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FINANCIAL DISRUPTIONS AND THE EVOLUTION OF MALAYSIAN BANKING SECTOR'S EFFICIENCY: A NON-STOCHASTIC FRONTIER APPROACH

In the mid-1990s, the East Asian countries experienced severe financial crisis, followed by deep economic downturns. A variety of methodologies have been used to explain the Asian financial crisis. However, the impact of the Asian financial crisis of 1997 on the efficiency of the financial industry has not been studied yet. This paper investigates the performance of the Malaysian banking sector around the Asian financial crisis with the emphasis on the domestic versus foreign banks debate. The efficiency estimates of individual banks are evaluated using the non-parametric Data Envelopment Analysis (DEA) method. The results suggest that the foreign banks have exhibited higher technical efficiency compared to their domestic bank counterparts. However, the results suggest also that the foreign banks were severely affected by the Asian financial crisis, implying that they are not insulated from unexpected events like the Asian financial crisis of 1997.
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1. **Introduction**

The economic costs of an occurrence of banking distress to an economy could be severe. According to estimations by the World Bank (2000), the fiscal costs of restructuring a banking sector to restore the intermediation functions effectively after a banking crisis or an occurrence of banking distress can be as large as a half of a country's annual GDP[3]. The total adverse economic impacts could be substantially higher than this estimate, given that banking distress may cause other crises, such as currency crises, which could further adversely affect the weakening economy[4]. In

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[3] World Bank (2000) estimated the recapitalization costs of banks in the four affected countries in the Asian financial crisis ranged from 10% in Malaysia to 58% in Thailand as a share of GDP.
[4] In the literature, this phenomenon is referred to as the 'twin crises'. During a banking crisis or an occurrence of banking distress, investors may re-allocate their portfolios away from domestic assets to foreign assets. A large capital outflow due to re-allocation of portfolio capital can lead to a significant run-out of foreign reserves and may encourage currency speculations.

addition, any credit tightening after an occurrence of banking distress could lead to misallocation and underutilization of funds, which could undermine the potential growth of the crisis or distress economy.

As in virtually all-emerging financial markets, banks are the dominant financial institutions in Malaysia. Banks control most of the financial flows and possess more than 70% of the banking system's total assets. Therefore, their health is very critical to the health of the general economy at large, as demonstrated in the recent financial distress experienced by the country. It is contended that the efficiency and productivity analysis can be used to assess the impact of major economic events such as economic crisis or financial liberalization on the performance of banking firms (Isik and Hassan, 2003). However, despite its severity and deep influence on both the real and financial sectors, the impact of the Asian financial crisis on the Malaysian banking sector's efficiency has not been studied yet.

The purpose of the present study is to employ the Data Envelopment Analysis (DEA) method to examine the technical, pure technical, and scale efficiencies of the Malaysian banking sector in and around the 1997 Asian financial crisis period with the emphasis on the domestic versus foreign banks' efficiency debate.

We differentiate this paper from previous ones that focus on the Malaysian banking sector and add insights in several respects discussed below. Firstly, we employ two different estimating principles. The Data Envelopment Analysis (DEA) method, which is one of the techniques we employ, is non-parametric and oriented to frontier rather than central tendency estimates (Cooper et al. 2006). Unlike the previous studies focusing on the Malaysian banking sector, the present study employs a dynamic panel of the DEA method. Isik and Hassan (2002) pointed out that the dynamic panel is more flexible and thus more appropriate than estimating a single multiyear frontier for the banks in the sample. Furthermore, it alleviates, at least to an extent, the problems related to the lack of random error in DEA by allowing an efficient bank in one year to be inefficient in another, under the assumption that the errors owing to luck or data problems are not consistent over time.

Secondly, following the more recent approach suggested by Chang et al. (2008) among others, we also use the central tendency and parametric method that are involved in fixed effects panel regression analysis to investigate the Malaysian banking sector's production efficiency while controlling for the potential effects of the contextual variables. In this way, we protect against the 'methodological bias' that can occur when only one method is used (see the exchange between Evans and Heckman (1988) and Charnes et al. (1988)).

In essence, the paper raises two important fundamental questions: 1) Did the foreign banks escaped unscathed from the Asian financial crisis? 2) What are the factors that determine banks' efficiency during the Asian financial crisis period?

The following section reviews related studies in the main literature. Section 3 describes the data, sources and model specifications employed in the study. Section

4 presents the results of the efficiency of the Malaysian banking sector by using the DEA and the panel regression techniques. Finally, we conclude in section 5.

2. Review of the Related Literature

The literature examining the efficiency of financial institutions with parametric and/or non-parametric frontier techniques has expanded rapidly in recent times. While, a large body of literature spanning a half-century exists on banking efficiency in the United States (see surveys in Berger et al. 1993; Berger and Humphrey, 1997; Berger, 2007 and references therein), more recent studies examine several other countries such as India (Ataullah and Le, 2006), Hong Kong (Drake et al. 2006), Singapore (Sufian, 2007), Greece (Pasiouras, 2008), Turkey (Isik, 2008), and Ukraine (Kyj and Isik, 2008).

Apart from focusing on various countries, these studies also examine several other issues of bank efficiency i.e. the impact of risk on bank efficiency (e.g. Drake and Hall, 2003), the impact of off-balance sheet activities on bank efficiency (e.g. Lozano-Vivas and Pasiouras, 2008), the relationship between bank efficiency and share prices (e.g. Pasiouras et al. 2008), the impact of mergers on bank efficiency (e.g. Al-Sharkas et al. 2008). The comparison of efficiency between foreign and domestic banks has also been studied extensively. Generally, the empirical evidence showed that foreign banks in developing and transition countries have succeeded in capitalizing on their advantages and exhibit a higher level of efficiency than their domestic bank peers (Bhattacharyya et al. 1997; Isik and Hassan, 2002; Ataullah and Le, 2006; Havrylchyk, 2006).

Despite substantial studies performed in regard to the efficiency of financial institutions in the U.S., Europe, and other Asia-Pacific banking industries, empirical evidence on the Malaysian banking sector is relatively scarce. By using the DEA method from 1989 to 1995, Katib and Mathews (2000) examined the characteristics of the management structure and technical efficiency of the banking industry in Malaysia. They found that on the average Malaysian banks do not efficiently combine their inputs. They suggest that over the period of observation, average technical efficiency of Malaysian banks ranged from 68.0% to 80.0%. They also suggest that most of the Malaysian commercial banks do not operate at constant returns to scale and that the technical inefficiency of Malaysian banks were attributed to scale inefficiency.

In another study on the Malaysian banking sector, Okuda and Hashimoto (2004) employed the Stochastic Cost Function approach adjusted to non-performing loans to examine the production technology of Malaysian domestic commercial banks during the period 1991 to 1997. They found that fixed costs were higher for the large banks compared to the small and medium sized banks. They suggest that economies of scale do exist for the large banks, while it was not evident for the small and medium sized banks.

By employing a non-parametric Malmquist Productivity Index (MPI) approach Isik and Hassan (2003) examined the impact of financial crisis on different aspects of the Turkish banking sector's efficiency and productivity. They find a substantial productivity loss in 1994, which was mainly due to technical regress rather than efficiency decrease. They also examine the effect of the crisis on different groups of banks operating in Turkey. The results suggest that that while foreign banks suffered the most from the crisis, public banks apparently passed through the crisis unharmed, which could be explained by their relatively low open positions in foreign exchange in the advent of the crisis and relative soundness and safety in the event of the crisis. They find that even though the crisis affected all sizes of banks dramatically, its adverse impact on small banks was overwhelming.

To the best of our knowledge, no study has been undertaken to examine the impact of the Asian financial crisis in respect of the Malaysian banking sector's experience. In the light of these knowledge gaps, this paper seeks to examine the efficiency of the Malaysian banking sector in and around the Asian financial crisis.

3. Methodology and Data Issues

3.1. Data Envelopment Analysis (DEA)

The present study employs the non-parametric frontier approach DEA first introduced by Charnes et al. (1978) (hereafter CCR model) to estimate the input-oriented technical efficiency of Malaysian banks. This approach measures the efficiency of a decision making unit (DMU) relative to other similar DMUs with the simple restriction that all DMUs lay on or below the efficiency frontier. The purpose of DEA is to empirically characterize the so-called efficient frontier (surface) based on the available set of DMUs and projects all DMUs onto this frontier. If a DMU lies on the frontier, it is referred to as an efficient unit; otherwise, it is labelled as inefficient. The data are enveloped in such a way that radial distances to the frontier are minimized.

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

Banker et al. (1984) extended the CCR model by relaxing the CRS assumption. The resulting "BCC" model is used to assess the efficiency of DMUs characterized by variable returns to scale (VRS). The VRS assumption provides the measurement of pure technical efficiency (PTE), which is the measurement of TE devoid of the 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 scale inefficiency i.e. TE = PTE x SE. The former relates to the capability of managers to utilize banks' given

resources, whereas the latter refers to exploiting scale economies by operating at a point where the production frontier exhibits CRS.

The input oriented DEA model with VRS technologies can be represented by the following linear programming problem:

$$\begin{aligned} & min_{\varphi, \lambda,} \varphi \\ \text{subject to } & -\varphi y_i, + Y\lambda, \geq 0 \\ & x_i - X\lambda \geq 0 \\ & N1' \lambda = 1 \\ \text{and} \quad & \lambda \geq 0 \end{aligned} \tag{1}$$

where λ is an N x 1 intensity vector of constants and φ is a scalar ($1 \geq \varphi \leq \infty$). $N1$ is an N x 1 vector of ones. For N number of banks, y_i and x_i are the M x N and K x N output and input vectors, respectively. Y comprises the data for all the N banks. Given a fixed level of inputs for the ith bank, the proportional increase in outputs to be achieved by the bank is indicated by $\varphi - 1$. Note that without the convexity constraint $N1' \lambda = 1$, equation (1) becomes a DEA model with CRS technology. The convexity constraint implies that an inefficient bank is benchmarked against banks of a similar size and therefore the projected point of that bank on the DEA frontier will be a convex combination of observed banks. In other words, each bank would produce on or to the right of the convex production possibility frontier. If TE scores for a particular bank with or without the convexity constraint imposed are the same, then the bank is operating under CRS. If these scores are different, the bank operates under VRS technology. However, in such a case, it would be necessary to identify whether the bank operates with increasing returns to scale (IRS) or decreasing returns to scale (DRS). To do this, assumption of non-increasing returns to scale (NIRS) is imposed in (1) and the convexity constraint $N1' \lambda = 1$ is substituted with $N1' \lambda \leq 1$. This is given as follows:

$$\begin{aligned} & min_{\varphi, \lambda,} \varphi \\ \text{subject to } & -y_i, - Y\lambda, \geq 0 \\ & \varphi x_i - X\lambda \geq 0 \\ & N1' \lambda \leq 1 \\ & \lambda \geq 0 \end{aligned} \tag{2}$$

Solution of the equation (2) reveals the nature of SE. IRS exists if TE score obtained with NIRS technology differs from the TE estimates with VRS technology. If both the efficiency scores are equal, then the corresponding bank operates with DRS.

Hauner and Kyobe (2008) pointed out that the DEA method is more adept than parametric approaches at describing frontiers as opposed to central tendencies. Instead of fitting a regression through the center of the data, DEA constructs a piecewise linear frontier that connects the efficient entities, yielding a convex production possibilities set. DEA has been widely used in efficiency measurement, particularly in services industries, because it does not require the assumption of a particular functional form, deviations from which are misinterpreted as inefficiency by parametric techniques.

However, DEA has the disadvantage that it interprets random errors as inefficiency, making it sensitive to outliers and its results tend to be sensitive to the degrees of freedom. Simar and Wilson (2007) proposed two algorithms to address some of these problems. However, as their Monte Carlo simulations yield similar results with and without the algorithms with *N*=100 and as Afonso and Aubyn (2006) also find "strikingly similar" results with and without them for *N*=25, we follow Hauner and Kyobe (2008) among others to use the more transparent traditional approach, given that *N* here is greater than 25. To avoid the effect of varying degrees of freedom across periods on the DEA scores, we calculate the efficient frontier for the pool of observations. Another issue with DEA is that the algorithm chooses the weights such that the efficiency score is maximized; if a bank is excellent in one outcome, but extremely poor in the two others, it will get an excellent score. It is thus useful to compute DEA where the weights are chosen endogenously and where the weights are exogenously imposed (Hauner and Kyobe (2008)).

3.2. Multivariate Regression Analysis

To test the relationship between the efficiency of the Malaysian banking sector and other bank specific traits and macroeconomic conditions, the following regression model is estimated:

$$\begin{aligned}\lambda_{jt} = {} & \delta_0 + \beta_1 \mathrm{LLP/TL}_{jt} + \beta_2 \mathrm{NII/TA}_{jt} + \beta_3 \mathrm{NIE/TA}_{jt} + \beta_4 \mathrm{LOANS/TA}_{jt} \\ & + \beta_5 \mathrm{LNDEPO}_{jt} + \beta_6 \mathrm{LNTA}_{jt} + \beta_7 \mathrm{EQASS}_{jt} + \beta_8 \mathrm{ROA}_{jt} \\ & + \zeta_1 \mathrm{LNGDP}_t + \zeta_2 \mathrm{INFL}_t \\ & + \varepsilon_{jt} \\ & \varepsilon_{it} = v_{it} + u_{it}\end{aligned} \tag{3}$$

where

λ_{jt} = technical, pure technical, and scale efficiencies of the *j*th bank in period *t* obtained from the DEA method;

$\mathrm{LLP/TL}_{jt}$ = loan loss provisions over total loans;

$\mathrm{NII/TA}_{jt}$ = non-interest income over total assets;

$\mathrm{NIE/TA}_{jt}$ = non-interest expense over total assets;

$\mathrm{LOANS/TA}_{jt}$ = total loans over total assets;

LNDEPO_{jt} = natural logarithm of total deposits;

LNTA_{jt} = natural logarithm of total assets;

EQASS_{jt} = total book value of shareholders equity over total assets;

ROA_{jt} = profit after tax divided by total assets;

$LNGDP_t$ = natural logarithm of gross domestic products;

$INFL_t$ = the rate of inflation;

ε = the disturbance term, with v_{it} capturing the unobserved bank specific effect and u_{it} is the idiosyncratic error and is independently identically distributed (i.i.d), $e_{it} \sim N(0,\sigma^2)$.

Eq. (3) is estimated through a fixed effects regression taking each bank's technical, pure technical, and scale efficiencies derived from the DEA as the dependent variable. The opportunity to use a fixed effects rather than a random effects model has been tested with the Hausman test. As suggested by McDonald (2009) we estimate Eq. (3) by using White's (1980) transformation to control for cross section heteroscedasticity of the variables. In an influential development, McDonald (2009) points out that if White (1980) heteroskedastic consistent standard errors are calculated, large sample tests can be performed which are robust to heteroskedasticity and the distribution of the disturbances in the second stage regression analysis involving DEA scores as the dependent variable.

The independent variables and their hypothesized relationship with bank efficiency are detailed in Table 1.

Table 1

Descriptive of the Variables Used for the Panel Fixed Effects Regression Models

Explanatory Variables	Description	Hypothesized Relationship with Efficiency
Bank Characteristics		
LLP/TL	Loan loss provisions over total loans	-
NII/TA	Non-interest income over total assets	+
NIE/TA	Non-interest expense over total assets	-
LOANS/TA	Total loans over total assets	+/-
LNDEPO	Natural logarithm of total deposits	+/-
LNTA	Natural logarithm of total assets	+/-
EQUITY/TA	Total book value of shareholders equity over total assets	+/-
ROA	Profit after tax divided by total assets	+
Economic Conditions		
LOGGDP	Natural logarithm of gross domestic products	+/-
INFL	The rate of inflation	+

3.3. Data

This paper uses data of banks operating in Malaysia during the period 1995-1999. Our source of data is the balance sheets of the respective banks for the years included. The total number of banks operating in Malaysia varied from 38 in 1995, 36 in 1996, and 33 in 1997, 1998, and 1999. The number of observations varied across time due to bank entry and exit during the years. This gives us a total of 171

bank year observations, which represents 100% of the banks operating in Malaysia during the period.

Table 2

Summary Statistics of the Variables Employed in the DEA Model (in billion of Ringgit)*

	Domestic		Foreign	
	Mean	S.D.	Mean	S.D.
Outputs				
1995				
Total Loans (y1)	6,698,619.36	10,764,078.09	3,074,048.64	3,045,451.19
Investments (y2)	2,164,237.82	4,145,746.47	748,109.07	927,110.46
1996				
Total Loans (y1)	8,777,875.91	12,289,630.21	3,678,635.64	3,771,251.40
Investments (y2)	2,633,861.95	4,128,688.09	1,152,298.93	1,250,438.52
1997				
Total Loans (y1)	10,653,761.35	14,483,251.96	4,808,010.00	4,945,479.99
Investments (y2)	3,192,063.90	5,216,868.65	1,526,211.15	1,672,466.02
1998				
Total Loans (y1)	12,837,021.75	17,465,110.83	4,866,902.62	5,117,604.04
Investments (y2)	3,839,504.45	5,678,962.98	1,454,305.00	1,699,703.81
1999				
Total Loans (y1)	12,950,538.40	17,567,260.76	4,763,643.77	4,793,420.95
Investments (y2)	3,361,879.60	5,762,771.47	2,290,445.62	4,436,039.60
Inputs				
1995				
Total Deposits (x1)	9,471,984.95	14,879,614.66	3,587,924.64	3,771,896.61
Fixed Assets (x2)	131,178.77	223,717.65	48,696.29	71,095.88
Labour (x3)	98,752.05	150,485.51	40,207.43	49,839.10
1996				
Total Deposits (x1)	11,572,336.64	16,480,767.31	4,267,051.00	4,442,634.90
Fixed Assets (x2)	158,827.14	243,529.91	57,354.00	74,200.74
Labour (x3)	112,776.59	166,875.62	44,237.36	54,591.69
1997				
Total Deposits (x1)	14,488,070.90	20,297,632.11	5,989,143.46	6,283,218.28
Fixed Assets (x2)	173,267.60	247,950.17	68,670.46	91,059.41
Labour (x3)	134,415.45	199,030.46	55,126.77	63,484.75
1998				
Total Deposits (x1)	16,321,158.45	21,224,855.54	5,737,325.92	6,214,965.73
Fixed Assets (x2)	210,005.50	267,746.10	90,889.31	102,827.52
Labour (x3)	149,909.70	201,552.02	62,224.15	70,687.09
1999				
Total Deposits (x1)	17,366,798.65	22,747,379.77	6,021,941.46	6,453,176.25
Fixed Assets (x2)	235,803.00	295,186.97	77,518.00	100,859.53
Labour (x3)	125,891.65	165,466.51	67,236.92	80,222.68

* The table presents mean and standard deviation of Malaysian banks input and output variables used to construct the DEA efficiency frontier during the period 1995, 1996, 1997, 1998 and 1999, respectively. Domestic and foreign denotes domestic banks and foreign banks respectively.
Source: Individual Banks Annual Reports.

As in most recent studies, (e.g. Pasiouras, 2008), we adopt the intermediation approach. Malaysian banks are regarded as intermediary between savers and

borrowers, producing two outputs namely, *Total Loans* (*y1*), which include loans to customers and other banks and *Investments* (*y2*), which include investment securities held for trading, investment securities available for sale (AFS), and investment securities held to maturity. In performing its functions, we assume banks employ three inputs, namely, *Total Deposits* (*x1*), which include deposits from customers and other banks, *Capital* (*x2*), measured as the book value of property, plant, and equipment, and *Labour* (*x3*), which is inclusive of total expenditures on employees such as salaries, employee benefits and reserve for retirement pay.[5]

Table 2 presents the summary statistics of the output and input variables used to construct the efficiency frontiers. It is observed that during the earlier period of study, the domestic banks were almost three times larger (in terms of asset size), commands higher market share, have greater intensity towards loans financing, and employed more personnel relative to their foreign bank peers. However, after the Asian financial crisis, the foreign banks seem to have shifted their focus towards investments activities rather than the more traditional loans based financing relative to their domestic bank peers. It is also clear that the difference in the investments amount between the domestic and foreign banks have significantly reduced to only 1.47 times in 1999 compared to 2.89 times during the pre-crisis period.

4. Rresults and Discussion

4.1. Efficiency of the Malaysian Banking Sector around the Asian Financial Crisis

The results of the foreign and domestic banks derived from a common frontier are presented in Table 3.[6] The results seem to suggest that Malaysian banks mean TE has been on an increasing trend during the earlier part of the studies, before declining during the latter years. The decomposition of TE into its mutually exhaustive components of PTE and SE suggest that scale inefficiency outweighs pure technical inefficiency of Malaysian banks during all years. Overall, the results seem to imply that Malaysian banks have been inefficient in exploiting economies of scale given their scale of operations.

[5] As data on the number of employees are not readily made available, personnel expenses have been used as a proxy measure.

[6] Following the procedures outlined in Isik and Hassan (2002) among others, a series of parametric (ANOVA and *t*-test) and non-parametric (Kolmogorov-Smirnov, Mann-Whitney [Wilcoxon Rank-Sum]), and Kruskal-Wallis tests are performed to test the null hypothesis of identical frontiers between the foreign and domestic banks. In general, both the parametric and non-parametric tests statistics failed to reject the null hypothesis at the 5% levels of significance that the foreign and domestic banks are drawn from the same population and have identical technologies, implying that there is no significant difference between the foreign and domestic banks' efficiency (frontiers). The results imply that we could assume the variances among the foreign and domestic banks to be equal and it is appropriate to construct common frontiers by pooling data on both the foreign and domestic banks. For brevity purposes, the results are not reported in this paper, but are available upon request.

Table 3

Summary Statistics of Efficiency Scores*

Banks	N		Mean		Minimum		Maximum		Std. Dev.	
	DB	FB	DB	FB	DB	FB	DB	FB	DB	FB
Panel A: 1995										
Technical Efficiency	22	14	0.456	0.617	0.135	0.345	1.000	1.000	0.207	0.210
Pure Technical Efficiency			0.747	0.844	0.141	0.570	1.000	1.000	0.242	0.134
Scale Efficiency			0.621	0.733	0.395	0.400	1.000	1.000	0.167	0.203
Panel B: 1996										
Technical Efficiency	23	14	0.481	0.568	0.307	0.370	1.000	1.000	0.190	0.210
Pure Technical Efficiency			0.838	0.844	0.502	0.562	1.000	1.000	0.137	0.150
Scale Efficiency			0.574	0.682	0.388	0.392	1.000	1.000	0.189	0.224
Panel C: 1997										
Technical Efficiency	20	13	0.542	0.614	0.371	0.402	1.000	1.000	0.164	0.198
Pure Technical Efficiency			0.877	0.895	0.643	0.652	1.000	1.000	0.111	0.121
Scale Efficiency			0.616	0.687	0.457	0.402	1.000	1.000	0.156	0.187
Panel D: 1998										
Technical Efficiency	20	13	0.536	0.584	0.379	0.339	0.965	1.000	0.153	0.252
Pure Technical Efficiency			0.856	0.811	0.614	0.421	1.000	1.000	0.125	0.211
Scale Efficiency			0.625	0.721	0.448	0.432	0.965	1.000	0.141	0.202
Panel E: 1999										
Technical Efficiency	20	13	0.339	0.310	0.149	0.107	0.640	1.000	0.140	0.233
Pure Technical Efficiency			0.762	0.754	0.303	0.245	1.000	1.000	0.211	0.263
Scale Efficiency			0.451	0.435	0.251	0.141	0.703	1.000	0.129	0.276
Panel F: Pre-Crisis (1995-1996)										
Technical Efficiency			0.468	0.592	1.000	1.000	0.135	0.345	0.197	0.208
Pure Technical Efficiency			0.792	0.844	1.000	1.000	0.141	0.562	0.200	0.140
Scale Efficiency			0.598	0.707	1.000	1.000	0.388	0.392	0.178	0.211
Panel G: Crisis (1997)										
Technical Efficiency			0.542	0.614	1.000	1.000	0.371	0.402	0.164	0.198
Pure Technical Efficiency			0.877	0.895	1.000	1.000	0.643	0.652	0.111	0.121
Scale Efficiency			0.616	0.687	1.000	1.000	0.457	0.402	0.156	0.187
Panel H: Post-Crisis (1998-1999)										
Technical Efficiency			0.437	0.447	0.965	1.000	0.149	0.107	0.176	0.275
Pure Technical Efficiency			0.809	0.782	1.000	1.000	0.303	0.245	0.178	0.235
Scale Efficiency			0.538	0.578	0.965	1.000	0.251	0.141	0.160	0.278

* The table presents mean, minimum, maximum, and standard deviation of Malaysian banks technical efficiency (TE) scores derived from DEA, along with its mutually exhaustive components of pure technical efficiency (PTE) and scale efficiency (SE). Panel A, B, C, D, and E shows the mean, minimum, maximum, and standard deviation of domestic banks (DB) and foreign banks (FB) TE, PTE, and SE for the years 1996, 1997, 1998, and 1999, respectively. Panel F, G and H presents the TE, PTE, and SE scores of DB and FB mean, minimum, maximum, and standard deviation, during the pre-, during, and post-crisis periods respectively. The TE, PTE, and SE scores are bounded between 0 and 1.

From Table 3 it is observed that the mean TE of the domestic banks between 1995 and 1999 was 47.0%. Relative to their cost frontier, the domestic banks operate efficiently with actual costs ranging from 45.8% to 66.1% above the minimum costs levels. As to the TE in each year, we then find that it was 45.6% in 1995, increasing to 48.1% and 54.2% in 1996 and 1997 respectively, followed by a gentle decline to

53.6% in 1998, before declining sharply to 33.9% in 1999. It is also clear that the average TE declined slightly in 1998 relative to 1997, a year after the Asian financial turmoil hit the Malaysian banking industry, before declining abruptly in 1999. The results seem to suggest that the domestic banks' TE score of 46.8% during the period of 1995-1996 was higher than that during the period 1998-1999 at 43.7%. Similar results can be found when the SE scores are analyzed. The SE score of 59.8% in 1995-1996 i.e. before the Asian financial crisis was also higher than the 53.8% score during the period of 1998-1999 i.e. after the Asian financial crisis. On the other hand, the PTE score of 79.2% in 1995-1996 was lower than the 80.9% recorded over the period of 1998-1999.

Likewise, from Table 3 it is observed that the mean TE of the foreign banks between 1995 and 1999 was 54.0%. Relative to their cost frontier, the foreign banks operate efficiently with actual costs ranging from 38.3% to 69.0% above the minimum costs levels. As to the TE in each year, we then find that it was 61.7% in 1995, declining to 56.8% in 1996, increased again in 1997 to 61.4%, followed by a decline to 58.4% in 1998, before declining steeply in 1999 to 31.0%. It is clear that average TE declined slightly in 1998 relative to 1997, a year after the Asian financial crisis, before declining dramatically in 1999. The results seem to suggest that the foreign banks' TE score of 59.2% during the period of 1995-1996 was higher than that during the period 1998-1999 at 44.7%. Unlike their domestic bank counterparts, the foreign banks seem to have exhibited higher PTE score of 84.4% in 1995-1996, than the 78.2% over the period of 1998-1999, whilst the SE score of 70.7% in 1995-1996 was also higher than the 57.8% score during the period of 1998-1999.

The results also seem to suggest that the mean SE scores of banks were lower than the mean PTE score during the 1995-1999 period. Similar results can be found when periods of data are used for 1995-1996 and 1998-1999, with the respective mean PTE scores of the domestic banks (79.2%, 80.9%) being higher than the respective mean SE scores (59.8%, 53.8%). Likewise, the respective mean PTE scores of the foreign banks (84.4%, 78.2%) were also higher than the respective mean SE scores (70.7%, 78.2%). This seems to suggest that scale inefficiency has greater significance than pure technical inefficiency as a source of inefficiency within all inefficient banks. Thus, given input prices, the effects on technical inefficiency could be attributed to the under utilization of inputs, rather than managerial best practice.

Interestingly, the empirical findings seem to suggest that the foreign banks to be the hardest hit by the Asian financial crisis. This come as a surprise as earlier findings by among others Berger et al. (2005) found that foreign owned banks from developed nations in developing countries may have access to superior technologies, particular information technologies for collecting and assessing "hard" quantitative information. Thus, the findings from this study suggest that although the foreign owned bank in general have been relatively more efficient compared to their domestic bank peers, they may not be insulated from unexpected events like the Asian financial crisis in 1997.

Table 4

Composition of Production Frontiers*

Bank	*Type*	1995	1996	1997	1998	1999	Count
Affin Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Alliance Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Arab-Malaysian Bank Berhad	DB	CRS	DRS	CRS	DRS	DRS	2
Ban Hin Lee Bank	DB	DRS	DRS	DRS	DRS	DRS	0
Bank Bumiputra Malaysia Berhad	DB	DRS	DRS	DRS	DRS		0
Bank of Commerce Berhad	DB	DRS	DRS	DRS	DRS		0
Bank Utama (M) Berhad	DB	DRS	DRS	DRS		DRS	0
BSN Commercial Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Bumiputra-Commerce Bank Berhad	DB					DRS	0
EON Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Hock Hua Bank (Sabah) Berhad	DB	IRS	IRS	IRS	IRS	IRS	0
Hock Hua Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Hong Leong Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Kwong Yik Bank Berhad	DB	IRS	DRS				0
Maybank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Oriental Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Phileo Allied Bank (M) Berhad	DB	IRS	DRS	DRS	DRS	DRS	0
Public Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
RHB Bank Berhad	DB	DRS	DRS		DRS	DRS	0
Sabah Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Southern Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
The Pacific Bank Berhad	DB	DRS	DRS	DRS	DRS	DRS	0
Wah Tat Bank Berhad	DB	IRS	CRS	IRS	IRS	IRS	1
ABN-AMRO Bank (M) Berhad	FB	DRS	DRS	DRS	DRS	IRS	0
Bangkok Bank (M) Berhad	FB	IRS	IRS	IRS	IRS	IRS	0
Bank of America (M) Berhad	FB	DRS	IRS	DRS	IRS	IRS	0
Bank of Nova Scotia (M) Berhad	FB	CRS	CRS	CRS	CRS	CRS	5
Chung Kiaw Bank Berhad	FB	DRS	DRS				0
Bank of Tokyo (M) Berhad	FB	DRS	DRS	DRS	DRS	DRS	0
Citibank (M) Berhad	FB	DRS	DRS	DRS	DRS	DRS	0
Deutsche Bank (M) Berhad	FB	DRS	DRS	DRS	IRS	IRS	0
Hongkong Bank (M) Berhad	FB	DRS	DRS	DRS	DRS	DRS	0
JP Morgan Chase (M) Berhad	FB	IRS	IRS	IRS	IRS	IRS	0
OCBC Bank (M) Berhad	FB	DRS	DRS	DRS	DRS	DRS	0
OUB Bank (M) Berhad	FB	CRS	CRS	CRS	CRS	DRS	4
Standard Chartered Bank (M) Berhad	FB	DRS	DRS	DRS	DRS	DRS	0
UOB Bank (M) Berhad	FB	DRS	DRS	DRS	DRS	DRS	0
Number of Banks		3	3	3	2	1	

* The table shows the evolution of returns to scale in the Malaysian banking sector during the period 1995-1999. *CRS*, *DRS,* and *IRS* denote constant returns to scale, decreasing returns to scale and increasing returns to scale respectively. *DB* indicates domestic banks; *FB* indicates foreign banks. *Count* denotes the number of times a bank appeared on the efficiency frontier during the period of study. The banks corresponds to the shaded regions have not been efficient in any year in the sample period compared to the other banks in the sample.

Since the dominant source of total technical (in) efficiency in the Malaysian banking sector seems to be scale related, it is worth further examining the trend in the returns to scale of the Malaysian banks. Table 4 shows the composition of banks that lie on the efficiency frontier. The composition of the efficiency frontier suggests that the number of banks that span the efficiency frontier varies between one to three banks. During the period under study, foreign banks seem to have dominated the efficiency frontier. It is apparent from Table 4 that two foreign banks namely, Bank of Nova

Scotia and OUB Bank appeared to be the global leaders i.e. have appeared the most times on the efficiency frontier. The results seem to suggest that only two domestic and two foreign banks have managed to appear on the frontier, while 21 domestic and 12 foreign banks have never made it to the efficiency frontier throughout the period under study.

Overall, the results seem to suggest that in the case of the Malaysian banking sector, technical inefficiency has much more to do with the scale of production rather than the inefficient utilization of resources. The dominant effect of the scale inefficiency indicates that most of Malaysian banks have been operating at the 'incorrect' scale of operations. They either experience economies of scale (i.e. (IRS)) due to being at less than the optimum size, or diseconomies of scale (i.e. (DRS)) due to being at more than the optimum size. Thus, decreasing or increasing the scale of production could result in cost savings or efficiencies. It is worth highlighting that the scale inefficiency due to IRS may be attributed to small banks, whereas, the scale inefficiency due to DRS may be related to the large banks (Miller and Noulas, 1996; Noulas et al. 1990).

The composition of the efficiency frontier shows that the majority of Malaysian banks, particularly the domestic ones, have experienced diseconomies of scale (operating at DRS), ranging from 75.0% to 80.6%, suggesting the extra production costs faced by the rapidly growing domestic banks. The share of scale efficient banks i.e. operating at CRS declined from 8.3% in 1995 to 3.0% in 1999, signalling worsening scale efficiency over time. On the other hand, the share of banks experiencing economies of scale (operating at IRS) rose from 16.7% in 1995 to 21.2% in 1999, which was mainly attributed to the foreign banks.

4.2. The Determinants of Banks' Efficiency

The stepwise regression results focusing on the relationship between bank technical, pure technical, and scale efficiencies and the explanatory variables are presented in Tables 5, 6, and 7 respectively. Several general comments regarding the test results are warranted. The model performs reasonably well in at least two respects. Firstly, the overall fit of the model measured by the level of R^2s are reasonably high ranging between 56.2% to 65.8%, which indicates that these models are quite well specified. Secondly, the *F*-statistics for all models is significant at the 1% level.

It is observed from column 1 of Table 5 that the coefficient of the LLP/TL variable has a negative relationship with Malaysian banks' TE, indicating increase in inefficiency. The results imply that Malaysian banks should focus more on credit risk management, which has been proven problematic in the recent past. Serious banking problems have arisen from the failure of banks to recognize impaired assets and create reserves for writing off these assets. An immense help towards smoothing these anomalies would be provided by improving the transparency of the financial system, which in turn will assist banks to evaluate credit risk more effectively and avoid problems associated with hazardous exposure.

Table 5

Panel Fixed Effects Regression Results – Technical Efficiency

	Technical Efficiency										
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
CONSTANT	0.509*** (15.149)	0.533*** (15.113)	0.599*** (12.317)	0.109 (0.915)	1.295 (1.139)	0.808 (0.668)	0.584*** (11.696)	0.493*** (12.589)	6.178 (0.919)	0.381*** (2.886)	2.649 (0.447)
Bank Characteristics											
LLP/TL	-0.562* (-1.687)	-	-	-	-	-	-	-	-	-	-0.311 (-0.803)
NII/TA	-	-3.456 (-1.520)	-	-	-	-	-	-	-	-	-2.047 (-0.616)
NIE/TA	-	-	-6.458* (-1.886)	-	-	-	-	-	-	-	-7.729** (-2.272)
LOANS/TA	-	-	-	0.630*** (4.210)	-	-	-	-	-	-	0.386* (1.765)
LNDEPO	-	-	-	-	-0.052 (-0.681)	-	-	-	-	-	-0.221*** (-2.856)
LNTA	-	-	-	-	-	-0.019 (-0.250)	-	-	-	-	0.175 (1.308)
EQASS	-	-	-	-	-	-	-0.976*** (-3.383)	-	-	-	-1.001** (-2.341)
ROA	-	-	-	-	-	-	-	0.005 (0.811)	-	-	0.012 (1.487)
Economic Conditions											
LNGDP	-	-	-	-	-	-	-	-	-0.527 (-0.841)	-	-0.153 (-0.253)
INFL	-	-	-	-	-	-	-	-	-	0.033 (1.109)	0.041 (1.368)
No. of Observations	171	171	171	171	171	171	171	171	171	171	171
R^2	0.586	0.579	0.584	0.611	0.581	0.576	0.585	0.576	0.597	0.598	0.683
Adj. R^2	0.471	0.462	0.469	0.503	0.465	0.458	0.470	0.458	0.486	0.487	0.566
Durbin Watson Statistics	2.292	2.207	2.306	2.193	2.205	2.173	2.208	2.192	2.136	2.092	2.578
F-Statistics	5.097***	4.946***	5.066***	5.654***	4.998***	4.890***	5.086***	4.894***	5.344***	5.363***	5.825***

$\lambda_{ijt} = \delta_0 + \beta_1 \text{LLP/TL} + \beta_2 \text{NII/TA} + \beta_3 \text{NIE/TA} + \beta_4 \text{LOANS/TA}; + \beta_5 \text{LNDEPO} + \beta_6 \text{LNTA} + \beta_7 \text{EQASS} + \beta_8 \text{ROA}; + \zeta_9 \text{LNGDP} + \zeta_{10} \text{INFL}; + \varepsilon_j$

The dependent variables are bank's technical efficiency score derived from the DEA. LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans. NII/TA is a measure of bank's diversification towards non-interest income, calculated as total non-interest income divided by total assets. NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets. LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets. LNDEPO is a measure of bank's market share calculated as a natural logarithm of total bank deposits. LNTA is the size of the bank's total asset measured as the natural logarithm of total bank assets. EQASS is a measure of banks capitalization measured by banks total shareholders equity divided by total assets. ROA is return on assets calculated as profit after tax divided by total assets. LNGDP is natural logarithm of gross domestic product. INFL is the rate of inflation.

Values in parentheses are standard errors. w

***, **, and * indicate significance at 1, 5 and 10% levels.

Table 6

Panel Fixed Effects Regression Results – Pure Technical Efficiency

	Pure Technical Efficiency										
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
CONSTANT	0.831*** (42.534)	0.873*** (48.326)	0.928*** (20.409)	0.365*** (4.208)	0.848 (1.363)	0.266 (0.417)	0.876*** (22.786)	0.832*** (45.590)	-0.781 (-0.231)	0.809*** (14.313)	-2.982 (-0.946)
Bank Characteristics											
LLP/TL	-0.521 (-1.027)	-	-	-	-	-	-	-	-	-	-0.293 (-0.842)
NII/TA	-	-5.145*** (-6.486)	-	-	-	-	-	-	-	-	-1.303 (-1.488)
NIE/TA	-	-	-6.826*** (-2.815)	-	-	-	-	-	-	-	-5.475** (-2.448)
LOANS/TA	-	-	-	0.738*** (4.914)	-	-	-	-	-	-	0.727*** (10.898)
LNDEPO	-	-	-	-	-0.001 (-0.043)	-	-	-	-	-	-0.244*** (-3.827)
LNTA	-	-	-	-	-	0.035 (0.850)	-	-	-	-	0.209* (1.902)
EQASS	-	-	-	-	-	-	-0.622* (-1.889)	-	-	-	0.306 (0.645)
ROA	-	-	-	-	-	-	-	-0.013*** (-4.520)	-	-	-0.021*** (-2.965)
Economic Conditions											
LNGDP	-	-	-	-	-	-	-	-	0.148 (0.473)	-	0.361 (1.040)
INFL	-	-	-	-	-	-	-	-	-	0.003 (0.253)	0.008 (0.576)
No. of Observations	171	171	171	171	171	171	171	171	171	171	171
R^2	0.574	0.572	0.576	0.629	0.561	0.565	0.567	0.570	0.564	0.562	0.689
Adj. R^2	0.456	0.453	0.458	0.526	0.440	0.444	0.447	0.451	0.443	0.440	0.574
Durbin Watson Statistics	2.175	2.247	2.253	2.131	2.163	2.144	2.174	2.173	2.156	2.163	2.379
F-Statistics	4.859***	4.817***	4.890***	6.115***	4.610***	4.672***	4.720***	4.779***	4.656***	4.615***	5.984***

$\lambda_{jt} = \delta_0 + \beta_1$LLP/TL + β_2NII/TA + β_3NIE/TA + β_4LOANS/TA; + β_5LNDEPO + β_6LNTA + β_7 EQASS + β_8ROA; + ζ_9LNGDP + ζ_{10}INFL; + ε_j

The dependent variables are bank's technical efficiency score derived from the DEA. LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans. NII/TA is a measure of bank's diversification towards non-interest income, calculated as total non-interest income divided by total assets. NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets. LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets. LNDEPO is a measure of bank's market share calculated as a natural logarithm of total bank deposits. LNTA is the size of the bank's total asset measured as the natural logarithm of total bank assets. EQASS is a measure of banks capitalization measured by banks total shareholders equity divided by total assets. ROA is return on assets calculated as profit after tax divided by total assets. LNGDP is natural logarithm of gross domestic product. INFL is the rate of inflation.

Values in parentheses are standard errors.

***, **, and * indicate significance at 1, 5 and 10% levels.

Table 7

Panel Fixed Effects Regression Results – Scale Efficiency

	Scale Efficiency										
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
CONSTANT	0.607*** (19.039)	0.610*** (15.409)	0.661*** (15.980)	0.508** (2.328)	1.533* (1.609)	1.304 (1.454)	0.678*** (13.769)	0.595*** (15.541)	8.935* (1.616)	0.471*** (4.014)	6.734 (1.414)
Bank Characteristics											
LLP/TL	0.010 (0.039)	-	-	-	-	-	-	-	-	-	0.245 (0.528)
NII/TA	-	-0.282 (-0.088)	-	-	-	-	-	-	-	-	-1.220 (-0.324)
NIE/TA	-	-	-3.449 (-0.897)	-	-	-	-	-	-	-	-6.768** (-1.993)
LOANS/TA	-	-	-	0.160 (0.495)	-	-	-	-	-	-	-0.026 (-0.095)
LNDEPO	-	-	-	-	-0.060 (-0.940)	-	-	-	-	-	-0.106 (-1.019)
LNTA	-	-	-	-	-	-0.044 (-0.751)	-	-	-	-	0.081 (0.863)
EQASS	-	-	-	-	-	-	-0.800** (-1.995)	-	-	-	-1.439*** (-5.291)
ROA	-	-	-	-	-	-	-	0.013** (2.078)	-	-	0.032*** (3.730)
Economic Conditions											
LNGDP	-	-	-	-	-	-	-	-	-0.772 (-1.500)	-	-0.525 (-1.128)
INFL	-	-	-	-	-	-	-	-	-	0.039 (1.467)	0.038 (1.631)
No. of Observations	171	171	171	171	171	171	171	171	171	171	171
R^2	0.578	0.578	0.580	0.580	0.586	0.582	0.585	0.585	0.630	0.612	0.692
Adj. R^2	0.460	0.460	0.464	0.463	0.472	0.465	0.470	0.469	0.527	0.504	0.578
Durbin Watson Statistics	2.187	2.194	2.264	2.213	2.217	2.196	2.238	2.281	2.096	2.054	2.436
F-Statistics	4.923***	4.924***	4.983***	4.97***	5.10***	5.006***	5.079***	5.072***	6.130***	5.685***	6.077***

$\lambda_{jt} = \delta_0 + \beta_1 \text{LLP/TL} + \beta_2 \text{NII/TA} + \beta_3 \text{NIE/TA} + \beta_4 \text{LOANS/TA}; + \beta_5 \text{LNDEPO} + \beta_6 \text{LNTA} + \beta_7 \text{ EQASS} + \beta_8 \text{ROA}; + \zeta_9 \text{LNGDP} + \zeta_{10} \text{INFL}; + \varepsilon_j$

The dependent variables are bank's technical efficiency score derived from the DEA. LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans. NII/TA is a measure of bank's diversification towards non-interest income, calculated as total non-interest income divided by total assets. NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets. LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets. LNDEPO is a measure of bank's market share calculated as a natural logarithm of total bank deposits. LNTA is the size of the bank's total asset measured as the natural logarithm of total bank assets. EQASS is a measure of banks capitalization measured by banks total shareholders equity divided by total assets. ROA is return on assets calculated as profit after tax divided by total assets. LNGDP is natural logarithm of gross domestic product. INFL is the rate of inflation.

Values in parentheses are standard errors.

***, **, and * indicate significance at 1, 5 and 10% levels.

From column 2 of Table 6 it is clear that NII/TA consistently exhibits a strong negative and significant relationship with Malaysian banks' PTE. The findings also suggest that the elasticity of PTE with respect to NII/TA is high and is statistically significant at the 1% level. The results imply that bank which derived a higher proportion of its income from non-interest sources such as fee based services tend to report a lower PTE level. The empirical findings provide support to earlier studies by among others Stiroh (2006a), Stiroh (2006b), and Stiroh and Rumble (2006). To recap, Stiroh and Rumble (2006) find that diversification benefits of the U.S. financial holding companies are offset by the increased exposure to non-interest activities, which are much more volatile but not necessarily more profitable than interest generating activities.

As expected, the findings seem to suggest that NIE/TA has consistently exhibit negative and significant impact on Malaysian banks' TE and PTE. Furthermore, the elasticity of all efficiency estimates in respect to NIE/TA is quite high, i.e. –6.458 in the case of TE and –6.826 in the case of PTE. The finding is in consonance with Berger and DeYoung (1997) *bad management* hypothesis. Clearly, efficient cost management is a prerequisite for the improved efficiency of the Malaysian banking system i.e. the high elasticity of efficiency to this variable denotes that banks have much to gain if they improve their managerial practices. Furthermore, the Malaysian banking sector has not reached the maturity level required to link quality effects pending from increased spending to higher bank efficiency.

Referring to the impact of bank liquidity, it is observed from column 4 of Tables 5 and 6 that the coefficient of LOANS/TA is positive and is statistically significant at the 1% level in the TE and PTE regression models, indicating a negative relationship between bank efficiency and the level of liquid assets held by the bank. As higher figures of the ratio denote lower liquidity, the results imply that more (less) liquid banks tend to exhibit lower (higher) efficiency levels. As pointed out by Sufian and Habibullah (2009), the positive relationship found between bank profitability and LOANS/TA may be supporting the efficient market hypothesis, since market power in the loan markets could be the result of efficient operations. Due to their ability to manage operations more productively, relatively efficient banks might have lower production costs, which enable them to offer more reasonable loan terms and ultimately gaining larger market shares over their inefficient peers.

The level of capitalization (EQUITY/TA) has negative relationship to all efficiency measures, which is in line with the findings of Akhigbe and McNulty (2005). The findings seem to suggest that the more efficient banks, *ceteris paribus*, use more leverage (less equity) compared to their peers. The results seems to suggest that the less efficient banks involved in riskier operations and in the process tend to hold more equity, voluntarily or involuntarily, i.e., the reason may be banks' deliberate efforts to increase safety cushions and in turn decrease the cost of funds, or perhaps regulatory pressures that mandate riskier banks to carry more equity.

It is observed from column 8 of Table 6 that ROA exhibits positive relationship with SE implying that the more profitable banks are relatively more scale efficient. On the other hand, the empirical findings presented in column 8 of Table 8 seem to suggest that during the period under study, ROA has a negative relationship with PTE. If anything could be delved, the empirical findings seem to suggest that the relatively managerially efficient bank may not be necessarily the one that is more profitable.

In the final step, we repeat Eq. (3) by taking into consideration all explanatory variables simultaneously. The results are presented in Column 11 of Tables 5-7. The empirical findings clearly suggest that the overall fit of the model measured by the level of R^2s improved considerably to 68.3%, 68.9%, and 69.2% in the case of the TE, PTE, and SE regression models respectively. From column 11 of Tables 5-7 it is observed that the *F*-statistics for all models continued to remain significant at the 1% level in all cases. It is also worth mentioning that in most of cases, the coefficient of the variables continued to remain robust in terms of directions and significance levels, albeit at different degrees.

The empirical findings presented in column 11 of Table 5 seem to suggest that the coefficient of the LLP/TL variable loses its explanatory power when we control for other bank specific and macroeconomic variables in the regression model. On the other hand, we find that network embeddedness (LNDEPO) has a negative and statistically significant impact on Malaysian banks' TE. Turning to the PTE regression results, it is observed from column 11 of Table 6 that NII/TA and EQASS are no longer statistically significantly related to Malaysian banks' PTE. Similar to the TE case, the empirical findings seem to suggest that network embeddedness has a negative and statistically significant impact on Malaysian banks' PTE when other bank specific and macroeconomic conditions are controlled for in the regression model. Finally, it is observed from column 11 of Table 7 that NIE/TA has a negative and statistically significant impact on Malaysian banks' SE.

5. Concluding Remarks and Directions for Future Research

The paper examines the comparative performance of the foreign and domestic banks in Malaysia around the Asian financial crisis period. The efficiency estimates of individual banks are evaluated using the non-parametric Data Envelopment Analysis (DEA) approach. To complement the results of the efficiency measures derived from the DEA model, we have analyzed the determinants of the foreign and domestic banks' efficiency using various accounting measures of bank performance. The preceding empirical analysis allows us to shed some light on the relationship between bank characteristics and bank performance measures.

The empirical findings suggest that during the period of study, the foreign banks have exhibited higher technical efficiency relative to their domestic bank counterparts. The decomposition of technical efficiency into its pure technical and scale efficiency components reveal that scale inefficiency dominates pure technical inefficiency in the Malaysian banking sector implying that the Malaysian banks have

been inefficient in exploiting the economies of scale given their scale of operations. The results suggest that foreign banks have exhibited higher technical efficiency compared to their domestic bank peers, which was mainly attributed to higher pure technical efficiency. Overall, during the period of study, the findings seem to suggest that the foreign banks were relatively more managerially efficient in controlling their costs.

The results from the panel regression analysis suggest that loans intensity is positively and significantly associated with technical and pure technical efficiencies, suggesting that the more (less) liquid banks tend to exhibit lower (higher) efficiency levels. On the other hand, we find that Malaysian banks which incur higher overhead costs and credit risk tend to be relatively inefficient in their intermediation function. During the period under study, we find that the level of capitalization has negative relationships to all efficiency measures, suggesting that the more efficient banks, *ceteris paribus*, use more leverage (less equity) compared to their peers.

The impact of income diversification is negatively related to Malaysian banks' pure technical efficiency, suggesting that banks which derived a higher proportion of its income from non-interest sources such as fee based services tend to report a lower PTE level. The results imply that the benefits for diversification of Malaysian banks are offset by the volatility of the non-interest income, which may not necessarily be more profitable than interest generating activities. The profitability measure for banks, ROA, exhibits positive relationship with Malaysian banks' scale efficiency implying that the more profitable banks are relatively more scale efficient. On the other hand, the empirical findings seem to suggest that ROA has a negative relationship with PTE suggesting that the relatively managerially efficient bank may not be necessarily the one that is more profitable.

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