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Determinants of bank efficiency during unstable macroeconomic environment: Empirical evidence from Malaysia

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ABSTRACT

The present study investigates for the first time the efficiency of Malaysian banking sector around the Asian financial crisis 1997. The efficiency estimates of individual banks are evaluated by using the Data Envelopment Analysis (DEA) approach. To examine the robustness of the estimated efficiency scores under various alternatives and to differentiate how efficiency scores vary with changes in inputs and outputs, the present study focuses on three major approaches viz., intermediation approach, value added approach, and operating approach. The analysis further links the variation in calculated efficiencies to a set of explanatory variables, i.e. bank size, profitability, and ownership. The empirical findings clearly bring forth the high degree of inefficiency in the Malaysian banking sector, particularly a year after the East Asian crisis. The results suggest that the decline in technical efficiency is more abrupt under the intermediation approach relative to the value added approach and operating approach. The regression results focusing on bank efficiency and other bank specific traits suggest that efficiency is negatively related to expense preference behavior and economic conditions, while bank efficiency is positively related to loans intensity.

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1. Introduction

The world was stunned when East Asia, the highest growth region during the 1990s, was hit by a banking crisis in 1997. The crisis, which started in Thailand and spread rapidly throughout the region, drew widespread attention from economists and financial analysts. It was characterized by skyrocketing interest rates (+34% in Korea; +13% in Indonesia), a dramatic drop in stock price indexes (−55% in Thailand; −52% in Malaysia), real exchange rate depreciation (−97% in Korea; −87% in Thailand), a decline in net capital flow to the region (−$20 billion), and a drop in the region's gross domestic product (−$481 billion).

In order to understand the nature of the East Asian crisis, as well as similar crises around the world, economists have used a variety of methodologies while focusing primarily on macro-level variables. Papers in the macro-tradition include Frankel and Rose (1996), Sachs et al. (1996), Kaminsky et al. (1998), Corsetti et al. (1998), Eichengreen and Rose (1998), Chinn (1998), Kaminsky and Reinhart (1998), Krugman (1999), Berg and Pattillo (1999), Alba et al. (1999), and Tanner (2000), among others. In addition to these studies, a number of papers have adopted a microperspective deriving from bank's balance sheet and income statements. Generally, the variables examined in these papers follow the well-known CAMEL framework.[1] These include Sinkey (1975), Barth et al. (1985), Lane et al. (1986), Thomson (1991), and Gonzalez-Hermosillo et al. (1997). There were also papers which combined macro- and microvariables, including those of Goldstein and Turner (1996), Honohan (1997), and Gonzalez-Hermosillo (1999).

The characteristics of banking systems that are more prone to experience banking and financial crisis and its impact has also drawn academic interests in recent years. Barth et al. (2000) suggests that greater regulatory restrictions on bank activities are associated with higher probability of suffering a major banking crisis. Beck et al. (2006) find that the likelihood of financial crises is lower in more concentrated banking systems, yet higher in less competitive and countries with less developed legal systems. Daniel and Jones (2007) suggests that even if a banking system is well designed, countries will enjoy an initial period of rapid low risk growth, before entering a period with an elevated risk of banking crisis. By using aggregate and bank level data for 35 developed and developing countries, Dermiguc-Kunt et al. (2006) find that depositors leave weaker banks for stronger ones following a banking crisis. Kroszner et al. (2007) find that sectors that are highly dependent on external finance tend to experience greater contraction during a banking crisis in countries with deeper financial systems than in countries with shallower financial systems.

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), Greece (Pasiouras, 2008b), Singapore (Sufian, 2007), 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 (e.g. Bhattacharya et al., 1997; Isik and Hassan, 2002; Ataullah and Le, 2006).

Despite its severity and deep influence on both the real and financial sectors, the impact of the East Asian crisis of 1997 on the efficiency of the financial industry has not been critically examined yet. Fukuyama (1995), Humphrey and Pulley (1997), Leightner and Lovell (1998), and Isik and Hassan (2003a) have suggested that frontier techniques can be used to assess the impact of major economic events such as economic crisis or financial liberalization on the performance of banking firms. How-

[1] The CAMEL framework is used by financial regulators to rate the health of financial institutions. The framework criteria are associated with *C*apital Adequacy (C), *A*sset Quality (A), *M*anagement (M), *E*arnings (E), and *L*iquidity (L).

Table 1
Short-term claims on the East Asian economies (% change Y-o-Y)

Year	Hong Kong	Indonesia	Korea	Malaysia	Philippines	Singapore	Taiwan	Thailand
1990	7.44	60.32	31.01	11.03	12.10	17.74	26.02	−17.06
1991	5.38	12.28	17.25	44.96	0.28	2.70	84.87	39.23
1992	3.89	13.87	11.49	36.90	−2.30	9.59	24.69	3.46
1993	22.39	9.38	10.17	81.49	−24.87	9.11	24.13	18.71
1994	20.09	13.27	36.79	−11.02	34.42	17.83	49.21	20.11
1995	−1.33	29.53	35.20	20.00	28.26	25.46	40.53	3.16
1996	−18.11	24.19	24.38	41.58	90.24	−14.06	25.37	−3.97
1997	1.69	2.50	−12.90	28.99	53.81	11.34	−4.75	12.28
1998	−44.19	−32.48	−49.49	−35.43	−27.18	−40.13	−39.60	−22.24
1999	−21.49	−19.69	18.11	−16.77	−11.99	−18.14	−30.85	−7.10

Source: Bank of International Settlements. Units are in millions of U.S. Dollars.

ever, to the best of our knowledge, Isik and Hassan's (2003a) study is the only empirical research performed to directly examine the impact of financial disruptions on bank efficiency by using the frontier technique.

By employing a unique data set of all banks operating in Malaysia during the period of 1995–1999, this study contributes to the existing literature by providing new empirical evidence on the impact of the East Asian crisis on the Malaysian banking sector's efficiency. Given that banks are the dominant financial institution in Malaysia, their health is very critical to the health of the general economy at large, as demonstrated during the East Asian crisis which left many financial institutions in distress. However, at the present time, this type of analysis is completely missing in the literature.

To do so, the non-parametric frontier-based Data Envelopment Analysis (DEA) method is used to estimate the technical, pure technical, and scale efficiency. To examine the robustness of the estimated efficiency scores under various alternatives, the present study focuses on three major approaches, namely intermediation approach, value added approach, and operating approach. Finally, we analyze how ownership structure and different bank characteristics, such as capitalization, problem loans ratio, and size, influences the efficiency estimates.

The following section identifies those factors that characterize the Asian financial crisis. Section 3 describes the data, sources and model specifications, which are employed in the study. Section 4 presents the results of the analysis of Malaysian banking sector using DEA and the panel regression techniques. Finally, we conclude in Section 5.

2. The Asian financial crisis in perspective

Over the last quarter of the 20th century, both developed and developing countries have experienced severe banking crisis (Chile, Argentina, and Mexico, 1980s; Sweden, 1990s; Thailand, Malaysia, Korea, Philippines and Indonesia, 1997; Paraguay, 1995−1998; Russia, 1998; Turkey, 1994, 2000, and 2001; Argentina, 2001). The main causes of these crises are poor banking practices and lack of revenue diversification, inadequate capital, shortcomings in the assessment of credit risk, lending to connected enterprises, excessive maturity or currency mismatches, and rapid rise of non-performing loans.

Due to less than fully developed stock markets in the East Asian region, equity financing was not an important source of financing. Rather, banks' borrowing from both offshore and onshore became an important focus of financing in East Asia (Suetorsak, 2006). A huge accumulation of foreign debt financing relative to equity increasingly raised banks' leverage risk. Interest rate risk and maturity risk were also a concern of the East Asian banks. Interest rate risk reflects a maturity mismatch between banks' assets and liabilities. For example, East Asian banks often borrowed abroad with a short-term maturity and lent domestically with a long-term maturity for domestic projects. The total short-term maturity claims of the East Asian region are shown in Table 1.

Banks in East Asia also assumed exceptional liquidity risk. From Table 2 it is clear that East Asian banks had a high proportion of short-term debts relative to long-term debts. They exposed themselves to liquidity risk due to problems with short-term debt renewal. It is observed from Table 2 that prior to

Table 2
Percentage of short-term maturity claims to long-term maturity claims on banks

East Asian economies	Short-term maturity claims on banks	Long-term maturity claims on banks	Percentage of short-term claims to long-term maturity claims on banks
1995			
Indonesia	5,516	3,384	163
Korea	35,016	14,984	233.7
Malaysia	2,115	2,385	88.7
Philippines	1,078	1,122	96.1
Thailand	8,073	17,727	45.5
Hong Kong	7,845	19,819	39.6
Singapore	1,251	7,171	17.4
1996			
Indonesia	7,282	4,518	161.2
Korea	44,531	21,369	208.4
Malaysia	3,273	3,227	101.4
Philippines	3,048	2,152	141.6
Thailand	6,989	19,011	36.8
Hong Kong	14,186	23,917	59.3
Singapore	1,978	7,879	25.1
1997			
Indonesia	7,428	4,972	149.4
Korea	38,268	29,032	131.8
Malaysia	5,257	5,243	100.3
Philippines	4,609	891	517.3
Thailand	7,968	18,132	43.9
Hong Kong	10,305	26,031	39.6
Singapore	2,765	9,747	28.4

Source: Bank of International Settlements. Units are in millions of U.S. Dollars.

the crisis in 1997, among the crisis affected countries, Korea had the highest percentage of short-term debts relative to long-term debts, followed by Indonesia, while Thailand and Malaysia the least. On the other hand, Singapore and Hong Kong, which were relatively unscathed by the East Asian crisis had relatively low percentage of short-term debts relative to long-term debts. Another risk resulting from excessive external debt accumulations was exchange rate risk. After increasing their offshore borrowing in foreign currencies, East Asian banks lent out money domestically with little restraint in local currencies. This lending boom led to excessive domestic credit growth (Frankel and Rose, 1996). Nevertheless, banks were also exposed to foreign exchange losses risk in the event of domestic currency depreciation (Chang and Velasco, 1999). This was problematic since the domestic credit expansion was inconsistent with the East Asian quasifixed exchange rate regimes, causing a depletion of foreign exchange reserves and eventually causing a collapse of the fixed exchange rate regime (Krugman, 1999). This suggests that the internal imbalance of the banking industry triggered an unsustainable external balance. In other words, microdecisions of banks caused macro-imbalances in these countries. Regardless of the cause of the East Asian crisis, all economists have agreed that the crisis has been severe. Although initially only financial in nature, the crisis has led to significant real economic losses in the once fast growing developing economies.

The Malaysian situation possesses some important characteristics. Basic macroeconomic fundamentals were not signaling imminent danger. Low inflation and falling unemployment rate characterized the country over the decade preceding the East Asian crisis. Despite the sound macroeconomic fundamentals, a few other major indicators pointed towards serious problems by the mid-1990s, further compounded by the financial system's weakness. The financial institutions were weakened by large-scale exposure to the property sector, high non-performing loans and short-term loans that were unhedged against currency movements. Furthermore, the credit expansion especially to the private sector was pronounced during 1995–1997, particularly towards the real estate and property sectors.

Prior to the crisis, the banking system had relatively high exposures to the property and equity sectors, which amounted to approximately 42.6% of total loans, compared to only 21% exposure towards

the manufacturing sector. Once devaluation and drops in real estate and stock markets got underway, the crisis took on a life of its own. The drop in property and equity prices caused large losses and outright defaults by many property companies as well as those who participate in the equity market by margin accounts resulting in a dramatic increase in the amount of non-performing loans (NPLs).

In sum, the domestic banks were hit simultaneously on many fronts, namely the withdrawal of foreign funds, foreign exchange losses, a sharp rise in NPLs and losses on equity holdings. The erosion of the banking system's capital base due to all these factors had severely constrained their ability to lend to even solvent companies in the midst of the crisis, due to the need to comply with international capital adequacy rules.

3. Methodology and data

3.1. Data Envelopment Analysis

The present study employs the non-parametric frontier DEA approach with variable returns to scale (VRS) assumption to measure input-oriented technical efficiency of Malaysian banks. DEA involves constructing a non-parametric production frontier based on the actual input–output observations in the sample relative to which efficiency of each firm in the sample is measured (Coelli, 1996). Let us give a short description of the DEA.[2] Assume that there is data on K inputs and M outputs for each N bank. For the ith bank, these are represented by the vectors x_i and y_i, respectively. Let us call the $K \times N$ input matrix – X and the $M \times N$ output matrix – Y. To measure the efficiency for each bank we calculate a ratio of all inputs, such as $(u'y_i/v'x_i)$ where u is an $M \times 1$ vector of output weights and v is a $K \times 1$ vector of input weights. To select optimal weights we specify the following mathematical programming problem:

$$\min_{u,y} \left(\frac{u'y_i}{v'x_i} \right), \qquad \frac{u'y_i}{v'x_i} \leq 1, \quad j = 1, 2, \ldots, n, \quad u, v \geq 0 \tag{1}$$

The above formulation has a problem of infinite solutions and therefore we impose the constraint $v'x_i = 1$, which leads to

$$\min_{\mu,\varphi} (\mu' y_1) \varphi' x_i = 1, \qquad \mu' y_i - \varphi' k_j \leq 0, \quad j = 1, 2, \ldots, N, \quad \mu, \varphi \geq 0 \tag{2}$$

where we change notation from u and v to μ and φ, respectively, in order to reflect transformations. Using the duality in linear programming, an equivalent envelopment form of this problem can be derived:

$$\min_{\theta,\lambda} \theta, \quad y_i + Y\lambda \geq 0, \quad \theta x_i - X\lambda \geq 0, \quad \lambda \geq 0 \tag{3}$$

where θ is a scalar representing the value of the efficiency score for the ith bank which will range between 0 and 1. λ is a vector of $N \times 1$ constants. The linear programming has to be solved N times, once for each bank in the sample. In order to calculate efficiency under the assumption of VRS, the convexity constraint ($N1'\lambda = 1$) will be added to ensure that an inefficient bank is only compared against banks of similar size, and therefore provides the basis for measuring economies of scale within the DEA concept. The convexity constraint determines how closely the production frontier envelops the observed input–output combinations and is not imposed in the constant returns to scale (CRS) case.

3.2. Multivariate Tobit regression analysis

Coelli et al. (1998) suggested several ways in which environmental variables can be accommodated in a DEA analysis. The term "environmental variables" is usually used to describe factors, which could influence the efficiency of a firm. In this case, such factors are not traditional inputs and are assumed to be outside the control of the manager. As defined in Eq. (3), the DEA score falls between the interval 0

[2] Good reference books on efficiency measures are Coelli et al. (1998), Thanassoulis (2001), and Cooper et al. (2000).

and 1 ($0 \leq \theta \leq 1$) making the dependent variable a limited dependent variable. A commonly held view in previous studies is that the use of the Tobit model can handle the characteristics of the distribution of (in) efficiency measures and thus provide results that can provide important policy guidelines to improve performance. Accordingly, DEA efficiency scores obtained in the first stage is used as a dependent variable in the second stage and are regressed against a set of bank characteristics and other environmental variables.

The standard Tobit model can be defined as follows for observation (bank) *i*:

$$y_i^* = \beta' x_i + \varepsilon_i; \quad y_i = y_i^*, \ \text{if} \, y_i^* \geq 0 \, \text{and} \, y_i = 0, \ \text{otherwise} \tag{4}$$

where $\varepsilon_i \sim N(0, \sigma^2)$, x_i and β are vectors of explanatory variables and unknown parameters, respectively, while y_i^* is a latent variable and y_i is the DEA efficiency score.[3]

3.3. Specification of bank inputs, outputs, and data

It is commonly acknowledged that the choice of variables in efficiency studies significantly affects the results. The problem is compounded by the fact that variable selection is often constrained by the paucity of data on relevant variables. The cost and output measurements in banking are especially difficult because many of the financial services are jointly produced and prices are typically assigned to a bundle of financial services. The role of commercial banks is generally defined as collecting the savings of households and other agents to finance the investment needs of firms and consumption needs of individuals. Three approaches dominate the literature: the production approach, the intermediation approach, and more recently, the revenue or (value added) approach. The operating approach of defining inputs and outputs of banks has also been popular (Jemric and Vujcic, 2002). The first two approaches apply the traditional microeconomic theory of the firm to banking and differ only in the specification of banking activities. The third and fourth approach goes a step further and incorporates some specific activities of banking into the classical theory and thereby modifies it.

Under the production approach, pioneered by Benston (1965), a financial institution is defined as a producer of services for account holders, that is, they perform transactions on deposit accounts and process documents such as loans. Hence, according to this approach, the number of accounts or its related transactions is the best measure for output, while the number of employees and physical capital are considered as inputs. This approach has primarily been employed in studying the efficiency of bank branches (Berger and Humphrey, 1992). 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. The operating approach (or income based approach) views banks as business units with the final objective of generating revenue from the total cost incurred for running the business (Leightner and Lovell, 1998). Accordingly, it defines banks' output as total revenue (interest and non-interest income) and inputs as the total expenses (interest and non-interest expenses). More recently, Drake et al. (2006) proposed the revenue approach (or value added approach) in DEA. The value added approach identifies those balance sheet categories as outputs that contribute to the bank value added. In general, under this approach, deposits and loans are viewed as outputs because they are responsible for the significant proportion of value added.

The appropriateness of each approach varies according to the circumstances. It is apparent that banks undertake simultaneous functions. However, based on practical considerations and to examine the robustness of the estimated efficiency scores under various alternatives, the present study focuses on three major approaches: intermediation approach, value added approach, and operating approach. Under the intermediation approach, we assume deposits (x2), labour (x3), and capital (x1) as inputs

[3] likelihood function (L) is maximized to solve β and σ based on 171 observations (banks) of y_i and x_i is $L = \prod_{y_i=0} 1 - F \prod_{y_i>0} (1/(2\Pi\sigma^2)^{1/2}) e^{-[1/(2\sigma^2)](y^i - \beta x_i)^2}$ where, $F_i = \int_{-\infty}^{\beta x_i/\sigma} (1/2\Pi^{(1/2)}) e^{-t^2/2} \, dt$. The first product is over the observations for which the banks are 100% efficient ($y = 0$) and the second product is over the observations for which banks are inefficient ($y > 0$). F_i is the distribution function of the standard normal evaluated at $\beta' x_i/\sigma$.

Table 3
Descriptive statistics for inputs and outputs

	1995 (RMm)	1996 (RMm)	1997 (RMm)	1998 (RMm)	1999 (RMm)
Outputs					
Total loans					
Mean	5289064.08	6794838.03	8350889.61	9697277.85	9725398.09
S.D.	8727859.64	10112353.57	11921960.75	14372644.31	14434512.30
Investments					
Mean	1613521.08	2057698.56	2535818.88	2899880.42	2939799.55
S.D.	3334935.92	3368228.95	4229836.41	4651120.56	5232611.54
Interest income					
Mean	577317.19	787591.81	1043310.55	1474555.03	1056095.00
S.D.	955016.44	1228357.93	1561006.93	2227187.85	1723865.25
Non-interest income					
Mean	88874.19	106284.72	126336.61	140381.48	139285.82
S.D.	150511.84	171256.09	196006.68	197730.07	214812.35
Inputs					
Capital					
Mean	99102.25	119365.36	132062.67	163080.94	173448.30
S.D.	183221.80	200364.86	205685.34	223658.71	248435.07
Total deposits					
Mean	7183739.28	8731392.22	11140008.58	12151769.88	12897612.48
S.D.	12107408.71	13540517.62	16649632.38	17593915.10	18829157.76
Labour					
Mean	75984.69	86122.44	103180.52	115366.91	102785.24
S.D.	123886.90	137708.91	163032.27	166993.56	139702.62
Interest expense					
Mean	341416.42	473067.78	645038.00	989116.03	662298.70
S.D.	559249.49	746479.21	941994.38	1476739.93	1103409.95
Non-interest expense					
Mean	67580.75	80613.11	92714.52	118182.21	103391.67
S.D.	110356.23	127388.36	139156.52	166043.21	133410.85

Source: Individual Banks Annual Reports. The table presents summary statistics of the variables used to construct the efficiency frontier for the DEA intermediation, operating, and value added approaches over the period 1995–1999.

for producing loans (y1) and investments (y2). Under the value added approach, labour (x3), capital (x1), and interest expenses (x4) are used as inputs producing outputs like deposits (x2), loans (y1), and investments (y2). Under the operating approach, three types of inputs are considered namely, interest expenses (x4), labour (x3), and other operating expenses excluding employee expenses (x5). The relevant outputs are interest income (y3) and non-interest income (y4) emanating mostly from commission, exchange, brokerage, etc.

We use annual bank level and macroeconomic data of all Malaysian commercial banks over the period 1995–1999. The variables are obtained from published balance sheet information in annual reports of each individual institution, while the macroeconomic variable is sourced from various issues of Bank Negara Malaysia's annual reports. The dataset covers the whole gamut of the industry's total assets. The final sample consists of 36 banks in 1995 and 1996 and 33 banks in 1997, 1998, and 1999 yielding a total of 171 bank-year observations. Table 3 presents summary statistics of the output and input variables used to construct the DEA model.

Several bank and industry specific attributes may influence a particular bank's efficiency level. Some of these factors may be neither inputs nor outputs in the production process, but rather circumstances faced by a particular bank. We use an array of bank specific variables to control banks' production technologies, the input and product market share they are facing, and other factors that might confound the empirical relationship between bank characteristics and efficiency. The independent variables used to explain Malaysian banks' efficiency are grouped under two main characteristics. The first

represent bank-specific attributes, while the second encompass economic conditions during the period examined. The bank-specific variables included in the regressions are LNDEPO, ROA, LOANS/TA, LNTA, LLP/TL, NII/TA, NIE/TA, and EQASS. To measure the relationship between economic conditions and bank efficiency, LNGDP is used.

Agency issues associated with different types of firm ownership are an area of concern in many banking systems. To capture the effects of organizational forms and governance on Malaysian bank efficiency, binary dummy variables DUMFORB, DUMPUBL, and DUMGOVT are included in the regression models.

Finally, to explore the home field and *global advantage* hypotheses suggested by Berger et al. (2000), we have further classified foreign banks operating in Malaysia into three major groups according to their origins, namely DUMAMER, DUMEURO, and DUMASIA. During the period of investigation, there were four banks headquartered in the North America and Canada, four banks headquartered in the European countries, and six foreign banks from other Asian countries operating in Malaysia. The independent variables, their hypothesized relationship with efficiency and notations are detailed in Table 4.

To test the relationship between Malaysian bank efficiency and the bank specific and macroeconomic determinants described above, the following regression model is estimated:

$$\theta_{jt} = \beta_0\beta_1 \sum \text{Characteristics} + \beta_2 \sum \text{Ecom} + \beta_3 \sum \text{Ownership} + \beta_4 \sum \text{Origins} + \varepsilon_{jt} \qquad (5)$$

where θ_{jt} is the technical efficiency of the jth bank in period t obtained from DEA intermediation, operating, and value added approaches, 'Characteristics' is a set of bank characteristics, 'Econ' is a vector of economic conditions, 'Ownership' is an array of bank ownership characteristics and finally, 'Origins' is a set of bank origins variables.

4. Results and discussion

In this section, we will discuss the technical efficiency (TE) change of the Malaysian banking sector, measured by the DEA method and its decomposition into pure technical efficiency (PTE) and scale efficiency (SE) components. The efficiency of Malaysian commercial banks is first examined by employing the DEA method for each year under investigation. The results are classified into two broad heads. First, we describe the estimates of technical efficiency during the East Asian crisis under three alternative approaches. Second, to substantiate the results under the DEA approach, a multivariate regression framework is employed to relate bank efficiency level to a set of bank specific traits and other macroeconomic determinants.

4.1. Efficiency of the Malaysian banking sector

The summary results of technical, pure technical, and scale efficiency estimates under the three approaches are presented in Tables 5–7, respectively. The average technical efficiency estimate (M) represents the average of all optimal values obtained from CRS model for each commercial bank (Table 5).[4] The empirical results suggest a large asymmetry between banks regarding their technical efficiency scores. In particular, the different approaches of classifying inputs and outputs of banks produced divergent sets of efficiency estimates. The estimates of technical efficiency were observed to be consistently higher under operating approach vis-à-vis the intermediation and value added approaches. On the other hand, under the intermediation approach, banks are characterized by relatively low level

[4] The CRS assumption is only justifiable when all decision-making units (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 CRS assumption when not all DMUs are operating at the optimal scale, the computed measures of technical inefficiency will be contaminated with scale inefficiency. Banker et al. (1984) extended the CCR model by relaxing the CRS assumption. The resulting "BCC" model was used to assess the efficiency of DMUs characterized by VRS. The VRS assumption provides the measurement of PTE, which is the measurement of technical efficiency 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.

Table 4
Descriptive of the variables used in the regression models

Variable	Description	Hypothesized relationship with efficiency	Remarks
Bank characteristics			
ROA	Return on assets	+	Is used as a proxy of bank profitability. A positive relationship with bank efficiency is expected
LNDEPO	Natural logarithm of total deposits	+/−	Is used as a proxy of market share. We do not have a priori expectation on the variable sign
LOANS/TA	Total loans over total assets	+	Is used as an indicator for bank liquidity position. Liquidity is an indication of bank's ability to meet its customers' day-to-day cash needs and respond to sudden cash withdrawals. The variable is expected to enter the regression model positively
LNTA	Natural logarithm of total assets	+	Is used as a proxy of bank size to capture the possible cost advantages associated with size (economies of scale). The variable is expected to take a positive sign
LLP/TL	Loan loss provisions over total loans	−	Is used as a proxy for asset quality. It is expected that higher levels of non-performing assets will result in lower efficiency levels
NII/TA	Non-interest income over total assets	+/−	Is used as a proxy for bank's diversification strategy into non-traditional activities. We do not have a priori expectation on the variable sign
NIE/TA	Non-interest expense over total assets	−	Is used as a proxy for management quality. An inverse relationship is expected between this variable and bank efficiency level
EQASS	Total book value of shareholders equity over total assets	+	Is used as a proxy of capital adequacy. A positive sign is expected. Regulators view a higher level of equity as a cushion of future losses
Economic conditions			
LNGDP	Natural logarithm of gross domestic products	+/−	Is used as a proxy for economic conditions. We do not have a priori expectation on the variable sign
Ownership			
DUMFORB	Dummy variable that takes a value of 1 for foreign banks, 0 otherwise	+	Is used to examine the relationship between foreign bank ownership with efficiency. The variable is expected to take a positive sign
DUMPUBL	Dummy variable that takes a value of 1 for publicly listed banks, 0 otherwise	+/−	Is used to examine the relationship between publicly listed banks with efficiency. We do not have a priori expectation on the variable sign
DUMGOVT	Dummy variable that takes a value of 1 for government links banks, 0 otherwise	−	Is used to examine the relationship between government ownership and efficiency. The variable is expected to take a negative sign
Origins			
DUMAMER	Dummy variable that takes a value of 1 for American banks, 0 otherwise	+/−	Is used to test the home field advantage versus global advantage and liability of unfamiliarness hypotheses
DUMEURO	Dummy variable that takes a value of 1 for European banks, 0 otherwise	+/−	Is used to test the home field advantage versus global advantage and liability of unfamiliarness hypotheses
DUMASIA	Dummy variable that takes a value of 1 for Asian banks, 0 otherwise	+/−	Is used to test the home field advantage versus global advantage and liability of unfamiliarness hypotheses

Table 5
Average technical efficiency of Malaysian banks

Year	# of banks	# of efficient banks	Average efficiency (M)	Average inefficiency $[(1-M)/M]$	Standard deviation (σ)	Minimum	Interval		% of banks in I
							($I = M-\sigma$)	($I = M+\sigma$)	
Intermediation approach									
1995	36	3	0.519	0.927	0.220	0.135	0.299	0.739	75.0
1996	36	3	0.515	0.942	0.200	0.307	0.315	0.715	80.6
1997	33	3	0.570	0.754	0.179	0.371	0.391	0.749	72.7
1998	33	2	0.555	0.802	0.195	0.339	0.360	0.750	75.8
1999	33	1	0.327	2.058	0.179	0.107	0.148	0.506	81.8
Value added approach									
1995	36	3	0.551	0.815	0.200	0.294	0.351	0.751	80.6
1996	36	6	0.817	0.224	0.138	0.404	0.679	0.955	66.7
1997	33	6	0.852	0.174	0.132	0.518	0.720	0.984	69.7
1998	33	11	0.898	0.114	0.114	0.562	0.784	1.012	84.8
1999	33	5	0.702	0.425	0.173	0.323	0.529	0.875	72.7
Operating approach									
1995	36	7	0.889	0.125	0.095	0.584	0.794	0.984	66.7
1996	36	5	0.865	0.156	0.079	0.750	0.786	0.944	63.9
1997	33	5	0.872	0.147	0.093	0.684	0.779	0.965	60.6
1998	33	4	0.773	0.294	0.115	0.594	0.658	0.888	72.7
1999	33	4	0.752	0.330	0.129	0.540	0.623	0.881	72.7

Table 6
Average pure technical efficiency of Malaysian banks

Year	# of banks	# of efficient banks	Average efficiency (M)	Average inefficiency $[(1-M)/M]$	Standard deviation (σ)	Minimum	Interval		% of banks in I
							($I = M - \sigma$)	($I = M + \sigma$)	
Intermediation approach									
1995	36	7	0.784	0.276	0.210	0.141	0.574	0.994	66.7
1996	36	7	0.840	0.190	0.140	0.502	0.700	0.980	58.3
1997	33	10	0.884	0.131	0.114	0.643	0.770	0.998	51.5
1998	33	10	0.838	0.193	0.163	0.421	0.675	1.001	87.9
1999	33	8	0.759	0.318	0.229	0.245	0.530	0.988	57.6
Value added approach									
1995	36	11	0.834	0.199	0.163	0.428	0.671	0.997	55.6
1996	36	16	0.912	0.096	0.124	0.463	0.788	1.036	83.3
1997	33	18	0.930	0.075	0.106	0.633	0.824	1.036	75.8
1998	33	19	0.944	0.059	0.091	0.691	0.853	1.035	87.9
1999	33	10	0.790	0.266	0.188	0.411	0.602	0.978	54.5
Operating approach									
1995	36	16	0.930	0.075	0.080	0.719	0.850	1.010	80.6
1996	36	15	0.926	0.080	0.080	0.770	0.846	1.006	77.8
1997	33	12	0.936	0.068	0.084	0.731	0.852	1.020	84.8
1998	33	10	0.880	0.136	0.109	0.654	0.771	0.989	48.5
1999	33	13	0.878	0.139	0.140	0.600	0.738	1.018	78.8

Table 7
Average scale efficiency of Malaysian banks

Year	# of banks	# of efficient banks	Average efficiency (M)	Average inefficiency $[(1-M)/M]$	Standard deviation (σ)	Minimum	Interval		% of banks in I
							($I = M-\sigma$)	($I = M+\sigma$)	
Intermediation approach									
1995	36	3	0.665	0.504	0.187	0.395	0.478	0.852	63.9
1996	36	3	0.616	0.623	0.207	0.388	0.409	0.823	72.2
1997	33	3	0.644	0.553	0.170	0.402	0.474	0.814	63.6
1998	33	2	0.663	0.508	0.172	0.432	0.491	0.835	66.7
1999	33	1	0.445	1.247	0.196	0.141	0.249	0.641	75.8
Value added approach									
1995	36	3	0.662	0.511	0.187	0.404	0.475	0.849	61.1
1996	36	6	0.896	0.116	0.090	0.637	0.806	0.986	72.2
1997	33	6	0.917	0.091	0.099	0.559	0.818	1.016	90.9
1998	33	11	0.950	0.053	0.063	0.803	0.887	1.013	81.8
1999	33	5	0.902	0.109	0.140	0.504	0.762	1.042	87.9
Operating approach									
1995	36	7	0.957	0.045	0.075	0.584	0.882	1.032	97.2
1996	36	5	0.936	0.068	0.065	0.760	0.871	1.001	83.3
1997	33	5	0.934	0.071	0.070	0.767	0.864	1.004	81.8
1998	33	4	0.882	0.134	0.098	0.666	0.784	0.980	57.6
1999	33	4	0.863	0.159	0.103	0.626	0.760	0.966	66.7

of technical efficiency. Illustratively, in year 1999, i.e. a year after the East Asian crisis, only one bank (3%) was found to be efficient and the average technical efficiency for all banks stood at 32.7% under the intermediation approach. The number of efficient banks during the sample period ranged from three banks in 1995–1997 to only one bank in 1999 under the intermediation approach and seven banks in 1995 to four banks in 1998 and 1999 under the operating approach. It is interesting to note that the number of efficient banks was the highest under the value added approach ranging from 3 banks in 1995 to 11 banks in 1998. In sum, in and around the East Asian crisis period, there was no perceptible change in number of efficient banks under the intermediation and operating approaches, although a noticeable increase was observed under the value added approach.

Under the operating approach, the dispersion of technical efficiency scores as measured by its standard deviation depicts an increasing trend during the years 1997–1999. On the other hand, the percentage of banks wherein technical efficiency lies within the interval of 1 S.D. around the mean hovered around 61% in 1997 to 73% in 1998 and 1999 under the operating approach and 67% in 1996 to 85% in 1998 under the value added approach. These numbers were higher under the intermediation approach. As the technical efficiency estimates itself is time varying, these proportions do not necessarily corroborate the degree of (in) efficiency of the banking system. For example, under the intermediation approach, around 75% in 1995 and around 82% in 1999 of banks recorded technical efficiency within the interval of 1 S.D. around the mean. Yet, banks were much more efficient in 1995 than in 1999.

As against the changing benchmark of comparison, these proportions quantify the number of banks that are close to the average over time and thus merely capture the kurtosis of the efficiency distribution depending on the approach. For instance, under the intermediation approach the efficiency scores displays a leptokurtic distribution, i.e. the efficiency scores has a high peak with a small variance, suggesting that a lot of scores fall in the center of the distribution. On the other hand, under the operating approach the efficiency of the Malaysian banking sector seem to follow a mesokurtic distribution, i.e. the efficiency scores displays a moderate peak with gradual curves suggesting a normal number of scores in the middle range of the distribution.

Overall, the empirical findings presented in Table 5 clearly bring forth the high degree of inefficiency of Malaysian banking sector around the East Asian crisis period, particularly a year after the East Asian crisis. Most of the inefficiency stemmed from the under utilization of resources (inputs). Finally, considering the evolution of efficiency over time, a clear temporal pattern does not emerge from these different approaches. However, under the intermediation approach, inefficiency exists in the production of banking services and appears to be an important determinant of banks' costs. It is also observed from Table 5 that although in general technical efficiency level seems to deteriorate abruptly a year after the East Asian crisis under all approaches, the deterioration seems to be more pronounced under the intermediation approach model.

The set of input–output is run under both CRS and VRS assumptions. If the efficiency score of each bank produced by these models varies, then the bank is said to experience VRS (Avkiran, 1999). Once pure technical efficiency is estimated using VRS, scale efficiency is derived by dividing the technical efficiency by pure technical efficiency. Table 6 presents the PTE estimates, while SE estimates under all three approaches are presented in Table 7. It is observed that over the sample period, both pure technical and scale efficiency measures, especially under intermediation approach, display significant variation and the Malaysian banking sector did not achieve sustained efficiency gains. Estimates of pure technical efficiency under the intermediation approach vary from a low of 76% in 1999 to a high of 88% in 1997. In most of the years, about 20% of banks were found to be pure technically efficient under the intermediation approach. Interestingly, the percentage of banks whose pure technical efficiency falls within the interval of 1 S.D. around the mean displayed a large asymmetry particularly during the period 1997–1999 under all approaches. It is observed from Table 6 that under the intermediation approach the percentage stood at around 52% in 1997 to 88% in 1998, while under value added approach and operating approach the figures stood at around 55% in 1999 to 88% in 1998 and 49% in 1998 to 85% in 1997, respectively.

It is interesting to note that the number of efficient banks under CRS (technical efficiency) assumption and VRS (pure technical efficiency) assumption differs markedly, irrespective of the choice of various inputs and outputs. This clearly demonstrates the existence of sizable scale inefficiency among

Table 8
Multivariate Tobit regression analysis

Explanatory variables	Model 1		
	Intermediation approach	operating approach	Value added approach
CONSTANT	7.500*** (2.103)	4.462*** (1.149)	3.383*** (1.132)
Bank characteristics			
LNDEPO	−0.231*** (0.541)	−0.026 (0.028)	−0.043 (0.028)
LOANS/TA	0.541 (0.107)	0.194*** (0.058)	0.159*** (0.058)
LNTA	0.208*** (0.056)	0.015 (0.031)	0.029 (0.030)
LLP/TL	−0.056 (0.291)	0.292* (0.159)	0.162 (0.157)
NII/TA	0.448 (2.008)	3.208*** (1.097)	3.308*** (1.080)
NIE/TA	−16.007*** (2.269)	−10.413*** (1.239)	−8.475*** (1.221)
EQASS	−0.542 (0.449)	−0.282 (0.245)	−0.552** (0.242)
ROA	0.005 (0.009)	0.033*** (0.005)	0.033*** (0.005)
Economic conditions			
LNGDP	−0.626*** (0.194)	−0.322*** (0.106)	−0.213** (0.105)
No. of observations	171	171	171
Log likelihood	81.395	184.796	187.381
R^2	0.495	0.500	0.460
Adj. R^2	0.464	0.469	0.426

$\theta_{jt} = \alpha + \beta_1 \text{LNDEPO} + \beta_2 \text{LOANS/TA} + \beta_3 \text{LNTA} + \beta_4 \text{LLP/TL} + \beta_5 \text{NIE/TA} + \beta_6 \text{EQUITY/TA} + \beta_7 \text{ROA} + \beta_8 \text{LOGGDP} + \varepsilon_j$. The dependent variable is bank's efficiency scores derived from DEA intermediation, operating, and value added approaches; LNDEPO is a measure of bank's market share calculated as a natural logarithm of total bank deposits; LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets; LNTA is the size of the bank's total asset measured as the natural logarithm of total bank assets; LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans; NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets; NII/TA is a measure of bank's diversification towards non interest income, calculated as total non-interest income divided by total assets; EQUITY/TA is a measure of banks leverage intensity measured by banks total shareholders equity divided by total assets; ROA is a proxy measure for bank profitability calculated as bank profit after tax divided by total assets; and LNGDP is natural logarithm of gross domestic product. Values in parentheses are standard errors. ***, **and * indicate significance at 1%, 5%, and 10% levels, respectively.

Malaysian commercial banks around the East Asian crisis period. Under the intermediation approach for example, Table 6 reveals that eight banks were found to be efficient under VRS in 1999, whereas only one bank was found to be efficient under CRS. This indicates that the remaining seven banks failed to reach the CRS frontier owing solely to scale inefficiencies. Therefore, scale inefficiency does appear to be a serious problem for Malaysian banks. In general, average scale efficiency estimates of Malaysian banks were found to be low and varying below 70% for most of the years under the intermediation approach (Table 7).

It is observed from Table 7, under the intermediation approach, scale inefficiency seem to outweigh pure technical inefficiency in determining the total technical inefficiency of the Malaysian banking sector during both the pre-and post-crisis periods. On the other hand, under the value added approach, while scale inefficiency outweighs pure technical inefficiency in determining the total technical inefficiency of the Malaysian banking sector during the pre-crisis period, the empirical findings seem to suggest that pure technical inefficiency outweigh scale inefficiency during the post-crisis period. Finally, under the operating approach, although pure technical efficiency is generally lower during the pre-crisis period, the trend is less clear during the post-crisis period. Thus, with respect to their scale of operations, Malaysian banks are likely to lose sizeable output particularly in the case of the intermediation approach, although at a lesser degree under the value added approach.

4.2. The determinants of Malaysian banks' efficiency

Regression results focusing on the relationship between bank efficiency and the explanatory variables are presented in Table 8. The equations are based on 171 bank year observations during the 1995–1999 period. As pointed out by Saxonhouse (1976), heteroskadasticity can emerge when estimated parameters are used as dependent variables in the second stage analysis. Thus, following among

others Hauner (2005) and Pasiouras (2008a,b), QML (Huber/White) standard errors and covariates are calculated. Several general comments regarding the test results are warranted. The model performs reasonably well in at least two respects. For one, results for most variables remain stable across the various regressions tested. The R^2s are also reasonably high ranging from 43% to 47%. The findings suggest that all explanatory variables have the expected signs and in most cases are statistically different from zero.

In models 2–7 regressions, when we add the other group of variables to the baseline specification that include the bank specific attribute variables, the coefficients of the baseline variables stay mostly the same: they keep the same sign, the same order of magnitude, they remain significant as they were so in model 1 regressions (albeit sometimes at different levels), and with few exceptions, do not become significant if they were not in model 1 regressions. Therefore, for models 2–7 regressions, we will only discuss the results of the new variables added to the baseline specification.

From Table 8 it is observed that LNDEPO reveals a negative relationship and is statistically significant in intermediation approach regression model, suggesting that the more efficient banks are associated to the banks with lower market share, thus diminishing market leadership argument. The results imply that banks with small market share, like the foreign banks, can be at least as efficient as market dominant banks in their intermediation function because maintaining or expanding market share might involve extra costs and inputs and thus exacerbating inefficiency.

LOANS/TA reveals positive relationship and is statistically significant in all regression models. The findings imply that banks with higher loans-to-asset ratios tend to have higher efficiency scores. Thus, bank loans seem to be more highly valued than alternative bank outputs, i.e. investments and securities. The positive relationship found between technical efficiency and LOANS/TA may be supporting the efficient market hypothesis. Market power in loan markets may 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 inefficient banks.

Likewise, LNTA shows positive coefficients and is statistically significant in the intermediation approach regression model, suggesting that the larger the bank, the more efficient the bank will be, purely because of the economies of scale arguments. Hauner (2005) offers two potential explanations for which size could have a positive impact on bank efficiency. First, if it relates to market power, large banks should pay less for their inputs. Second, there may be increasing returns to scale through the allocation of fixed costs (e.g. research or risk management) over a higher volume of services or from efficiency gains from a specialized workforce. Thus, assuming that the average cost curve for Malaysian banks is U-shaped, the recent growth policies of the small and medium Malaysian banks seem to be consistent with cost minimization.

As expected LLP/TL shows negative relationship with bank's technical efficiency and is statistically significant in the operating approach regression model. The finding is consistent with earlier findings by among others, Kwan and Eisenbeis (1995), Resti (1997), and Barr et al. (2002). Furthermore, most research conducted on explaining the causes of bank or thrift industry failures have found that failing institutions carried a large proportion of non-performing loans in their books prior to failure (Dermiguc-Kunt, 1989; Whalen, 1991; Barr and Siems, 1994). Berger and Humphrey (1992), Barr and Siems (1994), and Wheelock and Wilson (1995) have also found that banks approaching failure tend to have low cost efficiency and experience high ratios of problem loans and that failing banks tend to be located far from the best practice frontiers. The results imply that Malaysian banks should focus more on credit risk management, which has been proven to be 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 systems, which in turn will assist banks to evaluate credit risk more effectively and avoid problems associated with hazardous exposure.

The empirical findings seem to suggest that NII/TA consistently possesses positive relationship with bank's technical efficiency and are statistically significant in all regression models. The findings also suggest that the elasticity of technical efficiency with respect to NII/TA is quite high particularly in the operating approach and value added approach regression models. The results imply that banks tend

to become more managerially efficient as they increase their income emanating from non-interest sources. The empirical finding is consistent with earlier findings by among others Jeon and Miller (2005).

The findings seem to suggest that NIE/TA consistently exhibit negative relationship with bank efficiency and are statistically significant in the operating approach and value added approach regression models. The finding is in consonance with the *bad management* hypothesis of Berger and DeYoung (1997). Low measure of technical efficiency is a signal of poor senior management practices, which apply to input-usage, day-to-day operations and managing the loan portfolio. Sub par managers do not sufficiently monitor and control their operating expenses. Managers in these banks might not practice adequate loan underwriting, monitoring, and control. 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 system has not reached the maturity level required to link quality effects pending from increased spending to higher bank efficiency.

From Table 8 it is clear that EQASS exhibits negative relationship with bank efficiency and is statistically significant in the value added approach regression model, which is in line with the findings of Akhigbe and McNulty (2005). The findings imply 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 could have been involved in riskier operations and in the process tend to hold more equity, voluntarily or involuntarily, i.e., the reason might 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 that ROA exhibits positive relationship and is statistically significant in the operating and value added approaches regression models. These findings indicate that the more profitable banks tend to exhibit lower inefficiency, which corroborates similar findings of some previous studies (Isik and Hassan, 2002; Hasan and Marton, 2003; Miller and Noulas, 1996). Banks reporting higher profitability ratios are usually preferred by clients and therefore attract the biggest share of deposits as well as the best potential creditworthy borrowers. Such conditions create a favourable environment for the profitable banks to be more efficient from the point of view of intermediation activities.

Another factor, which could explain Malaysian banks' inefficiency, is the relatively volatile rates of national income growth during the period of analysis measured by LNGDP, which exhibit negative and statistically significant relationship in all regression models. Demand for financial services tends to grow as economies expand and societies become wealthier. However, during the period of study, the Malaysian economy had experienced a volatile economic growth, i.e. from a robust 9.95% average growth in 1995 and 1996, declining to record 7.30% growth in 1997, falling into a recession in 1998, before recovering to register 6.15% growth in 1999. The volatile economic growth could have resulted in banks to suffer from lower demand for their financial services, increased loan defaults, and thus lower output.

4.3. Bank ownership and efficiency

Banks of different ownership forms may react differently to the same efficiency determinants. Thus, in the preceding analysis we repeat the regression models above to examine the factors that influence the efficiency of the foreign banks, publicly listed banks, and government linked banks. The regression results focusing on the relationship between bank ownership and efficiency are presented in Table 9.

As expected DUMFORB entered the regression models positively and is statistically significant in the value added approach regression models. The findings imply that banks with controlling share of foreign ownership are likely to be more efficient compared to their domestically owned counterparts. This should come as no surprise because of the ability of foreign owned banks to capitalize on their access to better risk management and operational techniques, which is usually made available through their parent banks abroad. In addition, since foreign ownership is likely to be concentrated, foreign owned banks are less prone to typical corporate governance conflicts (dispersed) owners and the management. The evidence seems to suggest that foreign owned banks are more likely to cherry-pick the best borrowers available in the market (especially those from their own countries of origin),

Table 9
Multivariate Tobit regression analysis

Explanatory variables	Model 2			Model 3		
	Intermediation approach	Operating approach	Value added approach	Intermediation approach	Operating approach	Value added approach
CONSTANT	7.511*** (2.102)	4.484*** (1.142)	3.427*** (1.104)	7.362*** (3.943)	4.555*** (3.683)	−8.068*** (−3.414)
Bank characteristics						
LNDEPO	−0.228*** (0.052)	−0.020 (0.028)	−0.032 (0.027)	−0.237*** (−5.169)	−0.022 (−0.946)	0.043 (0.900)
LOANS/TA	0.533*** (0.109)	0.179*** (0.059)	0.130** (0.057)	0.537*** (5.029)	0.197*** (2.820)	0.483*** (4.035)
LNTA	0.206*** (0.056)	0.012 (0.031)	0.022 (0.029)	0.220*** (4.155)	0.007 (0.287)	−0.022 (0.397)
LLP/TL	−0.060 (0.291)	0.284* (0.158)	0.146 (0.153)	−0.086 (−0.593)	0.313 (0.936)	0.369 (1.270)
NII/TA	0.020 (2.267)	2.396* (1.232)	1.676 (1.191)	0.039 (0.016)	3.485*** (2.852)	−0.579 (−0.243)
NIE/TA	−15.800*** (2.324)	−10.022*** (1.263)	−7.688*** (1.220)	−14.930*** (−4.829)	−11.142*** (−8.674)	−8.475*** (−2.681)
EQASS	−0.537 (0.449)	−0.273 (0.244)	−0.534** (0.236)	−0.467 (−0.887)	−0.333 (−1.037)	1.650*** (2.735)
ROA	0.005 (0.009)	0.033*** (0.005)	0.032*** (0.005)	0.005 (0.648)	0.034*** (4.631)	−0.008 (−0.669)
Economic conditions						
LNGDP	−0.629*** (0.194)	−0.327*** (0.106)	−0.023** (0.102)	−0.624*** (−3.536)	−0.324*** (−2.826)	0.763*** (3.413)
Bank ownership						
DUMFORB	0.012 (0.030)	0.023 (0.016)	0.047*** (0.016)			
DUMPUBL				−0.039 (−1.512)	0.027 (1.371)	−0.061 (−1.449)
DUMGOVT						
No. of observations	171	171	171	171	171	171
Log likelihood	81.478	185.791	191.615	81.970	185.678	63.024
R^2	0.496	0.506	0.486	0.498	0.505	0.287
Adj. R^2	0.461	0.472	0.451	0.464	0.471	0.237

Explanatory variables	Model 4		
	Intermediation approach	Operating approach	Value added approach
CONSTANT	7.584*** (4.057)	4.504*** (3.628)	−7.667*** (−3.256)
Bank characteristics			
LNDEPO	−0.232*** (−5.108)	−0.026 (−1.096)	0.050 (1.057)
LOANS/TA	0.539*** (5.087)	0.193*** (2.718)	0.485*** (4.083)
LNTA	0.212*** (4.114)	0.017 (0.665)	−0.032 (−0.604)
LLP/TL	−0.039 (−0.270)	0.300 (0.897)	0.455* (1.715)
NII/TA	0.293 (0.122)	3.130** (2.553)	−0.291 (−0.125)
NIE/TA	−16.143*** (−5.576)	−10.481*** (−8.440)	−10.450*** (−3.769)
EQASS	−0.535 (−1.029)	−0.278 (−0.867)	1.548*** (2.675)
ROA	0.005 (0.583)	0.033*** (4.448)	−0.009 (−0.739)

Explanatory variables	Model 4		
	Intermediation approach	Operating approach	Value added approach
Economic conditions			
LNGDP	−0.638*** (−3.600)	−0.328 (−2.852)	0.734*** (3.307)
Bank ownership			
DUMFORB			
DUMPUBL			
DUMGOVT	−0.023 (−0.950)	−0.012 (−0.620)	−0.052 (−1.537)
No. of observations	171	171	171
Log likelihood	81.661	185.017	62.979
R^2	0.497	0.501	0.286
Adj. R^2	0.462	0.467	0.267

$\theta_{jt} = \alpha + \beta_1 \text{LNDEPO} + \beta_2 \text{LOANS/TA} + \beta_3 \text{LNTA} + \beta_4 \text{LLP/TL} + \beta_5 \text{NIE/TA} + \beta_6 \text{EQUITY/TA} + \beta_7 \text{ROA} + \beta_8 \text{LOGGDP} + \beta_9 \text{DUFORB} + \beta_{10} \text{DUPUBL} + \beta_{11} \text{DUMGOVT} + \varepsilon_j$. The dependent variable is bank's efficiency scores derived from DEA intermediation, operating, and value added approaches; LNDEPO is a measure of bank's market share calculated as a natural logarithm of total bank deposits; LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets; LNTA is the size of the bank's total asset measured as the natural logarithm of total bank assets; LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans; NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets; NII/TA is a measure of bank's diversification towards non interest income, calculated as total non-interest income divided by total assets; EQUITY/TA is a measure of banks leverage intensity measured by banks total shareholders equity divided by total assets; ROA is a proxy measure for bank profitability calculated as bank profit after tax divided by total assets; LNGDP is natural logarithm of gross domestic product; DUMFORB, DUMPUBL, and DUMGOVT are dummy variables that take a value of 1 for foreign banks, publicly listed banks, and government related banks, respectively, 0 otherwise. Values in parentheses are standard errors. ***, ** and * indicate significance at 1%, 5%, and 10% levels, respectively.

thereby improving the quality of their loan portfolios. The empirical observation that foreign banks perform better than domestic banks in developing countries also implies the technical savvy of banks from developed countries generally overcomes the home field advantage in developing countries, especially when the domestic economy has relatively unsophisticated financial markets and institutions (Jeon and Miller, 2005). The results are in accordance with earlier findings by Isik and Hassan (2003b) on Turkish banks, Hasan and Marton (2003) on Hungarian banks, and Sathye (2003) on Indian banks.

To investigate the relationship between publicly traded and Malaysian bank efficiency, a binary dummy variable, DUMPUBL is introduced as an explanatory variable in model 2 regressions. It is observed from columns 4–6 of Table 9 that the variable entered the regression models with a negative sign, but is never significant in all the regression models. Although the market discipline hypothesis suggests that banks whose shares are publicly traded should exhibit higher efficiency, the empirical findings seem to suggest that the Malaysian capital market exerts no discipline over bank management. The results are in accord with Chu and Lim (1998) who suggests that stock markets respond more strongly to profit rather than cost efficiency.

And finally, to examine the relationship between government linked banks and efficiency, DUMGOVT is included in model 3 regressions. The results are presented in columns 7–9 of Table 9. The estimated coefficients entered the regression models with a negative sign, but are never significant in any of the regression models.

4.4. Bank origins and efficiency

As pointed out by Berger et al. (2000), the methodologies used in the previous studies may not be able to distinguish properly the *home field* and *global advantage* hypotheses. Following the procedures set by Berger et al. (2000) we address this drawback by distinguishing among nations of origin of foreign banks to test for the "limited form" of the *global advantage* hypothesis. Accordingly, we repeat Eq. (5) by further classifying foreign banks operating in Malaysia into three major groups according to their parents' continents. In each set, these regressions are performed by considering each bank origin at a time. The regression results are presented in Table 10 .

Under the intermediation approach, the empirical findings seem to suggest that foreign banks from the Americas and Europe are relatively more efficient compared to their domestic bank counterparts. On the other hand, efficiency is negatively related to foreign banks from Asian countries, suggesting that foreign banks from other Asian countries were the least efficient banking group during the period of study. Unlike the intermediation approach, it is observed from Table 10 that foreign banks from the Asian countries were the most efficient banking group under the operating approach and is statistically significant at the 1% level of significance. This is followed by banks from the Americas, although is not statistically significant at any conventional levels. It is clear from column 5 of Table 10 that efficiency is negatively related to banks from other European countries (statistically significant at the 1% level) implying that banks from the European countries were the least efficient banking group under the operating approach. Columns 7–9 of Table 10 presents the regression results for the value added approach. Similar to the operating approach, the empirical findings seem to suggest that banks from other Asian countries to be the most efficient banking group (statistically significant at the 1% level), followed by banks from the Americas. Again, it is clear from column 8 of Table 10 that efficiency is negatively related to banks from other European countries under the value added approach.

It is worth highlighting several important points from the findings. Firstly, the results highlight the importance to differentiate foreign banks according to their origins. The empirical findings clearly suggest that generalizations made in regard to the higher efficiency levels of the foreign banks without taking into account their nations or regions of origins could lead to bias conclusions. And secondly, different inputs and outputs may result in different conclusions. The empirical findings from this study suggest that foreign banks from European countries were found to be relatively more efficient than their domestic bank counterparts under the intermediation approach, but were relatively inefficient under the value added and operating approaches. Likewise, although foreign banks from Asian countries were found to be relatively efficient compared to their domestic bank peers under the value added and operating approaches, they were found to be relatively inefficient under the intermediation approach.

Table 10
Multivariate Tobit regression analysis

Explanatory variables	Model 5			Model 6		
	Intermediation approach			Operating approach		
	(1)	(2)	(3)	(1)	(2)	(3)
CONSTANT	7.562*** (2.105)	7.520*** (2.105)	7.504*** (2.107)	4.464*** (1.151)	4.376*** (1.139)	4.199*** (1.108)
Bank characteristics						
LNDEPO	−0.207*** (0.070)	−0.232*** (0.051)	−0.231*** (0.056)	−0.025 (0.038)	−0.025 (0.028)	−0.067** (0.029)
LOANS/TA	0.551*** (0.108)	0.541*** (0.107)	0.542*** (0.113)	0.194*** (0.059)	0.194*** (0.058)	0.121** (0.060)
LNTA	0.184** (0.073)	0.208*** (0.056)	0.207*** (0.061)	0.014 (0.040)	0.014 (0.303)	0.062* (0.032)
LLP/TL	−0.050 (0.291)	−0.050 (0.292)	−0.054 (0.295)	0.292* (0.159)	0.266* (0.158)	0.198 (0.155)
NII/TA	0.342 (2.016)	0.314 (2.103)	0.470 (2.105)	3.204*** (1.102)	3.793*** (1.139)	1.979* (1.107)
NIE/TA	−16.133*** (2.280)	−16.113*** (2.321)	−16.051*** (2.630)	−10.417*** (1.246)	−9.954*** (1.258)	−7.836*** (1.382)
EQASS	−0.540 (0.449)	−0.523 (0.458)	−0.539 (0.455)	−0.282 (0.245)	−0.365 (0.248)	−0.429* (0.239)
ROA	0.005 (0.009)	0.005 (0.009)	0.005 (0.009)	0.033*** (0.005)	0.033*** (0.005)	0.032*** (0.005)
Economic conditions						
LNGDP	−0.632*** (0.194)	−0.628*** (0.194)	−0.626*** (0.194)	−0.322*** (0.106)	−0.314*** (0.105)	−0.306*** (0.102)
Bank nationality						
DUMAMER	0.031 (0.059)			0.001 (0.038)		
DUMEURO		0.009 (0.040)			−0.038* (0.022)	
DUMASIA			−0.001 (0.040)			0.078*** (0.021)
No. of observations	171	171	171	171	171	171
Log likelihood	81.532	81.418	81.396	184.796	186.272	191.337
R^2	0.496	0.495	0.495	0.500	0.509	0.537
Adj. R^2	0.461	0.460	0.460	0.465	0.475	0.505

Explanatory variables	Model 7		
	Value added approach		
	(1)	(2)	(3)
CONSTANT	3.446*** (1.130)	3.363*** (1.132)	3.125*** (1.091)
Bank characteristics			
LNDEPO	−0.018 (0.021)	−0.043 (0.028)	−0.083*** (0.029)
LOANS/TA	0.170*** (0.058)	0.160*** (0.057)	0.088 (0.059)
LNTA	0.004 (0.023)	0.028 (0.030)	0.075** (0.032)
LLP/TL	−0.167 (0.156)	0.156 (0.157)	0.069 (0.153)
NII/TA	3.202*** (1.083)	3.446*** (1.131)	2.098* (1.090)

Table 10 *(Continued)*

Explanatory variables	Model 7		
	Value added approach		
	(1)	(2)	(3)
NIE/TA	−8.603*** (1.224)	−8.367*** (1.248)	−5.938*** (1.362)
EQASS	−0.551** (0.181)	−0.572** (0.246)	−0.697*** (0.236)
ROA	0.032*** (0.005)	0.032*** (0.005)	0.031*** (0.005)
Economic conditions			
LNGDP	−0.219** (0.104)	−0.211** (0.105)	−0.197* (0.101)
Bank nationality			
DUMAMER	0.031 (0.032)		
DUMEURO		−0.009 (0.022)	
DUMASIA			0.077*** (0.021)
No. of observations	171	171	171
Log likelihood	187.862	187.465	193.914
R^2	0.463	0.461	0.500
Adj. R^2	0.426	0.423	0.465

$\theta_{jt} = \alpha + \beta_1 \text{LNDEPO} + \beta_2 \text{LOANS/TA} + \beta_3 \text{LNTA} + \beta_4 \text{LLP/TL} + \beta_5 \text{NIE/TA} + \beta_6 \text{EQUITY/TA} + \beta_7 \text{ROA} + \beta_8 \text{LOGGDP} + \beta_9 \text{DUMAMER} + \beta_{10} \text{DUMEURO} + \beta_{11} \text{DUMASIA} + \varepsilon_j$. The dependent variable is bank's efficiency scores derived from DEA intermediation, operating, and value added approaches; LNDEPO is a measure of bank's market share calculated as a natural logarithm of total bank deposits; LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets; LNTA is the size of the bank' total asset measured as the natural logarithm of total bank assets; LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans; NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets; NII/TA is a measure of bank's diversification towards non interest income, calculated as total non-interest income divided by total assets; EQUITY/TA is a measure of banks leverage intensity measured by banks total shareholders equity divided by total assets; ROA is a proxy measure for bank profitability calculated as bank profit after tax divided by total assets; LNGDP is natural logarithm of gross domestic product; DUMAMER, DUMEURO, and DUMASIA are dummy variables that take a value of 1 for foreign banks originated from the Americas, European countries and Asia, respectively, 0 otherwise. Values in parentheses are standard errors.***, **and * indicate significance at 1%, 5%, and 10% levels, respectively.

In essence, the findings, which suggest that the American banks were relatively more efficient compared to other foreign banks and their domestic bank peers, do not lend support to the "limited form" of *global advantage* hypothesis. Berger et al. (2000) argued that "under the limited form of *global advantage* hypothesis, only the efficient institutions in one or a limited number of nations with specific favourable market or regulatory conditions in their home countries can operate more efficiently than domestic banks in other nations."

5. Concluding remarks

The present study investigates the efficiency of the Malaysian banking sector around the Asian financial crisis 1997. The efficiency estimates of individual banks are evaluated by using the DEA approach. Three different approaches viz., intermediation approach, value added approach, and operating approach have been employed to differentiate how efficiency scores vary with changes in inputs and outputs. A multivariate Tobit model is employed to examine the relationship between efficiency scores derived from the DEA to a set of explanatory variables, i.e. bank size, profitability, and ownership.

The estimates of technical efficiency were observed to be consistently higher under operating approach vis-à-vis the intermediation and value added approaches. On the other hand, under the intermediation approach, banks are characterized by relatively low level of technical efficiency. The empirical findings clearly bring forth the high degree of inefficiency of the Malaysian banking sector around the East Asian crisis period, particularly a year after the East Asian crisis. The results suggest that although in general technical efficiency level seems to deteriorate abruptly a year after the East Asian crisis under all approaches, the deterioration seems to be more pronounced under the intermediation approach model.

The empirical findings suggest that the number of efficient banks under CRS (technical efficiency) technology and VRS technology (pure technical efficiency) differs markedly, irrespective of the choice of various inputs and outputs, suggesting the existence of sizable scale inefficiency among Malaysian commercial banks during the East Asian crisis period. During the pre-and post-crisis periods, scale inefficiency seems to outweigh pure technical inefficiency in determining the total technical inefficiency of the Malaysian banking sector under the intermediation approach. On the other hand, under the value added approach, while scale inefficiency outweighs pure technical inefficiency in determining the total technical inefficiency of the Malaysian banking sector during the pre-crisis period, the empirical findings seem to suggest that pure technical inefficiency outweigh scale inefficiency during the post-crisis period. Finally, under the operating approach, although pure technical efficiency is generally lower during the pre-crisis period, the trend is less clear during the post-crisis period. Thus, with respect to their scale of operations, Malaysian banks are likely to lose sizeable output particularly in the case of the intermediation approach, although at a lesser degree under the value added approach.

The results from the multivariate regression analysis suggest that technical efficiency is positively and significantly associated with loans intensity, suggesting that banks with higher loans-to-asset ratios exhibits higher efficiency scores. On the other hand, it appears that the expense preference behaviour not to be holding in the Malaysian banking sector, thus supporting Berger and DeYoung's (1997) *bad management* hypothesis. The findings clearly suggest that efficient cost management to be a prerequisite for the improved efficiency of the Malaysian banking system and that banks have much to gain if they improve their managerial practices. Furthermore, the Malaysian banking system has not reached the maturity level required to link quality effects pending from increased spending to higher bank efficiency. Similarly, LNGDP is also negatively related to Malaysian banks' efficiency levels. This could be explained by the volatile economic growth which could have resulted in banks to suffer from lower demand for their financial services, increases loan defaults, and thus lower output.

We find that the foreign banks have succeeded in capitalizing on their advantages and exhibit a higher level of efficiency compared to their domestic bank peers. However, we do not find evidence of higher efficiency levels of the publicly listed banks. Similarly, efficiency is not significantly related to the government link banks. The empirical findings do not support for the "limited form" of *global advantage* hypothesis and rejects the *home field advantage* hypothesis as the results suggest that the American banks are relatively more efficient compared to their domestic bank counterparts.

Due to its limitations, the paper could be extended in a variety of ways. Firstly, the scope of this study can be extended to examine the efficiency of the conventional banks compared to the Islamic banks. Secondly, the present study can also be extended to estimate the determinants of pure technical and scale efficiency along with the technical efficiency estimates. Finally, investigation of changes in productivity over time as a result of technical change or technological progress or regress by employing the Malmquist Productivity Index (MPI) could also be another extension to the present paper.

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