking (see Avkiran, 2004; Reisman *et al.*, 2003; Webb, 2003 and Hartman and Storbeck, 1996). Asmild *et al.* (2004) combined a DEA like Malmquist Productivity Index with DEA window analysis on a sample of five Canadian banks over a 20-year period.

Applying a three-year window to a sample of 10 Australian trading banks during the period 1986-1995, Avkiran (2004) found that Australian trading banks have exhibited deteriorating efficiency levels during the earlier part of the studies, before progressively trending upwards in the latter part. During the period of study, he found that interest expenses were the main source of inefficiency of Australian trading banks. He suggest that most Australian banks have exhibited CRTS during the early period, DRTS and IRTS in the early 1990s and turn to exhibit CRTS during the latter part of the studies.

1 The Merger between Utama Banking group, comprising Bank Utama and Utama Merchant Bank with Arab-Malaysian banking group did not proceed due to a disagreement over the ultimate control of the merged entity initially.

2 Another Merger that failed to materialize was that of Multi-Purpose Bank and MBf Finance due to Multi-Purpose Bank's minority shareholders balking at the price involved. The Arab-Malaysian Banking Group however acquired MBf Finance from Danaharta.

Webb (2003) utilises DEA window analysis to investigate the relative efficiency levels of large UK retail banks during the period of 1982-1995. Following the intermediation approach, he found that during the period the mean inefficiency levels of UK retail banks were low compared to past studies on UK banking industry. He suggested that the overall long run average efficiency level was falling and that all the six large UK banks showed declining levels of efficiency over thee entire period.

Reisman *et al.* (2003) investigates the impact of deregulation on the efficiency of eleven Tunisian commercial banks during 1990 to 2001. Applying the intermediation approach to DEA with an extended window analysis, they find that deregulation had a positive impact on Tunisian commercial banks' overall efficiency. They suggest that public banks outperformed private banks in transforming deposits into loans. They also suggest that both public and private banks were inefficient in their investments.

Although studies performed to investigate banks' efficiency are voluminous, only a handful investigated the relationship between banks' efficiency and its share performances in the marketplace.

Adenso-Diaz and Gascon (1997), with reference to the Spanish banking sector, attempt to establish a link between stock performance and four different measures of partial efficiency: production costs, branch network distribution estimated by using DEA; systematic risk and specific risk. The main findings suggest that the most influential variable in determining stock performance is banks' specific risk.

Using DEA with three inputs and two outputs, Chu and Lim (1998) evaluate the relative cost and profit efficiency of a panel of six Singapore listed banks during the period 1992-1996. They found that during the period, the six Singapore listed banks have exhibited higher overall efficiency compared to profit efficiency and the large Singapore banks have reported higher overall and profit efficiency compared to the small banks. They also found that percentage change in the price of bank shares reflect percentage change in profit rather than cost efficiency.

Estimating the cost efficiency of a sample of large U.S. bank holding companies, Eisenbeis *et al.* (1999) examined the informativeness of the efficiency measure using both DEA and SFA in explaining risk-taking behaviour, managerial competence and bank stock returns. Based on their findings, they concluded that while both methods produce informative efficiency scores, for their dataset, decision-makers should put more weight on the stochastic frontier efficiency estimates.

More recently, Beccali *et al.* (2006) employed the non-parametric Data Envelopment Analysis (DEA) and Stochastic Frontier Approach (SFA) to investigate cost efficiency of listed banks in five main European banking markets namely, France, Germany, Italy, Spain and United Kingdom during the year 2000. They found that, the percentage change in stock prices reflect percentage change in cost efficiency, particularly those derived from DEA. They also suggest that stocks of cost efficient banks tend to outperform their inefficient counterparts.

Data and Methodology

Following Avkiran (2004), Reisman *et al.* (2003) and Webb (2003) among others, a non-parametric method, DEA, will be used in measuring the efficiency of the Malaysian banks. The method allows for the decomposition of the efficiency and productivity differences into one representing the banks' efficiency and productivity levels relative to their peers best practice frontiers. The DEA is a linear (mathematical) programming technique which forms a non-parametric surface / frontier (more formally a piecewise-linear convex isoquant) over the data points to determine the efficiencies of each DMU relative to this frontier. DEA has the advantage of being able to handle multiple inputs and outputs stated in different measurement units. It focuses on a best-practice frontier, rather than population central tendencies and does not require a functional form to be imposed relating to inputs and outputs (Charnes *et al.*, 1985).

The main reason for choosing the DEA approach is the expressed interest in the Malaysian banking industry of reducing costs in the recent years owing to the increased competition fostered by liberal policies. Furthermore, DEA permits a researcher to investigate the relative efficiency among DMUs and allows the study to focus on the input savings efficiency, which can further be detailed into its pure technical and scale efficiency components. Hence, through input oriented DEA, we can dwell on the sources of input waste among Malaysian banks and draw some policy conclusions.

The term Data Envelopment Analysis (DEA) was first introduced by Charnes, Cooper and Rhodes (1978), (CCR), to measure the efficiency of each Decision Making Units (DMUs), that is obtained as a maximum of a ratio of weighted outputs to weighted inputs. This denotes that the more the output produced from given inputs, the more efficient is the production. The weights for the ratio are determined by a restriction that the similar ratios for every DMU have to be less than or equal to unity. This definition of efficiency measure allows multiple outputs and inputs without requiring pre-assigned weights. Multiple inputs and outputs are reduced to single 'virtual' input and single 'virtual' output by optimal weights. The efficiency measure is then a function of multipliers of the 'virtual' input-output combination.

The CCR model presupposes that there is no significant relationship between the scale of operations and efficiency by assuming constant returns to scale (CRTS), and it delivers the overall technical efficiency (OTE). The CRTS assumption is only justifiable when all DMUs are operating at an optimal scale. However, firms or DMUs in practice might face either economies or diseconomies of scale. Thus, if one makes the CRTS 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 CRTS assumption. The resulting "BCC" model was used to assess the efficiency of DMUs characterised by Variable Returns to Scale (VRTS). The VRTS assumption provides the measurement of purely technical efficiency (PTE), which is the measurement of technical efficiency devoid of the Scale Efficiency (SE) effects. If there appears to be a difference between the TE and PTE scores of a particular DMU, then it indicates the existence of SE. PTE (or managerial efficiency) is input related and measures whether the DMU is using too much input to produce a given level of output. SE on the other hand is output related and determines whether the DMU is operating at the right scale or not. Based on the source of any scale inefficiency, conclusions can thus be reached on the production levels of the firm[d]. To establish whether scale inefficient DMUs exhibit Increasing Returns to Scale (IRTS) or Decreasing Returns to Scale (DRTS), the CCR technical efficiency problem is solved under the assumption of VRTS to provide

$$\textit{Min} \quad \lambda_0 \theta_0 \qquad (1)$$

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

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

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

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

DEA Window Analysis

In order to capture the variations of efficiency over time, Charnes *et al.* (1985) proposed a technique called 'window analysis' in DEA. The window analysis assesses the performance of a DMU over time by treating it as a different entity in each time period. This method allows for tracking the performance of a unit or DMU over time and provides a better degree of freedom (Avkiran, 2004 and Reisman, 2003). If a DMU is found to be efficient in one year despite the window in which it is placed, it is likely to be considered strongly efficient compared to its peers (Avkiran, 2004).

As there is no theory or justification underpins the definition of the window size (Tulkens and van den Eeckaut, 1995), this paper utilises a three-year window, which is consistent with the original work by Charnes *et al.* (1985). Furthermore, Avkiran (2004), Webb (2003) and Reisman (2003) have also utilised a three-year window to investigate banks' efficiency in Australia, U.K. and Tunisia respectively.

To illustrate, from Table 2 below the first window incorporates years 1994, 1995 and 1996. When a new period is introduced into the window, the earliest period is dropped. Hence, in window two, year 1994 will be dropped and year 1997 will be added to the window. Subsequently in window 3, years 1996, 1997 and 1998 will be assessed. The analysis is performed until window 8 analyses years 2001, 2002 and 2003. As DEA window analysis treats a DMU as different entity in each year, a three-year window with eight DMUs is equivalent to 24 DMUs. Subsequently, by applying an 8, three-year window, would considerably increase the number of observations of the sample to 192, providing a greater degree of freedom.

Table 2:
Window Breakdown

Window 1	**1994**	**1995**	**1996**								
Window 2		**1995**	**1996**	**1997**							
Window 3			**1996**	**1997**	**1998**						
Window 4				**1997**	**1998**	**1999**					
Window 5					**1998**	**1999**	**2000**				
Window 6						**1999**	**2000**	**2001**			
Window 7							**2000**	**2001**	**2002**		
Window 8								**2001**	**2002**	**2003**	

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. In the banking theory literature, there are two main approaches competing with each other in this regard: the production and intermediation approaches (Sealey and Lindley, 1977).

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

The intermediation approach on the other hand assumes that financial firms act as an intermediary between savers and borrowers and posits total loans and securities as outputs, whereas deposits along with labour and physical capital are defined as inputs. Previous researches that follow this approach among others are by 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 input and output definition[e]. According to Berger and Humphrey (1997), the production approach might be more suitable for branch efficiency studies as at most times bank branches basically process customer documents and bank funding, while investment decisions are mostly not under the control of branches. Furthermore, Sathye (2001) also noted that this approach is more relevant to financial institutions as it is inclusive of interest expenses, which often accounts for one-half to two-thirds of total costs depending on the phase of the interest rate cycles.

The aim in the choice of variables for this study is to provide a parsimonious model and to avoid the use of unnecessary variables that may reduce the degree of freedom[f]. Accordingly, we model commercial banks as multi-product firms, producing 3 outputs and employing 2 inputs. All variables are measured in millions of Ringgit. The input vector includes (*x1*) *Total Deposits*, which includes deposits from customers and other banks and (*x2*) *Interest Expenses* while (*y1*) *Total Loans*, which includes loans to customers and other banks and (*y2*) *Interest Income* are the output vectors. The variables selected for this study could be argued to fall under the intermediation approach to modelling bank behaviour.

To recognise that banks in recent years have increasingly been generating income from 'off-balance sheet' business and fee income generally, following Drake and Hall (2003) and Isik and Hassan (2003) among others, (*y3*) *Non-Interest Income* would be incorporated as a proxy to non-traditional activities as output. Non-interest income is defined as fee income, investment income and other income, which among others consist of commission, service charges and fees, guarantee fees, net profit from sale of investment securities and foreign exchange profit.

For the empirical analysis, *all* Malaysian commercial banks that are publicly listed on the KLSE from 1994-2003 would be used (see Table 3)[8]. During the study period, banks that were acquired or failed were dropped from the sample so that the final sample contains only surviving banks as of 2003. In order to focus on commercial banks and to maintain homogeneity, only commercial banks that make commercial loans and accept deposits from the public were included in the analysis. Therefore, Malaysian Islamic Banks, Development Banks, Investment Banks, Export-Import Banks and Cooperative Banks were 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.

Table 3:
Sample Banks Summary Statistics

Banks	Share Capital ('000)	Market Capital (RM'm)	Total Assets (RM'm)	Abbreviation Used
Affin Holdings Bhd	1,706.00	5,288.70	58,553.84	**AHB**
AMMB Holdings Bhd	993.50	1,063.00	35,360.50	**AMB**
Commerce Asset Holdings Bhd	2,593.10	10,631.70	97,933.98	**CAH**
Hong Leong Bank Bhd	1,435.00	7,461.70	43,568.60	**HLB**
Maybank Bhd	3,589.50	34,638.30	160,955.41	**MBK**
Public Bank Bhd	3,175.50	17,973.40	64,640.32	**PBK**
RHB Capital Bhd	1,823.50	3,792.80	69,485.70	**RHB**
Southern Bank Bhd	1,122.90	2,874.50	29,787.18	**SBK**

Banks Efficiency and Share Performance

Banks' share performances are represented by annual share returns, which were calculated for each bank by adding *daily* returns for each year in the window. This measure is believed to be a better measure than calculating a point increase with data from the first and the last day of the period under investigation. Daily returns have smaller standard deviations than do annual and monthly returns[3].

The share returns were then transformed into 8 windows by 3-year moving average. As the window analysis is commonly used in DEA for sensitivity analysis of external factors that may distort figures for a particular year and a varying group of reference units, the technique could potentially be useful particularly for emerging markets and developing economies like Malaysia where the economy and the market are more profound to exogenous shocks. Hence, by transforming the share returns into windows, it would thus help stabilise and smooth the excessive volatility effects in the Malaysian stock market particularly during the 1997/1998 Asian Financial Crisis.

Panel Data Estimation Procedures

Estimates obtained using panel data estimation procedures have a number of advantages over the simply pooled ordinary least squares (OLS) procedures (Hsiao, 1989). Simply pooled OLS estimation procedures cannot adjust for firm specific and time specific (i.e. year specific) effects, which, if correlated with other explanatory variables, would produce omitted variables bias and misspecified models. This problem is serious as it produces flawed estimates.

In the present context, panel data model can be estimated by using a fixed effects estimator or a random effect estimator (feasible GLS). The fixed effect estimator estimates a different constant for each bank. The fixed effects model (FEM) overcomes this problem by adjusting for these effects through the firm specific and time specific intercepts. The firm specific intercepts capture the unobserved and/or unmeasurable firm specific characteristics, while the time specific intercepts capture the unobserved and/or unmeasurable time varying characteristics. Since intercept terms vary across banks, they are indexed by individual bank. Coefficients are computed by running the OLS on transformed data, which are obtained by subtracting the time or "within group" (cross section specific) mean from each variable to eliminate the fixed effects from the regression. Alternatively, the problem of omitting specific effects (both firm- and year-specific) can be similarly overcome by random-effect model (REM), which assumed that the intercept consists of two parts; a constant, which is the same for all cross sectional units and a time-invariant random variable.

Various statistical tests can be used to determine which model (OLS, FEM and REM) produces the most adequate specifications. We estimated all three models and selected the appropriate model based on statistical tests. We initially obtain estimates from both models: simply pooled ordinary least squares regression model (OLS), fixed-effect (FEM) and random-effect models (REM). We run two tests to determine the most appropriate model to use (Hsiao, 1989), namely Likelihood Ratio Test (LR) and Hausman Test. The Likelihood Ratio Test (LR) suggests that FEM outperformed the simple pooled OLS whereas Hausman Test do not suggests that REM model outperformed FEM model. Thus, FEM estimates are reported in the paper.

To examine the relationship between X-efficiency and share performance, the bank share returns are regressed against X-efficiency estimates by employing all the three models (OLS, FEM and REM) and we ultimately chose the fixed-effects specification on the basis of Likelihood Ratio Test and Hausman test results. Accordingly, the estimated model is as follows:

$$SHR\_RET_{jt} = \alpha_0 + \beta_1 EFF_{jt} + \epsilon_{jt} \qquad (2)$$

where SHR_RET_{jt} is the moving average of bank *j*'s *daily* share returns in window *t;* α_0 are bank *j*'s fixed effects, EFF_{jt} is bank *j*'s mean annual percentage change in X-efficiency in window *t*; β_1 is a parameter excluding the constant; and ϵ_j is a normally distributed error term. The error term is assumed to be free of autocorrelation. Heteroskedasticity is allowed, but corrected in the estimations by using the robust variance covariance matrix.

Empirical Results

As mentioned earlier, there is currently no study in the literature to investigate the efficiency of publicly listed commercial banks in an emerging market and to further link with its share performance. Furthermore, to the best of our knowledge this is the first study that investigates listed banks efficiency and its price behaviour or share performance, by virtue of a DEA window analysis. Therefore, the results reported below provide valuable information and new insights into the relationship between listed banks efficiency and its share performance in the marketplace.

The DEA model is applied in eight-three-year windows and the results are reported for the general trend in overall efficiency for each window. Changes over time for the sequence of windows is then considered. The average of all scores, for each bank, is given in the column denoted "Mean". The column labelled "SD" indicates the standard deviation for the score of each bank during the entire period. The column labelled "LDY" indicates the largest difference in a bank's scores in the same year but in different windows. The column labelled "LDP" indicates the largest difference in a bank's score for the entire period. A bank can have different efficiency scores in different windows. A bank that is efficient in one year regardless of the window is said to be stable in its efficiency rating (Cooper *et al.*, 2000).

General Trends

The ten year range covered in this study encapsulates significant changes in economic climate, in which Malaysian commercial banks have experienced both difficult and profitable operating periods. The year 1994-1996 was marked as a period of robust growth in financial services output, followed by the "down" years of 1997 and 1998 and resurgent growth in 1999 to 2003. Looking at the average overall efficiency levels for each window in Figure 1, it is clear that Malaysian commercial banks average overall efficiency levels were highest in window 3, supported by the buoyant Malaysian economy during the period.

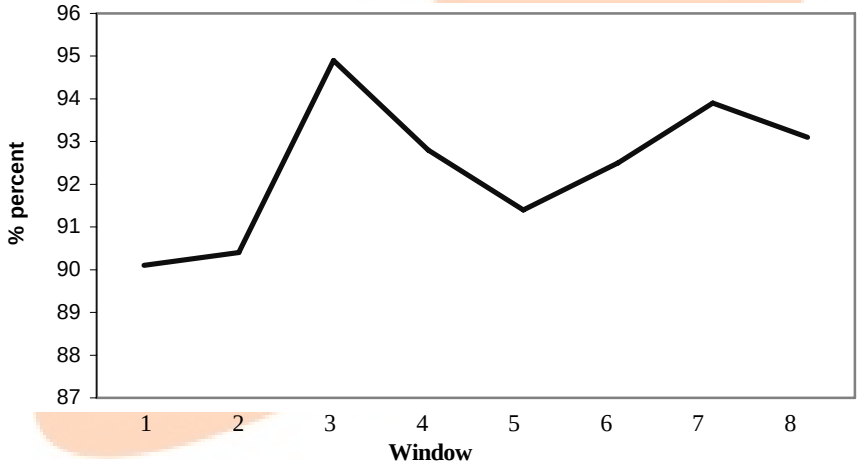

Figure 1:
Mean Efficiency Levels of Malaysian Listed Commercial Banks

However, the Malaysian commercial banks' mean overall efficiency levels exhibited marked decline in windows 4 and 5. One clear reason for the cause of the marked decline could be argued to be due to the Asian Financial Crisis that struck the country in 1997/1998 resulting in the credit market conditions in the region to deteriorate rapidly. The overall efficiency levels recovered in windows 6 and 7 in tandem with the country's economic recovery as credit markets returned to normal and banks resumed its normal activities to provide loans and financing to borrowers.

The average overall efficiency levels again declined in window 8, which could be attributed to a few factors. Firstly, it could be argued that during the period, Malaysian commercial banks have just completed the mega-merger program initiated by the government and was concluded during the year 2001. It could be argued that banks have had to absorb extra capacities, incur higher costs arising from systems integration, branch closures and employees lay off as a result of the merger.

Secondly, the 2001-2003 period was marked as a period of heightened geopolitical uncertainties, which has raised concerns over the sustainability of the economic growth in most part of the world. To mitigate the negative impacts and to stimulate economic activities, central banks from all over the world particularly the U.S. Federal Reserve Bank had taken steps to lower its interest rates. The Malaysian Central Bank was also not an exception as it has lowered its intervention rates, which in turn was used by the Malaysian commercial banks to determine the Base Lending Rates (BLR), the lending rates for loans to borrowers. During the period, the BLR declined from an average of 6.8% in 2001 to 6.0% in 2003 while interest rates on deposits were relatively stable at 3.00%. The lower BLR could be argued to have negative impacts on Malaysian commercial banks, which carry huge amounts of loans pegged to the BLR as these banks could have earned lower net interest margins during this period.

Thirdly, the period had also witness intensification of competition especially for hire purchase and housing loans. To stay competitive and to attract borrowers amidst the intensification of competition, Malaysian commercial banks have taken the steps to further lower its lending rates which have resulted in further margin compression especially for the small banks which, have mostly sourced its incomes from the hire purchase financing and housing loans.

Lastly, it could also be argued that the low interest rates environment has prompted Malaysian corporations to tap into the debt market as a source of funding instead of going to the banks for lines of credit during this period. As Malaysian corporations moved away from its traditional way of financing its business motivated by the cheap financing costs in the bond markets, banks that have traditionally concentrates on corporate loans could have experienced sluggish loan growth during this period.

Overall Efficiency

Table 4 decomposes overall average efficiency scores for each bank in each window while clarifying the trends. It is apparent that, Malaysian commercial banks have exhibited an average overall efficiency score of 92.4% during the 1994-2003 period, suggesting 7.6% input waste among the listed Malaysian commercial banks during the period of study. It is clear from Table 4 that AMB and SBK, the best performers for the period, had maintained their position with average overall efficiencies of 98.7% and 97.8% and standard deviations of 0.032 and 0.030 respectively.

Table 4:
Window Analysis of Overall Efficiency Scores

Bank	Window	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean/ Window	Mean	SD	LDY	LDP
	1	88.2	97.7	83.9								**89.9**				
	2		100.0	86.3	79.6							**88.6**				
	3			99.3	88.7	79.1						**89.0**				
AHB	**4**				90.0	79.1	89.1					**86.1**	**88.7**	**0.069**	**15.4**	**21.9**
	5					78.1	82.1	96.0				**85.4**				
	6						79.8	92.9	97.3			**90.0**				
	7							92.9	94.0	90.5		**92.5**				
	8								92.4	88.2	84.4	**88.3**				
	1	100.0	100.0	94.5								**98.2**				
	2		100.0	94.2	100.0							**98.1**				
	3			100.0	100.0	100.0						**100.0**				
AMB	**4**				100.0	100.0	89.9					**96.6**	**98.7**	**0.032**	**10.5**	**10.5**
	5					100.0	89.5	100.0				**96.5**				
	6						100.0	100.0	100.0			**100.0**				
	7							100.0	100.0	100.0		**100.0**				
	8								100.0	100.0	100.0	**100.0**				
	1	88.2	79.4	81.2								**82.9**				
	2		82.4	82.9	81.0							**82.1**				
	3			93.0	89.3	93.3						**91.9**				
CAH	**4**				91.9	93.3	80.0					**88.4**	**86.3**	**0.052**	**11.8**	**16.0**
	5					92.3	77.3	89.7				**86.4**				
	6						77.3	88.0	90.3			**85.2**				
	7							88.0	89.2	85.5		**87.6**				
	8								87.6	81.9	88.6	**86.0**				
	1		99.6	92.1								**95.9**				
	2		100.0	92.5	85.7							**92.7**				
	3			100.0	94.5	84.6						**93.0**				
HLB	**4**				92.4	85.3	83.1					**86.9**	**88.4**	**0.062**	**8.8**	**21.5**
	5					82.6	78.5	88.4				**83.2**				
	6						78.5	86.8	87.2			**84.2**				
	7							86.8	87.2	86.5		**86.8**				
	8								85.9	84.7	82.2	**84.3**				

Mean = Average score for the eight year period; **SD** = Standard Deviation for the period; **LDY** = Largest difference between scores in the same year; **LDP** = Largest difference between scores across the entire period.

Table 4:
Window Analysis of Overall Efficiency Scores (continued)

Bank	Window	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean/ Window	Mean	SD	LDY	LDP
	1	84.2	86.4	85.8								**86.1**				
	2		88.8	86.6	87.5							**87.6**				
	3			93.2	95.0	95.8						**94.7**				
MBK	**4**				96.0	95.8	93.3					**95.0**	**92.7**	**0.044**	**8.5**	**15.4**
	5					94.8	88.4	99.6				**94.3**				
	6						88.4	96.5	97.7			**94.2**				
	7							95.6	93.6	96.2		**95.1**				
	8								92.6	93.7	98.0	**94.8**				
	1	75.1	81.3	86.3								**83.8**				
	2		84.6	87.7	88.8							**87.0**				
	3			93.5	95.3	89.5						**92.8**				
PBK	**4**				96.9	89.7	100.0					**95.5**	**93.5**	**0.070**	**8.4**	**24.9**
	5					88.1	91.6	100.0				**93.2**				
	6						91.6	100.0	100.0			**97.2**				
	7							100.0	100.0	100.0		**100.0**				
	8								100.0	96.2	100.0	**98.7**				
	1	100.0	94.5	86.3								**90.4**				
	2		96.5	88.1								**92.3**				
	3			100.0		100.0						**100.0**				
RHB	**4**					100.0	89.0					**94.5**	**93.4**	**0.061**	**13.7**	**21.7**
	5					100.0	82.8	94.1				**92.3**				
	6						78.3	91.8	98.7			**89.6**				
	7							89.4	92.5	96.4		**92.8**				
	8								92.3	96.4	96.6	**95.1**				
	1	100.0	96.3	92.3								**94.3**				
	2		100.0	95.0	90.5							**95.2**				
	3			100.0	98.7	100.0						**99.6**				
SBK	**4**				99.1	100.0	100.0					**99.7**	**97.8**	**0.030**	**8.6**	**9.5**
	5					98.8	100.0	100.0				**99.6**				
	6						100.0	100.0	100.0			**100.0**				
	7							93.5	94.5	100.0		**96.0**				
	8								93.5	100.0	100.0	**97.8**				

Mean = Average score for the eight year period; **SD** = Standard Deviation for the period; **LDY** = Largest difference between scores in the same year; **LDP** = Largest difference between scores across the entire period

While SBK and AMB were the best banks in terms of minimising inputs, on the other hand our findings suggest that CAH and HLB were the worst performers with 86.3% and 88.4% overall efficiency levels and standard deviations of 0.052 and 0.062 respectively during the period. We also find that MBK and PBK exhibited improvements and upward trend in the latter part of the period, while the overall efficiency scores of AHB and RHB were relatively stable throughout the period. Our results suggest that the smaller banking groups with total assets of less than RM50 billion, exhibited the lowest efficiency score of 91.6% compared to its large (total assets of RM50 to RM100 billion) and very large counterparts overall efficiencies of 93.0% and 92.7% respectively. The very large bank, Maybank with total assets of over RM150 billion on the other hand reports slightly lower overall efficiency level compared to its large counterparts.

It is also interesting to note that the smaller banking groups were not able maintain its position throughout the period of study. Our results suggest that the small banks have outperformed its larger peers during the early period of our studies. However, it is clear from Table 3 that the large and very large banks have outperformed its smaller counterparts starting from window 3, which were marked as a period of economic crisis and windows 4 onwards, a period which has witnessed the intensification of competition in the Malaysian banking sector.

Similar to the findings by Drake and Hall (2003) on Japanese banks and Isik and Hasan (2003) on Turkish banks, which have generally found that the small banks are more susceptible to shocks compared to its larger counterparts, our findings also suggest that the small Malaysian commercial banks were generally more susceptible to exogenous shocks and intense competition.

As overall efficiency score is a composite of both pure technical and scale efficiency scores, the relative sizes of these indexes provide evidence as to the source of overall inefficiency. However, as the focus of this study is to examine the relationship between banks' overall efficiency and its share performance in the marketplace, this extension is left for another paper.

Efficiency and Malaysian Banks' Share Returns

For the purpose of this study, it is necessary to draw attention to the change in efficiency, calculated as the relative change in efficiency scores for every window in the sample of studies.

Table 5:
Malaysian Banks Summary of DEA Efficiency Scores

Windows	AHB	AMB	CAH	HLB	MBK	PBK	RHB	SBK
Window 1	89.9	98.2	82.9	95.9	86.1	83.8	90.4	94.3
Window 2	88.6	98.1	82.1	92.7	87.6	87.0	92.3	95.2
% Change	**-1.3**	**-0.1**	**-0.8**	**-3.2**	**1.5**	**3.2**	**1.9**	**0.9**
Window 2	88.6	98.1	82.1	92.7	87.6	87.0	92.3	95.2
Window 3	89.0	100.0	91.9	93.0	94.7	92.8	100.0	99.6
% Change	**0.4**	**1.9**	**9.8**	**0.3**	**7.1**	**5.8**	**7.7**	**4.4**
Window 3	89.0	100.0	91.9	93.0	94.7	92.8	100.0	99.6
Window 4	86.1	96.6	88.4	86.9	95.0	95.5	94.5	99.7
% Change	**-2.9**	**-3.4**	**-3.5**	**-6.1**	**0.3**	**2.7**	**-5.5**	**0.1**
Window 4	86.1	96.6	88.4	86.9	95.0	95.5	94.5	99.7
Window 5	85.4	96.5	86.4	83.2	94.3	93.2	92.3	99.6
% Change	**-0.7**	**-0.1**	**-2.0**	**-3.7**	**-0.7**	**-2.3**	**-2.2**	**-0.1**
Window 5	85.4	96.5	86.4	83.2	94.3	93.2	92.3	99.6
Window 6	90.0	100.0	85.2	84.2	94.2	97.2	89.6	100.0
% Change	**4.6**	**3.5**	**-1.2**	**1.0**	**-0.1**	**4.0**	**-2.7**	**0.4**
Window 6	90.0	100.0	85.2	84.2	94.2	97.2	89.6	100.0
Window 7	92.5	100.0	87.6	86.8	95.1	100.0	92.8	96.0
% Change	**2.5**	**0.0**	**2.4**	**2.6**	**0.9**	**2.8**	**3.2**	**-4.0**
Window 7	92.5	100.0	87.6	86.8	95.1	100.0	92.8	96.0
Window 8	88.3	100.0	86.0	84.3	94.8	98.7	95.1	97.8
% Change	**-4.2**	**0.0**	**-1.6**	**-2.5**	**-0.3**	**-1.3**	**2.3**	**1.8**
Mean	**(0.25)**	**0.26**	**0.44**	**(1.66)**	**1.24**	**2.13**	**0.67**	**0.5**

With the exception of AHB and HLB, which exhibited deterioration in X-efficiency of 0.25% and 1.66% respectively, it is clear from Table 5 that all percentage changes indicated improvements in X-efficiency among listed Malaysian commercial banks. It is also interesting to note that during the period of study our results indicated that on average all large Malaysian listed banks exhibited improvements in X-efficiency ranging from 0.67% to 2.13%. On the other hand, SBK was the only bank in the small banking group, which exhibited improvements in mean X-efficiency levels during the period of study. Overall, our results were similar to the findings by Chu and Lim (1998) on Singapore listed banks which suggested that the large Singapore listed banks were on average more X-efficient compared to its smaller peers.

Results of Panel Regression Analysis

Share performance may be expected to be the ultimate measure of efficiency. If bank share prices reflect almost all the information about the past, present, and expected future performance of firms, then this measure would be the more reliable indicator of bank efficiency. However, even if the choice of measures is correct, the previously described measures of efficiency may only be related to share performance in the long run. Short-term variations may not be explained by efficiency measures. In this case, individual bank's effects may explain the majority of total variations in share performance. As mentioned previously, for the purpose of this study, we believe that it is necessary to smooth the share returns by transforming a 3-year moving average share returns into a single window.

Table 6:
Window Analysis of Annual Stock Returns

	Windows								
	1	2	3	4	5	6	7	8	
Banks									Mean
AHB	17.67	-26.02	1.37	6.46	30.38	-4.55	-24.90	0.99	0.18
AMB	26.26	-39.87	-13.73	2.91	61.01	30.61	4.45	21.53	11.65
CAH	17.02	-18.68	6.11	36.22	74.50	40.68	-6.12	6.69	6.69
HLB	11.02	-25.44	-19.97	3.01	47.34	44.76	20.94	18.78	12.55
MBK	17.29	-3.36	3.93	14.93	41.78	21.17	-2.58	5.52	12.33
PBK	3.23	-15.43	10.46	19.91	41.59	21.48	7.50	24.94	14.21
RHB	17.15	-24.21	-9.54	11.81	41.93	19.74	-21.22	5.08	5.09
SBK	21.40	8.33	15.45	20.47	18.01	17.27	-15.71	15.63	12.61

The annual share return of Malaysian listed banks in Table 6 indicated that all banks have posted positive share returns over the years and five banks have exhibited more than 10 percent share returns. It is interesting to note from Table 6 that PBK, which exhibited the highest percentage change in mean X-efficiency levels of 2.13% have also reported the highest percentage change in share price of 14.21%, which corresponded positively to the change in the bank's X-efficiency levels during the period of study. On the other hand, AHB, which exhibited the lowest mean percentage change in share price during the period of study, is also among the weakest banks in our study, as the bank exhibit 0.25% deterioration in mean X-efficiency levels during the period of study. From Table 6 it is also apparent that AMB and SBK, which exhibited the highest level of mean overall efficiency level of 98.7% and 97.8% respectively, had also reported significantly positive percentage change in share prices during the period of study.

It is also surprising to note that HLB, with a mean overall efficiency score among the lowest in our sample has exhibit strong share performance despite reporting a very low mean overall efficiency score. Looking further into the trends, it is apparent that the bank's share price had been gaining momentum since window 5 onwards. One possible explanation would be the bank's proposed merger with Wah Tat Bank (WTB) during the year 1999. The proposed merger was widely expected to benefit the bank as WTB had a wide presence in the East Malaysian banking market, where HLB had little or no presence there prior to the merger. Hence, the merger is viewed positively by investors, which in turn may help to explain the bank's strong share performance during the latter part of our studies.

On the other hand, it is also interesting to note that RHB, which was among the best bank in our sample (in terms of X-efficiency), has lagged behind share performance wise. One possible explanation would be the bank's proposed merger with Utama Banking Group (UBG) in year 2001, which corresponded to window 7 in our studies, when the bank's share price had reported significant deterioration. As the price suggests, investors as well as the bank's minority shareholders were dissatisfied and were against the proposed merger plan due to valuation and pricing concerns.

To further examine whether statistical relationship exists between the X-efficiency scores derived from the DEA window analysis and listed Malaysian banks share performance, equation (2) was used by having the banks X-efficiency scores as independent variables against the banks' share returns as the dependent variable. To test for estimation robustness, we further categorised the banks into two groups; banks which are more efficient, defined by banks with DEA efficiency score of above 90 percent and the less efficient banks, defined by banks with DEA efficiency score of below 90 percent. It was expected that the efficiency scores would be positively correlated with banks' share prices. We further expected that share prices of the more X-efficient banks would perform better in the marketplace compared to the less X-efficient banks' share prices.

Table 7 presents the results from the fixed-effect estimator model. For the full sample and two other sub-samples (high and low X-efficient banks), the X-efficiency coefficients are positively and significantly explained share prices returns as expected at the 0.001 levels. It also appears that the explanatory power of the equation is relatively robust across all samples. The full sample, high X-efficient banks and low X-efficient banks explained 79%, 64% and 86% variation in share returns respectively. The higher explanatory power of the low X-efficient may be due to the fact that it has less observations which help to make the model fit reasonably well within the sample.

Table 7:
Results of Regression Analysis

	Full Sample	**High Efficiency**	**Low Efficiency**
Constant	16.78* (13.11)	14.43* (8.04)	20.19* (7.72)
X-Efficiency	3.61* (5.14)	3.57* (3.07)	2.89* (3.07)
R^2	0.79	0.64	0.86
Adjusted R^2	0.72	0.59	0.82
Observations	56	35	21

Note: * indicates significance at 1% level.
1/ High efficiency indicates banks with DEA score more than 0.90
2/ Low efficiency indicates banks with DEA score less than 0.90
3/ Numbers in parentheses indicate t-values

To further test this relationship, the reaction of changes in different X-efficiency scores on share returns was examined through the magnitudes of the coefficients that were derived from the regression. The magnitude of the coefficient of the high X-efficient banks was higher at 3.57 than the coefficient of the less X-efficient banks of 2.89, which indicated that a percentage change (improvement) in the high X-efficient banks would result in approximately 3.57% improvements in its share prices. On the other hand, our results also indicated that, a percentage change in the less X-efficient banks would result in only 2.89% in its share prices within the context of the Malaysian banking sector. Hence, our results tend to suggest that share prices to some extent react towards the higher improvement in banks' X-efficiency.

Conclusions

Utilising the non-parametric Data Envelopment Analysis (DEA) window analysis technique, we attempt to investigate the long-term trend in the efficiency change of listed Malaysian commercial banks during the period of 1994-2003. Our results suggested that during the period of study, Malaysian listed commercial banks have exhibited average overall efficiency of 92.4%. We have found that Malaysian commercial banks have exhibited the highest mean overall efficiency in window 3, which corresponded to the period of 1996, 1997, and 1998, supported by the robust growth in financial services output and buoyant domestic economy during the period.

During the period of study we found that the Malaysian commercial banks mean overall efficiency levels have deteriorated significantly in windows 4 and 5, which corresponded to the period 1997, 1998, 1999 and 1998, 1999 and 2000 respectively which could be due to the Asian Financial Crisis that struck the region in 1997/1998. In tandem with the resurgence of economic activities, credit markets returned to normal and the banks resumed its normal activities to provide loans and financing to borrowers, the Malaysian banks' mean overall efficiency has also recovered in windows 6 and 7.

The Malaysian banks' mean overall efficiency again declined in window 8, which corresponded to the years 2001, 2002 and 2003. Several factors have been identified as the cause. Firstly, Malaysian banks have just completed the mega-merger program during the period and hence would have to absorb extra capacities as well as incurred higher costs arising from systems integration, branch closures and employees laid off. Secondly, the period was marked as a period of heightened geopolitical uncertainties, which has resulted in the lowering of interest rates by the Malaysian Central Bank that subsequently led to the banks earning lower interest income. Thirdly, the period had also witnessed the intensification of competition in the Malaysian banking sector, which had resulted in further margin compression particularly among the small banks. Finally, the low interest rates environment had also prompted Malaysian corporations to tap into the capital markets to raise funds rather than going for the more traditional bank financing option. This new motivations may have resulted in the sluggish loan growth especially among the large Malaysian banks, which generally were more focused with a high concentration towards the financing of Malaysian corporations.

Our results from the decomposition of the overall efficiency into the pure technical and scale efficiency components suggest that during the period of study, Malaysian banks inefficiency could be largely attributed to pure technical (input related) rather than scale (output related). The results suggest that although Malaysian banks have been operating at the right scale of operations, they have been inefficient in controlling their costs during the period of study. We also found that the smaller Malaysian banks have exhibited the lowest mean overall efficiency compared to its larger counterparts. Despite that, our results suggest that the largest banks in our sample have exhibited lower mean overall efficiency score compared to its smaller counterparts. The results imply that during the period of study, Malaysian banks with total

assets in the range of RM50 to RM100 billion were the most scale efficient banks (CRTS), whereas Malaysian banks with total assets of below RM50 billion have the tendency to experience economies of scale (IRTS). The largest bank in our sample with total assets of over RM150 billion has consistently experienced diseconomies of scale (DRTS).

For data smoothing purposes, we have transformed a 3-year moving average share returns into a single window. The results suggest that while all Malaysian listed banks have exhibited positive share returns in all windows, 5 banks have exhibited more than 10 percent returns. We have also found that the bank with the highest percentage change in mean overall efficiency have also exhibited the highest percentage change in share prices. Likewise, the bank with the lowest percentage change in its mean overall efficiency has exhibited the smallest percentage gain in its share prices.

To further examine whether statistical relationship exists between the Malaysian banks efficiency and its share prices returns, we have further employed pool regression analysis in this paper, by combining the capital market research in accounting and banks efficiency literature to test the relationship between share performance and banks efficiency. We have further categorised Malaysian banks into two groups, namely banks with higher efficiency levels (>90 percent) and banks with lower efficiency levels (<90 percent).

The results from the fixed-effect estimator model for the full sample and the sub-samples of high and low efficient banks suggest that the efficiency coefficients are positively and significantly explained Malaysian banks' share returns as expected at 0.001 levels of significance. We have also found that that the explanatory power of the equation is relatively robust across all samples. The full sample, high efficient banks and low efficient banks explained 79%, 64% and 86% variation in share returns respectively. We have further examined the reaction of changes in different efficiency levels of Malaysian banks on its share return and found that the coefficient of high efficient banks is higher at 3.57 than the coefficient of the less efficient banks at 2.89. The results imply that a percentage change (improvements) in the more efficient banks would result in approximately 3.57% improvements in its share prices. On the other hand, our results suggest that, a percentage change in the less efficient banks would result in only 2.89% improvements in its share prices within the context of the Malaysian banking sector. Hence, our results suggest that share prices to some extent react towards the higher improvement in banks' efficiency. Our findings support earlier findings by Beccali *et al.* (2006) and Chu and Lim (1998), which suggest that efficiency to some extent reflects banks' share performance in the marketplace.

Due to its limitations, this paper can be extended in a variety of ways. It is suggested that further analysis into the investigation of X-efficiency of Malaysian banks be done to consider risk exposure factors. As to establish overall bank performance, risk exposure factors should be taken into account along with productive efficiency measures. The best bank may not necessarily be, the most efficient producer of loans, but one, which balances high efficiency with low risk assumptions. Moreover, this paper examined the intermediation functions of banks, which could be extended by considering the production function at the same time. Investigation of changes in productivity over time as a result of technical change or progress by using the Malmquist Total Factor Productivity Index could yet be another extension.

Acknowledgement

The author would like to thank the editor of the journal, the anonymous referees, the discussant and the participants at the AFA/FMA 2005 Conference for their helpful comments and suggestions.

References

Adenso-Diaz, B. and Gascon, F. (1997). Linking and Weighting Efficiency Estimates With Stock Performance in Banking Firms. *Wharton School Working Paper*, No. 97/21.

Asmild, M., Paradi, J.C., Aggarwal, V. and Schaffnit, C. (2004). Combining DEA Window Analysis with the Malmquist Index Approach in a Study of the Canadian Banking Industry. *Journal of Productivity Analysis*, 21 (1), 67-89.

Avkiran, N.K. (2002). *Productivity Analysis in the Service Sector with Data Envelopment Analysis*. Camira: N.K. Avkiran.

Avkiran, N.K. (2004). Decomposing Technical Efficiency and Window Analysis. *Studies in Economics and Finance*, 22 (1), 61-91

Ball, R. & Kothari, S.P. (1994). *Financial Statement Analysis*. New York, NY: Mc-Graw Hill.

Bank Negara Malaysia (1999). *The Central Bank and The Financial System in Malaysia – A Decade of Change*. Kuala Lumpur, MY: Bank Negara Malaysia Press.

Banker, R.D., Charnes, A. & Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science*, 30 (9), 1078-1092.

Bauer, P.W., Berger, A.N., Ferrier, G.D. & Humphrey, D.B. (1998). Consistency Conditions for Regulatory Analysis of Financial Institutions: A Comparison of Frontier Efficiency Methods. *Journal of Economics and Business*, 50 (2), 85-114.

Beccali, E., Casu, B. & Girardone, C. (2006). Efficiency and Stock Performance in European Banking. Forthcoming in *Journal of Business, Finance and Accounting.*

Berger, A.N. & Humphrey, D.B. (1997). Efficiency of Financial Institutions: International Survey and Directions for Future Research. *European Journal of Operational Research*, 98 (2), 175-212.

Berger, A.N., Hancock, D. & Humphrey, D.B. (1993). Bank Efficiency Derived from the Profit Function. *Journal of Banking and Finance*, 17 (2-3), 317-347.

Bhattacharyya, A., Lovell, C.A.K & Sahay, P. (1997). The Impact of Liberalisation on the Productive Efficiency of Indian Commercial Banks. *European Journal of Operational Research*, 98 (2), 333-346.

Charnes, A., & Cooper, W.W. (1985). Preface to Topics in Data Envelopment Analysis. *Annals of Operations Research*, 2 (6), 59-94.

Charnes, A., Cooper, W.W. & Rhodes, E. (1978). Measuring the Efficiency of Decision- Making Units. *European Journal of Operational Research*, 2 (1), 429-444.

Chu, S.F. & Lim, G.H (1998). Share Performance and Profit Efficiency of Banks in an Oligopolistic Market: Evidence from Singapore. *Journal of Multinational Financial Management*, 8 (2-3), 155-168.

Coelli, T., Rao, D.S.P. & Batesse, G. E. (1998). *An Introduction to Efficiency and Productivity Analysis*. Boston, MA: Kluwer Academic Publishers.

Cooper, W.W., Seiford. L.M. & Tone, K. (2000). *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software*. Boston, MA: Kluwer Academic Publishers.

Drake, L. and Hall, M.J.B. (2003). Efficiency in Japanese Banking: An Empirical Analysis. *Journal of Banking and Finance*, 27 (5), 891-917.

Eisenbeis, R.A., Ferrier, G.D. & Kwan, S.H. (1999). The Informativeness of Stochastic Frontier and Programming Frontier Efficiency Scores: Cost and Other Measures of Bank Holding Company Performance. *Working Paper* 99-23, Federal Reserve Bank of Atlanta.

Evanoff. D.D. & Israelvich, P.R. (1991). Productive Efficiency in Banking. *Economic Perspectives*, Federal Reserve Bank of Chicago (July/ August), 11-32.

Fama, E.F. (1976). *Foundations of Finance*. New York, NY: Basic Books.

Farrell, M.J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society A*, 120 (3), 253-281.

Fukuyama, H. (1993). Technical and Scale Efficiency of Japanese Commercial Banks: A Non-Parametric Approach. *Applied Economics*, 25 (8), 1101-1012.

Fukuyama, H. (1995). Measuring Efficiency and Productivity Growth in Japanese Banking: A Non-Parametric Approach. *Applied Financial Economics*, 5 (2), 95-107.

Gorton, G. & Rosen, R. (1996). Corporate Control, Portfolio Choice, and the Decline of Banking. *Journal of Finance*, 50 (5), 1377-1420.

Grifell–Tatje, E. & Lovell, C.A.K (1997). The Sources of Productivity Change in Spanish Banking. *European Journal of Operational Research*, 98 (2), 364-380.

Hartman, T.E. & Storbeck, J.E. (1996). Input Congestion in Loan Operations. *International Journal of Production Economics*, 46-47 (3), 413-421.

Humphrey, D.B. (1985). Cost and Scale Economies in Bank Intermediation. in: Aspinwall, R., Eisenbeis, R. (Eds.), *Handbook for Banking Strategy*. New York, NY: John Wiley and Sons.

Hsiao, C. (1989). *Analysis of Panel Data*. Cambridge, UK: Cambridge University Press.

Isik, I. & Hassan, M.K. (2003). Financial Disruption and Bank Productivity: The 1994 Experience of Turkish Banks. *The Quarterly Review of Economics and Finance*, 43 (2), 291-320.

Ito, T. & Hashimoto, Y. (2002). Bank Restructuring in Asia: Crisis Management in the Aftermath of the Asian Financial Crisis and Prospects for Crisis Prevention – Malaysia. *Discussion Paper*, Asian Development Bank.

Kane. E. & Kaufman, G.G. (1993). Incentive Conflict in Deposit Institutions Regulation: Evidence from Australia. *Pacific-Basin Finance Journal*, 1 (1), 1-17.

Kwan, S. H. & Eisenbeis, R. A. (1999). An Analysis of Inefficiencies in Banking: A Stochastic Frontier Approach. *Economic Review*, Federal Reserve Bank of San Francisco.

Lovell, C.A.K. (1993). Production Frontiers and Productive Efficiency, in *the Measurement of Productive Efficiency: Techniques and Applications*. (eds.) Fried, H.O., Lovell, C.A.K. and Schmidt S.S., New York, NY: Oxford University Press.

McAllister, P.H. & McManus, D.A. (1993). Resolving the Scale Efficiencies Puzzle in Banking. *Journal of Banking and Finance*, 17 (2-3), 389-405.

Miller, S. M. & Noulas, A. G. (1996). The Technical Efficiency of Large Bank Production. *Journal of Banking and Finance*, 20 (3), 495-509.

Parkan, C. (1987). Measuring the Efficiency of Service Operations: An Application to Bank Branches. *Engineering Costs and Production Economics*, 12 (1-4), 237-242.

Rangan, N., Grabowski, R., Aly, H.Y. & Pasurka, C. (1988). The Technical Efficiency of U.S Banks. *Economic Letters*, 28 (2), 169-175.

Reisman, A., Daouas, M., Oral, M., Rebai, S. & Gatoufi, S. (2003). Impact of Deregulation on Technical and Scale Efficiencies of Tunisian Commercial Banks: Window Extended Data Envelopment Analysis. *Working Paper*, Faculte des Sciences Economiques et de Gestion de Tunis, Universite El Manar, Tunisie.

Sealey, C. & Lindley, J.T. (1977). Inputs, Outputs and a Theory of Production and Cost at Depository Financial Institutions. *Journal of Finance*, 32 (4), 1251-1266.

Sherman, H. D. & Gold, F. (1985). Bank Branch Operating Efficiency: Evaluation with Data Envelopment Analysis. *Journal of Banking and Finance*, 9 (2), 297-315.

Webb, R. W. (2003). Levels of Efficiency in UK Retail Banks: A DEA Window Analysis. *International Journal of the Economics of Business*, 10 (3), 305-322.

Yeh, Q.J. (1996). The Application of Data Envelopment Analysis in Conjunction with Financial Ratios for Bank Performance Evaluation. *Journal of the Operational Research Society*, 47 (8), 980-988.

[1] *As pointed out by Eisenbeis et al. (1999) the ceteris paribus condition is important since cost is only one half of the profit equation and therefore does not tell the full story. For example, a bank may offer greater customer services, which while more costly, also increase revenues.*

[b] *As part of Malaysia's World Trade Organisation (WTO) commitment to further liberalised the banking sector and to give the foreign banks completely open access to the Malaysian markets by the end of 2006.*

[c] *Prior to the crisis, there were 21 commercial banks, 25 finance companies and 12 merchant banks (Bank Negara Malaysia (1999).*

[d] *For more details on Data Envelopment Analysis (DEA), see Lovell (1993), Cooper et al. (2000) and Avkiran (2002).*

[e] *Humphrey (1985) presets an extended discussion of the alternative approaches over what a bank produces.*

[f] *See Avkiran (2002) for discussion on the optimal number of inputs and outputs in DEA.*

[g] *EON Capital Berhad was not included in the analysis as the bank was listed only since 2002.*

[3] *The mean standard deviation of monthly returns for randomly selected securities is about 7.8%, while the corresponding mean standard deviation of daily returns will be approximately 1.8% if daily returns are serially independent (Fama, 1976, p p123).*