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Technical Efficiencies of Malaysian Commercial Banks: Two Stage Analysis

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ABSTRACT The purpose of this study is to investigate the efficiency of Malaysian Commercial Banks after the consolidation of the banking system. In this study, the data envelopment analysis (DEA) approach is used to measure the efficiency from 2001 to 2003. Further a Tobit regression is applied to examine the effect of factors that are beyond the control of the management on the bank efficiency. The significant factors are consolidated into the extended DEA model to reflect the true efficiency scores among the banks. The empirical findings indicate a wide diversity of efficiencies from one bank to another and also suggest that the diversity of the resources has had an influence on technical efficiency in Malaysian Commercial Banks.

ABSTRAK Tujuan kajian ini adalah bagi mengkaji tahap kecekapan bank perdagangan di Malaysia selepas penggabungan semula sistem perbankan tempatan. Di dalam kajian ini, kaedah analisis penyangkupan data (DEA) telah digunakan bagi mengukur tahap kecekapan bank dari tahun 2001 sehingga tahun 2003. Tambahan lagi, kaedah regresi Tobit turut digunakan bagi meneliti kesan faktor yang berada di luar kawalan pihak pengurusan bank bagi menentukan tahap kecekapan masing-masing. Faktor-faktor yang signifikan disatukan ke dalam model DEA lanjutan untuk mencerminkan tahap kecekapan bank yang sebenarnya. Hasil kajian empirikal menunjukkan perbezaan yang ketara dari aspek kecekapan di antara satu bank dengan bank yang lain dan juga mencadangkan bahawa perbezaan sumber mempengaruhi tahap kecekapan teknikal bank perdagangan di Malaysia.

(Technical Efficiency, DEA, Tobit Regression.)

INTRODUCTION

The Malaysian banking and capital markets have experienced unprecedented growth in the past 10 years. From 1989 to 1999, total assets in the commercial banking system grew at an average compound rate of 15% a year. Robust growth was also recorded for the capital and insurance market (Bank Negara Malaysia Annual Report 1999). The rapid development of the financial markets was achieved on the back of strong economic growth, which averaged an estimated 8.1% a year during the same period.

As part of the strategy to consolidate the banking sector, Bank Negara Malaysia, being the central bank, announced on July 29, 1999 the consolidation of the Malaysian Commercial Banking System. This resulted in the formation of only 10 core domestic commercial banks in the country from 81 in December 1998. These reforms were carried out with the aims of, firstly, improving the soundness of bank management and secondly, creating an internationally competitive banking sector. With such measures, banks will have to adjust to the needs of their customers and as the domestic market become more competitive, current differences in performance among the banks will largely determine how each bank should package itself to have a competitive advantage.

Therefore, in the increasingly harmonised Malaysian banking sector, it is important to observe, the possible differences or similarities between these commercial banks in efficiency after the consolidation of the Malaysian Banking sector. The main purpose of this study is to investigate factors affecting efficiency of Malaysian Domestic Commercial Banks. To estimate efficiency scores, the DEA method is applied to firm-level cross-sectional data from 2001 to 2003. The year 2001 is the first year after completion of bank mergers to form only 10 core commercial banks and is the initial evaluation point of the banks efficiency standings. The efficiency is decomposed into pure technical and scale efficiency.

Previous studies have investigated technical efficiency and its components covering the period before the merger (e.g., M. N. Katib [1], S. Yahya *et al.* [2]). More recently, Krishnasamy *et al.* [3] have investigated Malaysian banks post-merger productivity changes. However none of the studies have included environmental factors such as competition in their measurement of efficiency and productivity.

This paper measures and explains the technical efficiency and its components by incorporating the four largest foreign commercial banks of this country and taking into account the competitive environment. It enables more detailed understanding of the nature of technical efficiency of Malaysian Commercial Banks. This paper is organised into five sections. Following this introduction, the analytical framework is described. Next, data and their sources are described. The last two sections cover the empirical findings of this study, and conclusion.

ANALYTICAL FRAMEWORK

DEA is a linear programming technique that is used to identify technical efficiencies of DMU's and provides targets for improvement for inefficient DMU's. Charnes, Cooper and Rhodes (CCR) first introduced the Constant Return of Scale DEA model in 1978 [4].

According to Coelli, Rao and Battese [5], the constant returns to scale (CRS) DEA model is only appropriate when the firm is operating at an optimal scale. Some factors such as imperfect competition, constraints on finance, etc. may cause the firm to be not operating at an optimal level in practice. To allow for this possibility, c, Charnes and Cooper [6] introduced the variable returns to scale (VRS) DEA model. This was followed by Banker and Morey [7] and Berger and Humphrey [8] who extended the study of efficiency by controlling the differences in environmental conditions. DeYoung [9] incorporated both regulatory and economic variables directly into the cost function in order to control for differences in environmental conditions across states. Recently, Dietsch and Lozano-Vivas [10] have incorporated regulatory and economic variables for a cost efficiency comparison of the French and Spanish banking industries, using a distribution-free parametric

The environment in which a service provider operates can have an important influence on its relative performance if other providers are operating in different environments. Most of these operating environment factors are not under the control of managers, and ignoring them in assessing performance may lead to spurious results. Climate, topography, the socio-economic status of a neighbourhood, government restrictions and the degree of unionisation, for example, can affect performance, but be beyond management control. However, they could be directly included in the operating characteristic as part of the DEA calculation. This method is useful where the direction of influence of the characteristic is obvious. However, by including more variables in the analysis, the efficiency scores tend to be automatically inflated.

A two-stage procedure, which uses econometric methods to estimate the relationship between the environmental factor and the efficiency scores, could be employed. The efficiency scores obtained can be adjusted on the basis of this relationship. The advantages of this approach are that it can accommodate several factors, makes no prior assumptions about the direction of influence, and allows for tests of statistical significance something that usually is not possible in DEA studies (see [11]).

In the Malaysian banking context, Bank Negara's regulation as laid down in Section 67 of the Banking and Financial Institution Act 1989 (BAFIA), requires banking institutions to comply with the lending limits set by the central bank. This may indirectly result in the banking operators being unable to operate at the optimal scale of its operation. Therefore, technical efficiency in this study is calculated using both the input-oriented Constant Return to Scale (CRS) and variable returns to scale (VRS) DEA model. Both these models are presented as below.

Let us assume there are data available on K inputs and M outputs in each of the N decision making units (i.e., banks in our study). Input and output vectors are represented by the vectors x_i and y_i, respectively for the ith bank. The data for all banks may be denoted by the $K \times N$ input matrix (X) and $M \times N$ output matrix (Y). The envelopment form of the input-oriented CRS DEA model following CCR is specified as:

$$\min_{\theta,\lambda} \theta,$$

subject to

$$\begin{aligned} &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &\lambda \geq 0, \end{aligned} \tag{1}$$

where θ is the input technical efficiency (TE) score having a value $0 \leq \theta \leq 1$. If the θ value is equal to one, this indicates that the region is on the frontier. The vector λ is an $N \times 1$ vector of weights that defines the linear combination of the peers of the ith bank. The linear programming problem needs to be solved N times (i.e. for each decision making unit) and a value of θ is provided for each bank in the sample. The VRS DEA model is defined by adding the constraint:

$$\Sigma\lambda_i = 1. \tag{2}$$

Because the VRS DEA is more flexible and envelops the data in a tighter way than the CRS DEA, the VRS TE score is equal to or greater than the CRS or 'overall' TE score. The relationship can be used to measure scale efficiency (SE) of the ith bank as:

$$SE_i = \frac{TE_{i,CRS}}{TE_{i,VRS}} \tag{3}$$

where SE = 1 implies scale efficiency and SE < 1 indicates scale inefficiency. However, scale inefficiency can be due to the existence of either increasing or decreasing returns to scale.

The efficiency scores in this study are estimated using the computer program, Frontier Analyst [12] and PIM DEA SoftV1, developed by Thanassoulis and Emrouznejad [13].

There are two well-recognised approaches in modeling the bank behavior known as intermediation and production approach. Intermediation approach considers deposits as being able to be converted into loans (Mester, [14]). Deposits are listed as inputs because banks buy deposits and other funds to make loans and investments. Other key inputs are operating and interest costs (Athanassopoulos, [15]). The intermediation approach uses outputs measured in dollars. The alternative is the production approach where banks are accepted as using labor and capital (inputs) to generate deposits and loans (outputs). The production approach normally uses number of transactions or accounts for measuring outputs.

The DEA model in this study employs the intermediation approach (input orientation) by using two inputs (Operating Cost, and Fixed Cost) and two outputs (Interest Income and Deposit). These inputs and outputs are the traditional variables as in Berger and Humphrey [8].

Along with the variables above, three environmental variables are also being deployed, two to proxy competition (i.e. loan amount and number of bank branches) and a single dummy variable indicating the status of the bank, either local or foreign. They are all treated as non-discretionary variables in the model as they are beyond the control of the management. Typically the number and size of branches is a very effective yardstick to observe the intensity of competition (Berg *et al.* [16]).

The competition variables incorporated in the model are intended to examine the impact of factors beyond the control of management on the overall efficiency of the banks while the dummy variable was introduced as proxy for the status of the bank to investigate its effect on the efficiencies of the commercial banks. Possible differences in expertise, "know how" and even international resources are accounted for, through this inclusion of dummy variable in estimating the efficiencies.

The approach of this paper is to first run the basic DEA model (CRS) using the inputs and output variables as described in Table 1. The efficiency scores obtained are observed and compared to identify the banks that had formed the frontier line for all three years of study. Similarly, banks that had indicated continuous poor efficiency scores are also noted.

Next in order to examine the effects of uncontrollable factors on the bank efficiency level, a regression model is estimated where the level of efficiency from DEA is expressed as a function of these factors. However, as indicated in Dhungana, Nuthall and Nartea [17], the efficiency scores from DEA are limited to values between 0 and 1. That is, banks that achieved Pareto efficiency[1] always have an efficiency score of 1. Thus, the dependent variable in the regression equation cannot be expected to have a normal distribution. This suggests that the ordinary least squares regression is not appropriate. Because of this, Tobit estimation, as mentioned in Long [18], is used in this study.

The standard Tobit model (see e.g. Maddala [19]) can be defined as

$$y_i^* = x_i'\beta + \varepsilon_i, \quad \varepsilon_i \sim N(0,1) \qquad (4)$$

with the condition:

$$y_i = y_i^*, \;\; if \; y_i^* < 1$$

$$y_i = 1, \quad if \; y_i^* \geq 1.$$

The above y_i is the observable efficiency score, y_i^* is a latent variable while the dependent variable is TE_{VRS}. The Tobit model is estimated by the maximum likelihood method by assuming normally distributed errors μ_i.

Analysis of the effects of firm-specific factors on efficiency has generated considerable debate in the frontier studies. The most popular procedure is to first estimate efficiency scores and then to regress them against a set of firm-specific factors or to use nonparametric or analysis of variance (ANOVA) tests. While Kalirajan [20] and Ray [21] defended this two-step procedure, other authors (Kumbhakar *et al.* [22]; Battese and Coelli [23) challenged this approach by arguing that firm-specific factors should be incorporated directly in the estimation of the production frontier, because such factors may have a direct impact on efficiency. So with such dimension, the dependent variable, being the efficiency scores are now related with non-discretionary variables, being the uncontrollable characteristics of the banks. If these efficiently operating banks have certain common characteristics, this would allow us to identify possible causes of efficiency. The independent variables applied in the model include the amount of the competing loan, number of competing number of bank branches and a dummy variable being the main observed character of the bank being either local or foreign.

In this study, the regression model is as follows:

$$EFF = \beta_0 + \beta_1 CompLOAN + \beta_2 CompBRANCH + \beta_3 DummyStatus \qquad (5)$$

The unknown parameters, β_i, will be observed in determining its relationship and also coefficient of each β_1, β_2 and β_3. "*EFF*" represents the basic DEA efficient scores from the initial model, "*CompLOAN*" represents the amount of the competing loan amount, "*CompBRANCH*" is the number of competing number of bank branches and the "*DummyStatus*" represents the status of the banks either being local or foreign. From the Tobit output, the significant status of the independent variable could be examined; furthermore the direction of these variables could also be viewed in explaining the efficiency scores.

Finally, an extended DEA model is computed along with the non-discretionary variables and the results obtained would then reflect the true efficiency scores of the banks

DATA

The data used was obtained from the Banking Annual Reports for the years 2001 to 2003. The selected banks were all the 10 core domestic commercial banks, and four foreign commercial banks incorporated in Malaysia (HSBC Bank Malaysia Berhad, Citibank Berhad, Standard Chartered Bank Malaysia Berhad, United Overseas Bank Malaysia Berhad). The four foreign banks are predominantly the ones with the highest market capitalisation among the commercial banks in the country. The banks selected have similar economic and marketing environment resources as its local counterparts.

The inputs, outputs and environmental variables used in this study are defined as in Table 1, whilst Table 2 provides the descriptive statistics for all of the variables.

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[1] If an economic system is Pareto efficient, then it is the case that no individual can be made better off without another being made worse off. It is commonly accepted that outcomes that are not Pareto efficient are to be avoided.

Table 1. Input, output and non discretionary variables of DEA models

		Variables		**Model 1**	**Model 2**
Inputs	X1	Operating Cost	Which includes Interest Expenses, Non Interest Expenses (Establishment Cost, Marketing Cost and Administration & General Expenses) and Personal Expenses	√	√
	X2	Fixed Cost	Inclusive of all purchase of property, plant and machinery	√	√
Outputs	Y1	Total Deposits	Inclusive of Deposit from customers and Short Term Funding	√	√
	Y2	Interest Income	Includes all Dealing Securities, Investment Securities, Money at call & placement with Financial Institutions and Deposit & placement with banks and Financial Institutions	√	√
Non Discretionary	E1	Environmental Variable	- Loans amount of competing banks		√
	E2	Environmental Variable	- Number of Bank Branches of competing banks		√
	E2	Dummy Variable	-Representing 1 for foreign banks and 0 for local.		√

* The basic model (model 1) only uses the input and output variables while the extended model (model 2) includes the non-discretionary component in the model.

Table 2. Descriptive Statistics of the Input/Output and Non Discretionary Variables (Year 2001 to 2003)

	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Operating Cost (RM) mil	41.759	419.960	128.878	95.596
Fixed Cost (RM) mil	2.240	152.224	32.806	31.182
Deposit (RM) mil	593.310	9949.163	2547.292	2226.879
Interest Income (RM) mil	55.366	610.084	171.905	134.864
Competing amount of Loan (RM)	20395.628	31273.109	27674.185	2402.001
Competing Number of Bank Branches	1224	1834	1568.047	146.753

Table 3. Efficiency Scores (CRS Model) for 2001 to 2003

Commercial Banks	CRS Efficiency		
	2001	**2002**	**2003**
Maybank	64.85	83.86	73.36
BOC	53.68	80.97	72.85
RHB	61.22	75.93	78.95
PB	48.39	81.25	59.20
AMB	100.00	100.00	100.00
HLB	61.64	92.36	81.69
PAB	49.02	60.46	58.00
MPB	59.67	75.05	71.31
SB	55.99	67.46	66.78
EOB	64.65	92.88	72.51
CITIBANK	57.19	70.71	89.83
STDCHAR	63.98	89.92	100.00
HSBC	50.76	65.04	62.48
UOB	53.67	63.55	66.85

EMPIRICAL RESULTS

The efficiency scores using the basic model (CRS) excluding the non-discretionary variables are presented in Table 3.

From the CRS estimates above, only AMB Bank seems to be an efficient bank for all three years i.e. forming the bank on the frontier. However, Standard Chartered Bank also appeared to be efficient in the year 2003. Generally, the efficiency scores of 2002 show an improvement in their efficiency relatively as compared to year 2001. These efficiency scores may not reflect the true scores due to the uncontrollable factors in the production processes of the banks.

Next we regress the efficiency scores against the uncontrollable variables, the competing amount of loans, the competing number of bank branches and status of the bank to analyse the impact of the variable on the efficiency score using the Tobit Model. Table 4 presents the descriptive statistics of these variables used in the Tobit model.

Table 4. Descriptive Statistics of Tobit Regression

	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Efficiency	0.48	0.93	.6806	.12212
Amount of Competing loan (RM) mil	26.20	26.46	26.3503	.06971
Competing number of bank branches (units)	7.18	7.51	7.3600	.08198
Bank Status (units)	0.00	1.00	.3056	.46718

The Tobit regression results are summarised in Table 5. In order to investigate possible determinants of bank efficiency, the independent variables are tested at $\alpha = 0.05$ significance level with

$$H_0 : \beta_{1,2,3} = 0$$
$$H_0 : \beta_{1,2,3} \neq 0$$

where the null hypothesis indicates non-significant relationship between the independent variable used against the dependent variables while the alternate variable indicates the reverse.

Prior to the regression analysis, the data was transformed to compensate the magnitude range scales within the variables. Next the model was tested for its residuals plots and was confirmed to be normally distributed with non-extreme outliers. Similarly, there were no sign of autocorrelation and multicolinearity. Both were within the acceptable range through the Durbin-Watson and the tolerance and VIF level of collinearity statistics test. The skewness and kurtosis requirement of normality testing was also within the acceptable range, which does indicate the appropriateness of using the Tobit Model.

The results show an r-squared of 0.268 with an adjusted r-squared being 0.174. This implies that the selection of the uncontrollable variables represents approximately 27% in explained efficiency scores. Both the competition variables, LNCOMPLOAN and LNCOMBRANCH, are significant, indicating having an influence on the efficiency score. However, the dummy variable, DUMMYSTATUS, was not significant, which could indicate that it is not an important factor in determining the efficiency scores of commercial banks in Malaysia. To observe the impact of the tighter regulation of the foreign banks in operating new bank branches, an additional regression analysis was carried out excluding the foreign banks and again both the variables LNCOMPLOAN and LNCOMBRANCH were found to be significant. (Refer to Appendix 1 for results).

In analysing the Tobit output, the crucial elements that are observed are the direction of the cause of the independent variable and not the magnitude change that the independent variable could have towards the dependent variable. This direction would clearly indicate the importance of the variable and the decision in incorporating it as a non-discretionary variable in the new extended DEA model.

The competitive portion of competing bank loans indicates a positive relationship between it and the efficiency score, indicating that the smaller the loans of the bank under assessment, the better its efficiency score. It is generally understood that revenue is earned through the disbursement of loans and it is expected that capitalising on the total loans given out as compared to its peers would impact positively on in its efficiency standings. However, our results seem to indicate the opposite. This could be due to the problem of excessive nonperforming loans that could worsen the efficiency of the banks. The best evidence to that is the recent collapse of the subprime mortgage lending market in the US due to soaring mortgage delinquencies and defaults. Thus, making loans to people has to be carefully evaluated in terms of their credit history and whether they qualify for the loan.

The total number of bank branches of competing banks showed a negative relationship with the efficiency scores. This suggests banks with a large number of bank branches are able to reach out better to its clients. However, currently with a wide range of services provided by the banks via phone banking, online and internet banking, banking activities are now done with minimal physical contact between client and the bank, thus cutting costs. So the practice of having a wide spread of branches has to be effectively considered.

The results also shed some light on the effect of domestic versus foreign ownership on efficiency where it is normally presumed that banks with controlling foreign ownership are likely to be more efficient than the domestically owned counterparts because of the ability of foreign owned banks to capitalise on their access to better risk management and operational techniques, which is usually made available through their parent banks abroad. However, from the output of the Tobit regression analysis, it turns out that foreign banks are not necessarily more efficient than their local counterparts. It appears that the effects of the bank status is hardly significant which could indicate that after the consolidation of the Malaysian Banking System, local banks are moving ahead in being an internationally competitive banking sector and are almost on par with its foreign counterparts.

Next, with justifiable competition variables, both the competing loan amount, and the competing number of bank branches are now incorporated in the original DEA model as non-discretionary inputs. Table 6 shows the decomposition of the technical efficiency scores of Malaysian Commercial banks from 2001 to 2003.

Table 5. Decomposition by Tobit Regression Model^

Dependent Variable: EFFCRS
Method: ML - Censored Normal (TOBIT) (Quadratic hill climbing)
Included observations: 42
Left censoring (value) series: 0
Right censoring (value) series: 1
Convergence achieved after 4 iterations
Covariance matrix computed using second derivatives

	Coefficient	Std. Error	z-Statistic	Prob.
C	-23.78709	7.518295	-3.163895	0.0016
LNCOMPLOAN	1.175784	0.334033	3.519969	0.0004*
LNCOMPBRANCH	-0.885976	0.304944	-2.905375	0.0037*
DUMMYSTATUS	0.020254	0.040962	0.494461	0.6210
SCALE:C(5)	0.102971	0.012135	8.485285	0.0000

R-squared	0.268489	Mean dependent var	0.680556
Adjusted R-squared	0.174100	S.D. dependent var	0.122123
S.E. of regression	0.110984	Akaike info criterion	-1.430965
Sum squared resid	0.381841	Schwarz criterion	-1.211032
Log likelihood	30.75737	Hannan-Quinn criter.	-1.354202
Avg. log likelihood	0.854371		
Left censored obs	0	Right censored obs	6
Uncensored obs	36	Total obs	42

^ Using a 3 years DEA efficiency score with 36 observations after eliminating the extreme outliers

Table 6. Decomposition of Technical Efficiency Score of Malaysian Commercial Banks : Results of the extended DEA Model (Year 2001 to 2003).

Commercial Banks	2001				2002				2003			
	CRS Model	VRS Model			CRS Model	VRS Model			CRS Model	VRS Model		
	Technical Efficiency %	Pure Technical Efficiency %	Scale Efficiency %	Nature of Returns to Scale	Technical Efficiency %	Pure Technical Efficiency %	Scale Efficiency %	Nature of Returns to Scale	Technical Efficiency %	Pure Technical Efficiency %	Scale Efficiency %	Nature of Returns to Scale
Maybank	100.00	100.00	100.00	CRS	100.00	100.00	100.00	CRS	100.00	100.00	100.00	CRS
BOC	87.60	90.40	96.90	DRS	100.00	100.00	100.00	CRS	100.00	100.00	100.00	CRS
RHB	86.85	94.99	91.43	IRS	86.09	94.38	91.22	IRS	96.66	98.25	98.38	DRS
PB	69.08	100.00	69.08	IRS	88.42	98.44	89.82	IRS	71.62	82.43	86.89	DRS
AMB	100.00	100.00	100.00	CRS	100.00	100.00	100.00	CRS	100.00	100.00	100.00	CRS
HLB	62.41	63.45	98.36	DRS	100.00	100.00	100.00	CRS	93.59	98.15	95.35	IRS
PAB	58.29	70.21	83.02	DRS	63.61	66.56	95.57	DRS	61.70	61.73	99.95	DRS
MPB	72.87	93.63	77.83	IRS	80.07	91.14	87.85	IRS	72.22	72.51	99.60	DRS
SB	65.51	89.94	72.84	IRS	68.69	91.11	75.39	IRS	68.16	74.48	91.51	DRS
EOB	80.53	100.00	80.53	IRS	100.00	100.00	100.00	CRS	74.26	81.61	90.99	DRS
CITIBANK	78.82	87.10	90.49	DRS	98.24	100.00	98.24	IRS	100.00	100.00	100.00	CRS
STDCHAR	100.00	100.00	100.00	CRS	100.00	100.00	100.00	CRS	100.00	100.00	100.00	CRS
HSBC	63.66	63.76	99.84	DRS	65.96	69.44	94.99	DRS	71.26	71.40	99.80	DRS
UOB	54.27	54.64	99.32	DRS	65.32	72.60	89.97	DRS	68.82	68.82	100.00	DRS
Total												
Average	77.14%	86.29%	89.98%		86.89%	91.69%	94.50%		84.16%	86.38%	97.32%	
Standard Deviation	0.1589	0.1615	11.1713		0.1516	0.1249	7.1215		0.1534	0.1446	4.3763	
Minimum	54.27%	54.64%	69.08%		63.61%	66.56%	75.39%		61.70%	61.73%	86.89%	
No of Efficient Banks	3	5	3		6	7	6		5	5	6	

Technical, pure technical, and scale efficiency scores of the Malaysian Commercial Banks System were calculated using equations (1), (2) and (3) with the incorporation of the non-discretionary variables, i.e. the element of competition in the DEA model. With this incorporation, Table 7 shows the improvement in the efficiency scores with some bank having a huge change as compared to the others. The Basic Model scores are displayed in this table for ease of comparison.

As an initial outlook, the efficiency scores of extended models have increased for some banks as high as 36% from the basic model (STDCHAR). (These efficienct banks with 100% score form the frontier that envelops the inefficient banks within it and clearly show the relative efficiency of other banks.) Based on the results in the extended model, banks like Maybank, AMB and Standard Chartered, which are located on the frontier, are considered 100% technically efficient for all three years. The other banks are located below the production possibilities frontier and are relatively less efficient and are given a technical efficiency rating of less than 100%. These banks could become efficient by reducing their input while keeping their outputs the same, i.e. as in the input-orientated scenario (for example) in 2003, PB can produce its current output using only 71.62% of inputs using the extended DEA Model results.

Table 7. Technical Efficiency Change (CRS Model) - 2001 to 2003

	2001			2002			2003		
Commercial Banks	**Basic Model**	**Extended Model**	**Change (%)**	**Basic Model**	**Extended Model**	**Change (%)**	**Basic Model**	**Extended Model**	**Change (%)**
	CRS Efficiency %	**CRS Efficiency %**		**CRS Efficiency %**	**CRS Efficiency %**		**CRS Efficiency %**	**CRS Efficiency %**	
Maybank	64.85	100.00	35.15	83.86	100.00	16.14	73.36	100.00	26.64
BOC	53.68	87.60	33.92	80.97	100.00	19.03	72.85	100.00	27.15
RHB	61.22	86.85	25.63	75.93	86.09	10.16	78.95	96.66	17.71
PB	48.39	69.08	20.69	81.25	88.42	7.17	59.20	71.62	12.42
AMB	100.00	100.00	0.00	100.00	100.00	0.00	100.00	100.00	0.00
HLB	61.64	62.41	0.77	92.36	100.00	7.64	81.69	93.59	11.90
PAB	49.02	58.29	9.27	60.46	63.61	3.15	58.00	61.70	3.70
MPB	59.67	72.87	13.20	75.05	80.07	5.02	71.31	72.22	0.91
SB	55.99	65.51	9.52	67.46	68.69	1.23	66.78	68.16	1.38
EOB	64.65	80.53	15.88	92.88	100.00	7.12	72.51	74.26	1.75
CITIBANK	57.19	78.82	21.63	70.71	98.24	27.53	89.83	100.00	10.17
STDCHAR	63.98	100.00	36.02	89.92	100.00	10.08	100.00	100.00	0.00
HSBC	50.76	63.66	12.90	65.04	65.96	0.92	62.48	71.26	8.78
UOB	53.67	54.27	0.60	63.55	65.32	1.77	66.85	68.82	1.97
No of eff. Banks	1	3		1	6		2	5	
Max eff. score	100	100		100	100		100	100	
Min eff. score	48.39	54.27		60.46	63.61		58	61.7	
Average eff score	60.34	77.14		78.53	86.89		75.27	84.16	

Next the technical efficiency of a bank is calculated by the ratio of its distance from the origin over the distance from the origin to the point of intersection on the production possibilities frontier or the efficiency frontier where these scores could be estimated through constant returns to scale (CRS). However, often banking services production process is not linear, and thus it may be more appropriate to assume variable returns to scale (VRS). So, we estimated the DEA model assuming VRS, and the number of efficient banks from 2001 to 2003 increased to a total of 17 banks being on the frontier as compared to only 14 banks through CRS model. This is expected as VRS model envelops the data in a tighter way.

To conclude the output results, these empirical results obtained (Table 6) above suggest two important findings. First, there are significant possibilities to increase efficiency levels in Malaysian Commercial Banks. This is where the average overall technical inefficiency could be reduced by almost 23%, 13% and 16% in 2001, 2002 and 2003 respectively using the extended model. This could result in huge savings, approximately RM 5.2 million in 2003 on its inputs, which comprises both the operating cost and fixed cost, and is represented in Table 8 below.

Second, the results also indicate that the major cause of the overall technical inefficiency is pure technical inefficiency 14%, 8%, 14% in 2001, 2002 and 2003 but relatively less scale inefficiency being only 11%, 5% and 3% in 2001, 2002 and 2003, respectively. The technical efficiency here refers to the use of the productive resources available in the most technological efficient manner as possible. From results obtained it can be seen that the majority of banks reflect a departure from the best-practice bank. The only fully efficient banks are Maybank, AMB and Standard Chartered for all three years and are used as benchmark in analysing other banks. Thus, the way to eliminate the pure technical inefficiency in Malaysian Commercial Banks would be to adopt the best practices of these efficient banks.

Overall the scale inefficiency for all three years is less than 7%. However, it cannot be ignored completely. It is still worth examining factors causing variations in these scale inefficiency. In 2001 a total of the 3 scale-efficient banks displayed constant returns to scale (CRS), implying that they were operating at their most productive scale sizes. Five of the 11 scale-inefficient banks had increasing returns to scale (IRS), while the balance 6 of the banks revealed decreasing returns to scale (DRS). In order to operate at the most productive scale size (MPSS), a bank exhibiting DRS should scale down both its outputs and inputs. Similarly, if a bank is displaying IRS, it should expand both its outputs and inputs.

Another important finding, is that the spread of the scale efficiency among all the commercial banks over the period analysed (Table 6). There is a clear drop in the measurement of standard derivation among these banks. This is a positive indicator that these banks are relatively of equal size and with only a small room for expansion in term of scale efficiency.

CONCLUSIONS

An input-oriented DEA model was used for estimating overall technical, scale and pure technical, efficiencies of Malaysian Commercial Banks. Tobit regression was further employed to investigate whether non-controllable competition variables along with local or foreign status accounted for the change in these efficiency figures.

Table 8: Approximate saving in the industry inputs

	2001	2002	2003	Total
Total cost of Inputs (Operating Cost + Fixed Cost) RM (mil)	23.116	22.079	22.710	67.907
Inefficiency (%)	23	13	16	
Total Savings RM (mil)	5.316	5.078	5.223	15.618

We extended the traditional model in banking literature, including competition in the industry and found that the competition component being the non-discretionary variable in the model examined did play an important role in deciding the true efficiency scores of Malaysian banks. Omitting such component might provide misleading scores of these banks.

However, caution had to be placed when integrating the total number of banks branches of local and foreign banks in the analysis. This is due to the liberalisation regulation of the foreign banks in operating new bank branches. In this study this element was considered seriously and an additional regression analysis was carried out before concluding the appropriateness of the non discretionary variables in the two stage DEA analysis. Furthermore, during the DEA analysis it was found that nominal weights were attached to this variable as compared to the others, so it justifies maintaining the number of bank branches as part of the non-discretionary variable.

The empirical results also indicate potential for Malaysian Banks to increase efficiency levels which could result in an approximate saving of RM 16 million over the three year period of analysis in terms of industry spending on total operating cost and fixed cost. Furthermore, this also constitutes that the banks have a wide dispersion of efficiency.

Another important discovery is that domestic banks are also moving on par with foreign banks. This is an encouraging move by the domestic banks in striving to become global players in the banking industry along with its international counterparts.

APPENDIX 1

Decomposition by Tobit Regression Model (Local Commercial Banks only)

Dependent Variable: EFFCRS

Method: ML - Censored Normal (TOBIT) (Quadratic hill climbing)

Included observations: 30

Left censoring (value) series: 0

Right censoring (value) series: 1

Convergence achieved after 5 iterations

Covariance matrix computed using second derivatives

	Coefficient	Std. Error	z-Statistic	Prob.
C	-33.31733	12.73940	-2.615298	0.0089
LNCOMPLOAN	1.546089	0.572195	2.702034	0.0069*
LNCOMPBR	-0.912750	0.513209	-1.778516	0.0753*
SCALE:C(4)	0.146542	0.021944	6.678115	0.0000

R-squared	0.236662	Mean dependent var	0.719226
Adjusted R-squared	0.137096	S.D. dependent var	0.154231
S.E. of regression	0.143269	Akaike info criterion	-0.301703
Sum squared resid	0.472100	Schwarz criterion	-0.109727
Log likelihood	8.072995	Hannan-Quinn criter.	-0.244619
Avg. log likelihood	0.299000		

Left censored obs	0	Right censored obs	3
Uncensored obs	27	Total obs	30

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