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Productivity and Technical Change in Malaysian Banking: 1989–1998*

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Abstract. This study examines the impact of deregulation and technological change on the productivity of Malaysian banks over the period 1989–1998. Malmquist indices constructed with nonparametric DEA techniques are decomposed into their pure efficiency, scale efficiency, and technological change components. Our findings indicate an erosion of banking productivity that masks divergent tendencies among its component elements. These are dominated by adverse effects of technological change, which are associated with a reduction in the labor intensity of banking activity. Consistent with the mixed findings reported in the literature, the present investigation suggests that regulatory reform and liberalization are not sufficient conditions for productivity improvement.

Key words: banking, Malmquist index, Malaysia, productivity

JEL classification: D24, G21

1. Introduction

Rapid regulatory and technological change in Malaysian banking characterized the turbulent post-crisis decade of 1988–1998. Bank Negara Malaysia, the central bank, introduced wide-ranging reforms of the management of monetary aggregates, specifically of reserves and liquidity, and of the process of interest rate determination. At the same time, the commercial banks invested heavily in information technology to establish extensive ATM networks and to offer new services such as home banking and telebanking. At issue is the effectiveness of the regulatory changes against the backdrop of technological innovation in promoting efficiency and productivity in Malaysian banking.

This study examines the impact of deregulation and technological change on the productivity of Malaysian banks over the period 1989–1998. As such it provides a contribution to the discussion of banking performance in industrializing countries. Specifically, the study explores banking productivity by measuring changes in the efficiency and productivity of commercial banks with nonparametric efficiency

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methods. To our knowledge this is the first study to employ that approach in the examination of productivity in the Malaysian banking sector. Empirical investigations of productivity change have been conducted predominantly for industries in industrialized countries that typically offer large sample populations of hundreds of firms. The need to extend such work to other environments has been emphasized by Berger and Humphrey (1997)[1] on the grounds that "banking markets that are more national in scope with much higher levels of concentration [relative to the U.S. market]" may be useful for research and policy purposes (p. 206).

Our sample period covers one expansion phase of the Malaysian business cycle. This phase is bounded by the 1985–1986 recession and the 1997 financial crisis. During this period attempts were made at liberalization and consolidation of the Malaysian banking system, and they resulted in significant progress in the rationalization of the sector. At the same time, the authorities retained an active involvement in the sector by issuing directives for commercial banking operations ranging from lending to human resources policies. Evidently, the pursuit of efficiency has become more important in this more competitive environment since the inefficient institutions are less likely to survive. Hence, it is essential for managers to be knowledgeable about inefficiencies in the banking industry and their causes. No doubt the same information will be useful for the regulators as well.

In the following section of the paper we review the structure of the Malaysian banking system and important developments that occurred during the sample period. A two-step methodology for isolating efficiency gains from changes in technology is developed in Section 3. The first stage utilizes Data Envelopment Analysis (DEA) to develop technical efficiency measurements of individual banks. These results are used as inputs for the calculation, in the second stage, of Malmquist indices that measure the growth in productivity. Data issues are discussed in Section 4, our results are presented in Section 5, and concluding observations in Section 6.

2. Recent Developments in the Malaysian Banking System[2]

There are three types of banking institutions in Malaysia: commercial banks, merchant banks, and finance companies. Commercial banks are authorized to take demand deposits and to conduct business in retail and corporate banking. They also provide services like merchant banking, stock brokering and insurance through subsidiaries. Finance companies accept time and savings deposits to fund activities like hire purchase lending[3] and provision of installment credit to consumers and small businesses. Merchant banks can accept only large denomination time deposits exceeding RM 200,000 (equivalent to USD52,632 at the pegged exchange rate of RM3.8 per USD), and their primary activities are concentrated in the areas of loan syndication, corporate advisory services, securities underwriting, and portfolio management. Commercial banks clearly dominate the financial sector in terms of portfolio size, holding 74% of total sector assets at the end of 1998, while finance companies and merchant banks hold 20 and 6%, respectively.

The commercial banking sector experienced significant growth during the sample period even though the total number of commercial banks declined slightly from 38 to 35. Descriptive aggregate data show that total assets nearly quintupled, branch networks almost doubled, ATM networks more than trebled, and the number of employees increased by approximately 70%. Total assets per employee grew by some 175%, rising from RM 2.36 mn in 1988 to RM 4.58 mn in 1995 and to RM 6.46 mn in 1998. Taking assets per employee as a rough guide to labor productivity in banking, these figures suggest that the average product of bank employees in Malaysia has increased substantially throughout the decade under observation. However, pre-tax profits per employee experienced a dramatic reversal during the period. After increasing during the first half of the decade by some 359% they deteriorated sharply. At the end of the decade they had declined to slightly more than half (57%) of their 1988 level. While the post-crisis surge in bad debts may have contributed substantially to this deterioration, the evidence suggests that labor productivity and efficiency do not necessarily move in tandem.

Financial fallout from the 1985/6 recession left commercial banks holding net non-performing loans (NPL) of RM 8.7 billion, or 17.8% of banks' total loans, at the end of 1988.[4] Rapid economic growth during 1990–1996 strengthened earnings and improved debt servicing by clients. Pre-tax profits of commercial banks increased seven-fold during the economic recovery phase, from RM 679 million to RM 4.8 billion, while the NPL ratio declined to 1.9%. The expansion continued until the regional crisis of 1997 hit the Malaysian economy. The ensuing contraction, combined with high interest rates, compromised the quality of banks' loan portfolios, dramatically reversing the improvement in the NPL-ratio. By 1998 pre-tax profits had fallen below their 1988 level, and the NPL ratio had increased to 5.9%, almost three times the level it had attained at the height of the recovery three years earlier.[5] The sector incurred an aggregate pre-tax *loss* of RM 657.9 million, which represents a RM 5.5 billion turnaround over three years, and a decrease of nearly 200% from the depressed level at the beginning of the decade.

Some progress towards liberalization of the regulatory environment was achieved during the period of observation. Most notably, the central bank removed administrative controls over interest rates. In February 1991, banking institutions were permitted to set their own deposit and lending rates. Other reforms covered the "scope of investment of commercial banks in both equity and private debt securities; streamlining the classification of NPLs, suspension of interest on NPLs and provisioning for bad and doubtful debts; guidelines for minimum audit standards for internal auditors of financial institutions and duties of and responsibilities of directors of banking institutions" (BNM, 1999). At the same time, some quantitative lending directives remained in force. Malaysian commercial banks (and finance companies) were required to extend a certain amount of credit to priority sectors including the Bumiputra community of indigenous Malays, small and medium-sized enterprises, and prospective homebuyers from lower middle-income groups. The

Table I. Commercial banks (including foreign banks): Key data, income, and expenditure (With the exception of the first four and last rows all figures are in RM million)

	1988	1995	1998
Number	38	37	35[1]
Branch network	911	1433	1,690[1]
ATM network (*machines*)	861	2230	2,647[1]
Number of employees	41605	64461	71124
Assets[2,3]	98200	295460	459190
Net Non Performing Loans (NPL)[4,5]	8706	4332[6]	16739
Net NPL as percentage of Total Loans[4,5]	17.8	1.9[6]	5.9
Income and expenditure[2]			
Interest income (net of interest-in-suspense)	4972.2	16889.1	42763.0
(*interest-in-suspense*)[7]	1469.8	331.6	1589.3
Less: Interest expense	3418.7	10100.6	29400.1
Net interest income	1553.5	6788.5	13362.9
Add: Non-interest income	1705.4	3067.5	4958.0
Less: Bad debt provisions[8]	704.9	735.0	12189.3
Staff costs	909.9	2280.9	3167.0
Overheads	965.0	2013.7	3622.5
Pre-tax profit	679.1	4826.4	(657.9)
Coarse performance measures			
Assets per employee	2.36	4.58	6.46
Pre-tax profits per employee	16 323	74 873	(9250)

Sources: Bank Negara Malaysia (1994) and Bank Negara Malaysia (1999).

[1] From Bank Negara Malaysia Annual Report 2000.

[2] At financial year ends.

[3] Includes Bank Islam Malaysia Berhad.

[4] At calendar year ends.

[5] Net Non Performing Loans: Gross NPL− (interest-in-suspense) – (specific provisions for doubtful and bad debts). (See footnote 2 for definitions.)

[6] 1996 figures.

[7] Where an account is classified as non-performing, recognition of interest income is suspended until it is realised on a cash basis.

[8] Bad debt provisions are consisted of special and general provisions. General provision, is made to cover possible losses which are not specifically identified.

mandated priority lending requirements had to be met by financial institutions as a group (BNM, 1999).

During the recovery phase the banking industry implemented extensive technological innovations. Three ATM networks were established between 1987 and 1993, and the number of ATMs increased dramatically from 861 in 1988 to 2230 in 1995 (BNM, 1996). Banks also developed new payment systems and electronic delivery mechanisms (BNM, 1999),[6] and they introduced new instruments such as market-traded financial derivatives (financial futures). Coarse performance indicators are qualitatively consistent with the expected thrust of these innovations. During the decade under observation the productivity measure provided by the amount of assets per employee almost trebled as did the efficiency indicator of profits per employee before its deterioration during the last three years of the decade.

While some constraints on profit-maximizing behavior were substantially relaxed by the regulatory reforms, efficiency in the Malaysian banking system continues to be inhibited by particular institutional characteristics. One problem is the moral hazard created by bank bailouts.[7] Expectations that governments will not permit bank failures to occur may have adverse incentive effects that are detrimental to efficiency if they compromise standards of prudential management. In a similar vein, the limitations to competition created by the high concentration of the Malaysian banking system (52% of banking assets were held by the top five banks in 1992) tend to restrict the scope for potential gains from vigorous competition. Further limitations include regulations that prevent domestic banks from setting up new branches or new subsidiaries and the prohibition of foreign banks from opening new branches or even operating ATMs. At the same time, the Malaysian nationalization movement that started in the late 1980s has tended to restrain the enthusiastic adoption of foreign technological innovations. Restrictions on the number of expatriate staff that banks are permitted to hire and on the number of financial services they can offer are not conducive to promoting technology transfers and innovation (Dobson and Jacquet, 1998).

3. Methodology[8]

Since the level of productivity of an activity is determined jointly by the state of technology and by the efficiency in the use productive factors, cet. par., changes in productivity are similarly decomposable. The (relative) efficiency of an operation is reflected in its factor product compared to the optimum output that can be produced, given the state of technology. Technological change shifts the production function and, hence, the volume of potential optimum output. Accordingly, in order to identify secular changes in efficiency we need to trace movements in the relative position of actual to potential output over time while controlling for technical progress.

The empirical challenge is to determine a valid and robust decomposition of observed output changes into its constituent components that are attributable to changes in efficiency and to changes in technology. To this end we develop output distance functions that trace efficiency movements, and productivity indices that decompose productivity changes in order to isolate the effect of shifts of the production function. There are several established productivity indices developed by Fisher (1922), Törnqvist (1936), and Malmquist (1953). Calculation of the Fisher and Törnqvist indices requires information about prices, whereas the Malmquist index is quantity based. This is a powerful advantage when price information is unavailable or when price data are subject to severe contamination. On the other hand, calculation of the Malmquist index requires knowledge of the production function. We approximate that information by constructing the best-practice frontier. However, it must be noted that this surrogate measure is susceptible to distortion.

DEA relies on outlying observations in the sense that it estimates frontiers instead of central tendencies. It fits the frontier to the best-practice observations without accounting for the stochastic nature of the data. Consequently, existing transient outliers may bias the estimation of the frontier and the associated efficiency scores. In the present setting, choice between the alternative productivity indices was effectively preempted by the lack of reliable and transparent price information for the various banking activities and financial services in Malaysia. By the same token, we have to beware of the possible distortions that may be introduced into the positioning of the frontier by the potentially superior access to technology and personnel enjoyed by the Malaysian subsidiaries of foreign banks.

3.1. EFFICIENCY – SHEPHARD OUTPUT DISTANCE FUNCTIONS

One instrument for measuring efficiency is provided by the Shephard output distance function, which compares actual performance to best practice in the industry (Shephard, 1970). Industry best-practice is the empirical approximation of potential optimum output. Specifically, we calculate an efficiency indicator for each bank by measuring the distance of its location in input–output space from the production frontier. This distance can be measured either as the actual relative to the optimum position (Shephard “D”) or by its inverse, the optimum relative to the actual position on the frontier (Debreu–Farrell “DF”). The latter represents the proportionate expansion of output that is required to reach the potential optimum output for given input use and technology. By way of illustration, suppose actual output is 80 and potential optimum output is 100. Then the Shephard $D = 0.8$ – actual output amounts to 80% of optimum output – , and the Debreu–Farrell $(DF) = 1.25$ – actual output must be increased by 25% to reach the production frontier.

Best practice technology is represented by the frontier that envelops all current production points. This frontier is constructed by connecting the input-output combinations achieved by the best performing firms (banks). These are most efficient in the sense of achieving the highest level of output from given quantities of inputs. With constant returns to scale (CRS) the position of the linear frontier is fixed by the highest point in input–output space, irrespective of firm size as measured by the quantity of inputs used. Conversely, if returns are variable (VRS), then the frontier is constructed from the set of points representing the banks that are most efficient at different levels of operation. Banks situated below or inside the frontier are considered inefficient in the sense that they produce less than the maximum potential (best-practice) output from a given quantity of inputs indicated by the frontier. Changes in best practice performance are attributed to technical progress that shifts the frontier outward.

To formalize these concepts, consider S banks producing m outputs by using n inputs. Let $\mathbf{x}^{i,t} = (x_1^{i,t}, \ldots, x_n^{i,t}) \in \Re_+^n$ and $\mathbf{y}^{i,t} = (y_1^{i,t}, \ldots, y_m^{i,t}) \in \Re_+^m$ denote input and output vectors (*column* vectors), respectively, of bank $i = 1, \ldots, S$ in time period $t = 1, \ldots, T$. The production possibilities set at time t, which is assumed to be convex and available to any bank, is defined as:

$$P^t = \{(x, y) \mid \mathbf{x} \text{ can produce } \mathbf{y} \text{ at time } t\}.$$

The upper boundary of P^t is referred to as technology or production frontier. It is also possible to describe the production possibilities set by its output correspondence sets:

$$y^t(\mathbf{x}) = \{\mathbf{y} \in \mathbf{R}_+^m \mid (\mathbf{x}, \mathbf{y}) \in \mathbf{P}^t\}.$$

We assume that y^t has the following properties:

(i) y^t is convex, closed, and bounded for all $\mathbf{x} \in \Re_+^n$,
(ii) To produce non-zero output levels, some inputs must be used;
(iii) Both inputs and output are strongly disposable, that is, a bank can dispose its unwanted inputs or outputs costlessly.[9]

The Shephard output distance function for bank i at time t_q for given period t_k technology (as indicated by the superscript "t_k" attached to D) can be defined as

$$D^{t_k}(\mathbf{x}^{i,t_q}, \mathbf{y}^{i,t_q}) \equiv \inf\{\delta > 0 \mid \mathbf{y}^{i,t_q}/\delta \in y^{t_k}(\mathbf{x}^{i,t_q})\}.$$

Since it is not possible to observe distance functions directly, we must use approximations. Distance functions with CRS technology can be estimated based on the following:

$$\hat{y}^t_{\text{CRS}}(\mathbf{x}) = \{\mathbf{y} \in \mathbf{R}_+^m \mid \mathbf{y} \leq \mathbf{Y}^t\lambda, \mathbf{x} \geq \mathbf{X}^t\boldsymbol{\lambda}, \boldsymbol{\lambda} \in \Re_+^S\}$$

where $\mathbf{Y} = [\mathbf{y}^{1,t} \ldots \mathbf{y}^{S,t}]$ and $\mathbf{X} = [\,\mathbf{x}^{1,t} \ldots \mathbf{x}^{S,t}]$, and $\boldsymbol{\lambda}$ is a $(S \times 1)$ vector of intensity variables. The circumflex denotes the estimated value of a variable ("$\hat{y}$" represents the estimated output correspondence set). The corresponding estimated distance functions for the individual banks are given by

$$D^{t_k}_{\text{CRS}}(\mathbf{x}^{i,t_q}, \mathbf{y}^{i,t_q}) = \max\{\theta^i \mid \theta\mathbf{y}^{i,t_q} \leq \mathbf{Y}^{t_q}\boldsymbol{\lambda}^i, \mathbf{x}^{i,t_q} \geq \mathbf{X}^{t_q}\boldsymbol{\lambda}^i, \boldsymbol{\lambda}^i \in \Re_+^S\}.$$

Similarly, we obtain for VRS

$$\hat{y}^t_{\text{VRS}}(\mathbf{x}) = \{\mathbf{y} \in \mathbf{R}_+^m \mid \mathbf{y} \leq \mathbf{Y}^t\boldsymbol{\lambda}, \mathbf{x} \geq \mathbf{X}^t\boldsymbol{\lambda}, \vec{\mathbf{1}}\boldsymbol{\lambda} = 1, \boldsymbol{\lambda} \in \Re_+^S\}$$

and

$$D^{t_k}_{\mathrm{VRS}}(\mathbf{x}^{i,t_q}, \mathbf{y}^{i,t_q}) = \max\{\theta^i \mid \theta\mathbf{y}^{i,t_q} \leq \mathbf{Y}^{t_q}\boldsymbol{\lambda}^i, \mathbf{x}^{i,t_q} \geq \mathbf{X}^{t_q}\boldsymbol{\lambda}^i, \vec{\mathbf{1}}\boldsymbol{\lambda}^i = 1, \boldsymbol{\lambda}^i \in \Re^S_+\}$$

where $\vec{\mathbf{1}}$ is a $(1 \times S)$ vector of ones.

3.2. PRODUCTIVITY – MALMQUIST INDEX

The Malmquist index is the geometric mean of two productivity indices that use output distance functions for the alternative base periods t and $(t+1)$ as indicated by the D-superscripts:

$$M = \left[\frac{D^t(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})} \frac{D^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D^{t+1}(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}\right]^{1/2}$$

The first index relates the input–output combinations observed in the two time periods (t and $t+1$) to the period t technology frontier, and the second index relates the same input–output combinations to the period $(t+1)$ technology frontier. The terms in the numerator are the inputs used and outputs generated by firms i in period $t+1$, and those in the denominator represent the corresponding quantities observed for period t. Following popular convention, we use the geometric average of the two indices to avoid biasing the results by the choice of base period.

Following Fare et al. (1995), manipulation of the Malmquist index enables us to distinguish between efficiency changes and productivity changes:

$$M = \frac{D^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}\left[\frac{D^t(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})} \frac{D^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}{D^{t+1}(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}\right]^{1/2} = \Delta E \cdot \Delta T$$

The first term represents the change in technical efficiency (ΔE), and the expression in square brackets represents technological change (ΔT). Values greater than one for the Malmquist index indicate an improvement in productivity, and values less than one signal deterioration. The same interpretation applies to the numerical values obtained for the efficiency and technology indices. Formally, there is no presumption that the three indices must always move in the same direction. For instance, an improvement in productivity is entirely compatible with opposite movements in technical efficiency or technology, provided the deterioration in one component is more than offset by an improvement in the other to generate a value of M greater than 1. For illustration, suppose efficiency deteriorates by 50% such that $\Delta E = 0.5$ and technology improves by 120% such that $\Delta T = 2.2$. Then $M = 0.5 * 2.2 = 1.1$, i.e., productivity has increased by 10%.

By way of illustration, the rays from the origin in Figure 1 represent the estimated production frontiers for periods t and $t+1$, respectively. The slopes of those rays

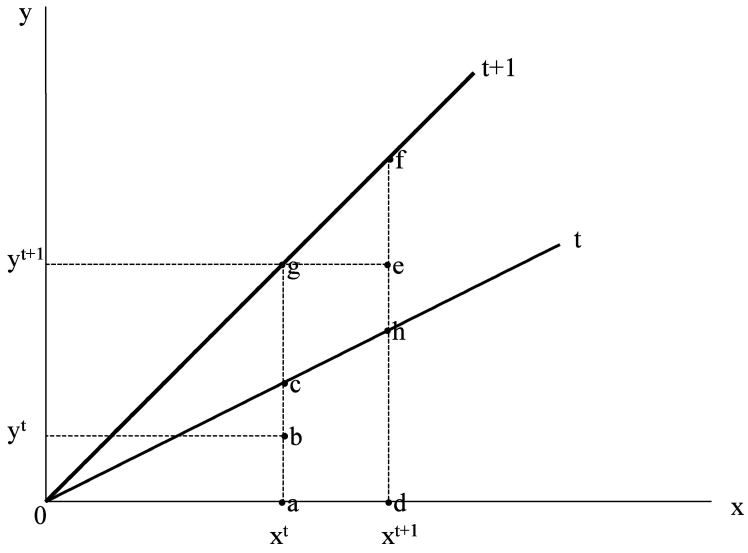

Figure 1. Estimated production frontiers for periods t and $t+1$.

are determined by factor productivity, and are obviously constant in the CRS case. Assume in period t bank i operates at point b, using x^t amount of inputs to produce y^t amount of output, and that it operates at point e in period $t+1$, using x^{t+1} inputs to produce y^{t+1} amount of output. We can now represent the output distance functions that constitute the Malmquist index in terms of the relevant coordinates in Figure 1:

(i) Distance functions

Technical efficiency in period t relative to frontier t:	$D^t(x^t, y^t) = ab/ac.$
Technical efficiency in period t relative to frontier $t+1$:	$D^{t+1}(x^t, y^t) = ab/ag.$
Technical efficiency in period $t+1$ relative to frontier $t+1$:	$D^{t+1}(x^{t+1}, y^{t+1}) = de/df,$
Technical efficiency in period $t+1$ relative to frontier t:	$D^t(x^{t+1}, y^{t+1}) = de/dh.$

(ii) Efficiency Indices. The change in technical efficiency can be expressed geometrically as

$$\Delta E = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} = \frac{de/df}{ab/ac},$$

and the change in technology as

$$\Delta T = \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})}\frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}\right]^{1/2} = \left[\frac{de/dh}{de/df}\frac{ab/ac}{ab/ag}\right]^{1/2} = \left[\frac{df}{dh}\frac{ag}{ac}\right]^{1/2}.$$

The change in productivity, as measured by the Malmquist index, is then

$$\begin{aligned} M = \Delta E * \Delta T &= \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)}\left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})}\frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}\right]^{1/2} \\ &= \frac{de/df}{ab/ac}\left[\frac{df}{dh}\frac{ag}{ac}\right]^{1/2}. \end{aligned}$$

Figure 1 also illustrates an alternative interpretation of the Malmquist index as the growth of total factor productivity (TFP): M = $\mathrm{TFP}^{t+1}/\mathrm{TFP}^t$. First, note that $ab = y^t$ and $de = y^{t+1}$. Define the slopes of rays t and $t+1$, the best-practice factor products, as τ and τ_1, respectively, to obtain the following definitions: $ac = \tau \mathrm{x}^t$, $ag = \tau_1 \mathrm{x}^t$, $dh = \tau \mathrm{x}^{t+1}$, and $df = \tau_1 \mathrm{x}^{t+1}$. Substituting these definitions into the equation for M transforms the Malmquist index into a measure of TFP growth:

$$\begin{aligned} \frac{y^{t+1}/\tau_1 x^{t+1}}{y^t/\tau x^t}\left[\frac{\tau_1 x^{t+1}}{\tau x^{t+1}}\frac{\tau_1 x^t}{\tau x^t}\right]^{1/2} &= \frac{y^{t+1}/x^{t+1}}{y^t/x^t} = \frac{TFP^{t+1}}{TFP^t} = \frac{de/df}{ab/ac}\left[\frac{df}{dh}\frac{ag}{ac}\right]^{1/2} \\ &= \Delta E * \Delta T = M \end{aligned}$$

3.3. SCALE EFFICIENCY

One implication of the CRS scenario is that bank size does not matter for productivity. The assumption that small banks generate as much output per unit of input as do large banks is not immune to challenge on a priori grounds, and it sits uneasily with the manifest global trend towards increasing concentration in the banking industry. Hence, investigations of efficiency in banking should allow, at least in principle, for the existence of variable returns to scale (VRS).

Computation of a scale efficiency index requires calculation of two additional distance functions (technical efficiencies) with reference to the production frontier generated by a VRS technology. The distance functions, $D_v^t(x^t, y^t)$ and $D_v^{t+1}(x^{t+1}, y^{t+1})$, identify the position of the individual banks relative to the maximum optimal output that can be achieved with VRS technology. Accordingly, with suitable algebraic manipulation we can further decompose the Malmquist Index to capture explicitly the contribution of economies of scale to productivity.

$$\begin{aligned} M_v = \frac{D_v^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D_v^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}&\left[\left(\frac{D^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D_v^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}\right)\Big/\left(\frac{D^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}{D_v^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}\right)\right] \\ \times &\left[\frac{D^t(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}\frac{D^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}{D^{t+1}(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}\right]^{1/2} \end{aligned}$$

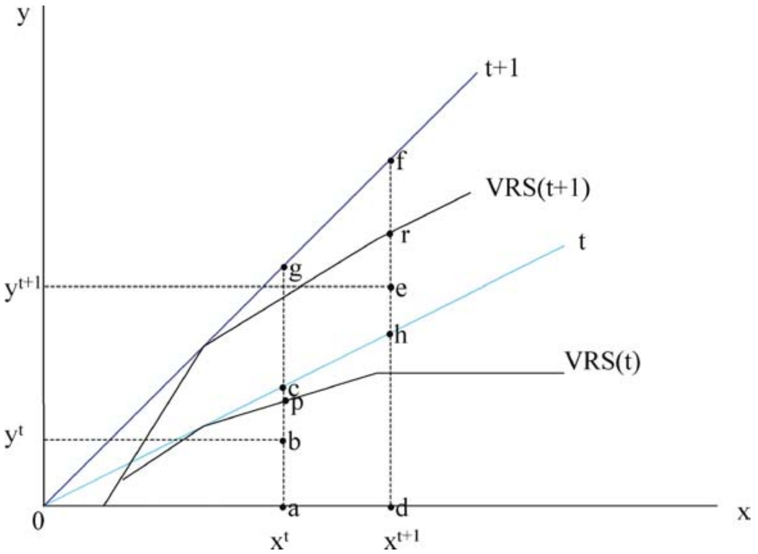

Figure 2. VRS and CRS production functions.

Or

$$M_v = \Delta P * \Delta S * \Delta T.$$

The first term (ΔP) represents an index measure of change in pure technical efficiency. The second term (ΔS) captures the effect of scale economies in terms of the distance between the optimal outputs that can be obtained from actual factor use at times (t) and ($t + 1$) under CRS and VRS technologies. In this comparison the relevant CRS frontier is fixed by the productivity obtained from the optimal VRS scale. That is to say, ΔP and ΔS are elements of the generic technical efficiency measure (ΔE) that was derived for the CRS case. The last term measures the change in technology (ΔT) as before.

For illustration, note that Figure 2 depicts both VRS and CRS production functions. In time period t production occurs at point b, and in time period ($t + 1$) it occurs at point e. The corresponding distance functions and efficiency indices with respect to either technology are represented geometrically as follows:

(i) Distance functions. In the presence of VRS, the output distance functions developed for CRS have to be augmented by two distance functions to capture the scale effect.

Technical efficiency in period t relative to the VRS frontier in t:	$D_v^t(x^t, y^t) = ab/ap$,
Technical efficiency in period $t + 1$ relative to the VRS frontier in $t + 1$:	$D_v^{t+1}(x^{t+1}, y^{t+1}) = de/dr$

(ii) Efficiency Indices

$$
\begin{aligned}
\Delta P &= \frac{D_v^{t+1}(x^{t+1}, y^{t+1})}{D_v^t(x^t, y^t)} = \frac{de/dr}{ab/ap} \\
\Delta S &= \left(\frac{D^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D_v^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}\right) \Big/ \left(\frac{D^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}{D_v^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}\right) \\
&= \frac{(de/df)/(de/dr)}{(ab/ac)/(ab/ap)} = \frac{dr/df}{ap/ac} \\
M_v &= \Delta P * \Delta S * \Delta T \\
&= \frac{D_v^{t+1}(x^{t+1}, y^{t+1})}{D_v^t(x^t, y^t)} \left[\left(\frac{D^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}{D_v^{t+1}(\mathbf{x}^{i,t+1}, \mathbf{y}^{i,t+1})}\right) \Big/ \left(\frac{D^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}{D_v^t(\mathbf{x}^{i,t}, \mathbf{y}^{i,t})}\right)\right] \\
&\quad \times \left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}\right]^{1/2} = \frac{de/dr}{ab/ap} \frac{dr/df}{ap/ac} \left[\frac{df/dh}{ac/ag}\right]^{1/2} \\
&= \frac{de/df}{ab/ag} \left[\frac{df/dh}{ag/ac}\right]^{1/2}
\end{aligned}
$$

3.4. DATA ENVELOPMENT ANALYSIS (DEA) AND THE CALCULATION OF THE DISTANCE FUNCTIONS

The output distance functions that constitute the Malmquist index can be calculated by DEA or they can be estimated econometrically. DEA is a non-parametric technique that does not require the imposition of any specific structure on the production technology (Grifell-Tatje and Lovell, 1997, p. 366). At the same time, its usefulness hinges on the strong assumption that there is no random error in the data since **all** observed deviations from the frontier are attributed to inefficiency. Specifically, DEA does not allow for measurement errors or chance factors that could bias the calculation of efficiency indicators. Conversely, econometric methods of estimating the production frontier, such as the Stochastic Frontier Approach (SFA), have their own structural shortcomings that potentially bias the results. They require a specific functional form (e.g. translog) and impose restrictive distributional assumptions on the joint error terms that are estimates of inefficiency and stochastic variation around the estimated frontier. These joint-distribution assumptions may not be sustained by the data.

DEA methodology requires solving a series of linear programming problems. As before assume that there are S banks producing m outputs by using n inputs. Let $\mathbf{x}^{i,t} = (x_1^{i,t}, \ldots, x_n^{i,t}) \in \Re_+^n$ and $\mathbf{y}^{i,t} = (y_1^{i,t}, \ldots, y_m^{i,t}) \in \Re_+^m$ denote input and output vectors, respectively, of bank $i = 1, \ldots, S$.

CRS output distance functions for bank k can be calculated as follows:

$$
[D^t(\mathbf{x}^{k,t}, \mathbf{y}^{k,t})]^{-1} = \max_{\theta, \boldsymbol{\lambda}} \theta
$$

s.t.

$$\theta y_m^{k,t} \leq \sum_{i=1}^{S_t} \boldsymbol{\lambda}^{i,t} y_m^{i,t}, \quad m = 1, \ldots, M$$

$$\sum_{i=1}^{S_t} \boldsymbol{\lambda}^{i,t} x_n^{i,t} \leq x_n^{k,t}, \quad n = 1 \ldots, N$$

$$\boldsymbol{\lambda}^{i,t} \geq 0, \ i = 1, \ldots, S_t$$

where t indexes the time period. $\boldsymbol{\lambda}$ is a column vector of intensity variables ($\lambda \in \Re_+^N$). The output distance functions required for constructing the VRS frontier can be calculated by including $\sum_{i=1}^{S_t} \lambda^{i,t} = 1$ as an additional constraint to the above problem. Distance functions must be calculated for all banks in the sample for each period (t and $t + 1$) separately. The remaining distance functions needed to compute Malmquist indexes require the solving of mixed period linear programming problems (see Coelli et al., 1998 for details).

4. Data

The potential sample size is limited to the twenty-one domestic banks that existed at the beginning of the sample period (1989–1998). We had to delete five banks from this list because we were not able to obtain complete data for the earlier period (see appendix). No new banks were established during the period of observation, but two mergers occurred in 1991 and 1997. In the former case we include the post-merger data in the period two subsample as we have no pre-merger data. In the second case, we were able to find data for one of the merged banks for the earlier period, and included this bank in the period one subsample. Hence, the number of banks that operated continuously throughout our entire sample period is sixteen. The potential "survivorship bias" is somewhat attenuated by the inclusion of four banks that did not operate throughout the entire sample period. Data were collected from the annual reports of individual banks, from the Association of Banks in Malaysia, and from Reports filed with the central bank of Malaysia. Data from banks operating on a financial year different from the calendar year (only seven banks) have been assigned to the calendar year in which the financial year ends.[10]

Our aim is to measure the effects on bank productivity of regulatory changes, reforms, and technological developments during the sample period. We exclude observations before 1989 and after 1998 because these are turbulent years of recession and crisis that are liable to introduce additional distortions into the data set. The sample period is divided into two sub-periods, 1989–1993 and 1994–1998, respectively, in recognition of the fundamental changes in the methods used to determine one of the key inputs, interest expense. In both sub-periods eighteen banks comprise the sample, but the two sets are not identical because the identity of the not-continuously operating banks changes between the two sub-periods. We examine the productivity of each member of the sample of sixteen continuously operating banks for each sub-period separately. We repeat the exercise for the full sample of eighteen banks and recalculate the relevant indices for each sub-period by including the two institutions that did not operate in both periods. The rationale for this exercise is that significant elements of both types of institutions existed in both periods, albeit in different configurations.

Some adjustments to the data were necessitated by idiosyncrasies in reporting, such as changes in the financial year or variable reporting dates and missing observations. (Information about the nature of the adjustments is presented in Appendix Table AIV.) We use these adjusted data to calculate the efficiency and Malmquist productivity scores for each bank. Later, we construct modified samples by deleting from the original samples those banks for which we used adjusted data, and recalculate the productivity indexes. This serves as test of sensitivity of our results to the data adjustments.

While our sample size is easily dwarfed by efficiency studies of US banks, there is ample precedent for investigations utilizing relatively small samples. In Australia Avkiran (1999) investigated 16–19 banks and Sathye (2001) 29 banks. Noulas (1997) examined 20 Greek banks, Giokas (1991) 20 branches of the Commercial Bank of Greece, and Oral and Yolalan (1990) a set of 20 bank branches of a major Turkish bank. Pastor et al. (1997) rely on small samples in their study of banking efficiency in Europe (e.g, 22 banks in Germany, 18 banks in UK, 31 banks in Italy, 17 banks in Belgium). Evanoff and Israilevich (1991, quoted in Avkiran, 1999) argue that DEA is quite suitable for working with small samples. Its methodology, aimed at the identification of frontiers, is not as susceptible to the distortion of small sample errors as are econometric methods that seek to estimate central tendencies of the relevant production functions.

Some guidance for acceptable sample size can be gleaned from reported rules of thumb. For instance, Soteriou and Zenios (1998) as well as Dyson et al. (1998) suggest that sample size should be larger than the product of the number of inputs and number of outputs. Alternatively, Nunamaker (1985) maintains that the sample size should be at least three times as large as the *sum* of the number of inputs and the number of outputs. Our sample satisfies both criteria.

There are a number of alternative approaches to the specification of inputs and outputs in ‘bank production’. The two main approaches used extensively are the production and intermediation approaches. The activity-based production approach treats the number of accounts and transactions processed as outputs, produced with the application of inputs of labor and capital. The intermediation approach emphasizes the conversion by banks of loanable funds (obtained from savers) into loans and other assets. Different variants of the intermediation approach (Mukherjee et al. (2001, p. 924: asset, value added, and user cost approach (Grifell-Tatje and Lovell, 1997, p. 369, citing Berger and Humphrey, 1992) select different input and output measures. In view of the central role of intermediation, the cost of the funds to be intermediated (that is, interest expense) constitute a major input. Other factors such as labor and operating costs are also potentially important inputs. We use three outputs – investment securities, loans & advances, and deposits from customers – and two inputs – labor and borrowed funds, as reflected in personnel costs and interest expense, respectively. Customer deposits include saving, current account, fixed deposits, and negotiable instruments of deposit. Since data on quantities (number of accounts, etc.) are not available, we use reported nominal values, deflated by the CPI to obtain constant 1995 ringgit values. The mean values of outputs and inputs used in the study are reported in Table II.[11]

Our choice of outputs may be criticized on the grounds that we do not provide evidence of the dominance of loans and deposits in the value additions produced by banking activity in Malaysia. Lacking adequate data to demonstrate such dominance we rely on the observations of Berger and Humphrey (1993) who have noted in similar investigations that deposits (demand, savings, and time) and loans do create most of the value added. Regarding the choice of inputs we note that the use of interest expense is not uncommon in the literature (for example, Avkiran (1999) and (2000), Bhattacharya et al. (1997), Yue (1992)[12]). Data limitations prevented us

Table II. Mean values of outputs and inputs used in the study (in thousands of 1995 Ringgit)

	Outputs			Inputs	
	Investment securities	Loans and advances	Deposits	Interest expense	Personnel expenditures
1989	8938.08	23856.01	32221.16	2066.65	422.22
1990	6781.48	27157.07	35572.49	2488.38	463.72
1991	7964.80	33170.18	40670.63	2998.35	532.96
1992	7583.98	37663.86	44935.92	3517.68	572.12
1993	8070.22	39227.15	52059.97	3816.26	624.85
1994	10722.47	43096.13	58052.64	3555.30	782.02
1995	13283.68	56025.90	66948.53	3571.67	875.56
1996	13443.43	68374.82	79028.37	4760.75	975.82
1997	17672.87	81165.97	89928.32	6125.93	1110.59
1998	16222.55	85958.36	95720.47	8819.51	1086.49
1989	8854.99	24536.83	32441.30	2037.54	444.57
1990	6766.66	27721.10	35294.79	2720.87	487.93
1991	7899.42	33014.72	39982.90	2889.06	549.30
1992	7742.12	37313.26	44451.54	3394.57	583.97
1993	8137.28	38416.36	50718.48	3682.99	630.69
1994	10459.22	43253.94	56585.34	3478.07	741.33
1995	12861.43	55945.66	66148.81	3582.51	834.11
1996	13384.75	67737.39	77462.84	4748.99	924.28
1997	17384.21	80742.72	88292.98	6149.21	1049.37
1998	16293.12	85178.31	93914.95	8792.11	1025.31

from including non-labor operating expenditures (establishment costs, marketing expenses, administration and general expenses) which could be used as proxy for expenditure on physical capital. Interest expense and personnel expenditure absorb approximately three-quarters of interest income, and staff costs have been of a similar order of magnitude as reported overheads (Table I). We have explored the sensitivity of our findings to alternative specifications of inputs by including, subject to data availability, depreciation expenditure and overhead expenditure. While the alternative models yield some expected variation in yearly measurements, the mean values of the Malmquist indices and their components are reasonably robust with respect to these specification experiments.[13]

Representing the labor input by the cost of personnel offers some protection against biases and distortions that could result from systematic variation of labor quality across banks and over time (Berg et al., 1992; Pastor et al., 1997). A bank could be more efficient simply because its employees are on average more capable (efficient) than staff employed by other banks. This might be the result of superior recruitment techniques or human resources management, or of preferential access to a larger and better-trained labor pool that may be enjoyed, for instance, by the Malaysian subsidiaries of foreign banks. Quality differentials of labor based on skill and education should be reflected in compensation and, hence, in commensurate differences in the personnel costs of different banks. This argument presupposes that the labor market is not sufficiently organized to exert market power for the effective redistribution of rents (Pastor *et al., loc cit)*. Interest expense is a similarly coarse proxy for the cost of borrowed funds. Even though we are controlling for inflation, these costs are unlikely to provide a reliable measure of the total expense incurred in raising loanable funds. Financial regulations and controls that impose lending directives and other restrictions on the commercial decisions of bank management invariably encourage cost-shifting and cross-subsidization between the various intermediation activities.

5. Results

5.1. EFFICIENCY

We present the annual (geometric) means of the Constant Returns to Scale technical efficiency scores (denoted by “E” in the preceding discussion) in Table III for both the sample of sixteen continuously operating banks (COBs henceforth) and for the full sample of eighteen banks. These are annual estimates of the distance functions $D^t(x^t, y^t)$. Given the evolving nature of the best practice benchmark, absolute efficiency measures are not directly comparable intertemporally. By normalizing the best practice benchmark at unity (=100%) for each year, our efficiency scores represent relative magnitudes. Hence, the proportionate efficiency scores, evaluated relative to the best practice standard for each observation year, are comparable over time in the sense that average banking practice (excluding the best-practice bank)

Table III. Technical efficiency scores

	Continuously operating banks, COB ($N = 16$)			Full sample ($N = 18$)		
	Mean	Gap (%)	Min	Mean	Gap (%)	Min
1989	0.918	8.2	0.728	0.912	8.8	0.728
1990	0.952	4.8	0.804	0.916	8.4	0.650
1991	0.933	6.7	0.793	0.930	7.0	0.773
1992	0.958	4.2	0.739	0.932	6.8	0.727
1993	0.958	4.2	0.767	0.953	4.7	0.765
1994	0.948	5.2	0.843	0.922	7.8	0.659
1995	0.919	8.1	0.791	0.912	8.8	0.791
1996	0.930	7.0	0.779	0.928	7.2	0.761
1997	0.928	7.2	0.697	0.935	6.5	0.697
1998	0.930	7.0	0.671	0.934	6.6	0.671

Gap: (1-mean) $*$ 100, indicates the difference between the best practice banks and the average performance of the remaining banks.

converges to, or diverges from, the performance of the best-practice bank. This disparity is reported as "gap" in our tables.

Our results suggest a tendency towards convergence of the average efficiency of individual banks during the first sub-period, followed by a tendency towards divergence and eventual stabilization during the second sub-period. There is considerable variability in average efficiency as well as in the relative performance of the least efficient banks for each sample during the entire period of observation. No sustained stable year-to-year trend is discernable even though the entire period and sub-period results do reveal consistent tendencies. While for both samples the point observations for the initial and terminal years of the entire sample period suggest

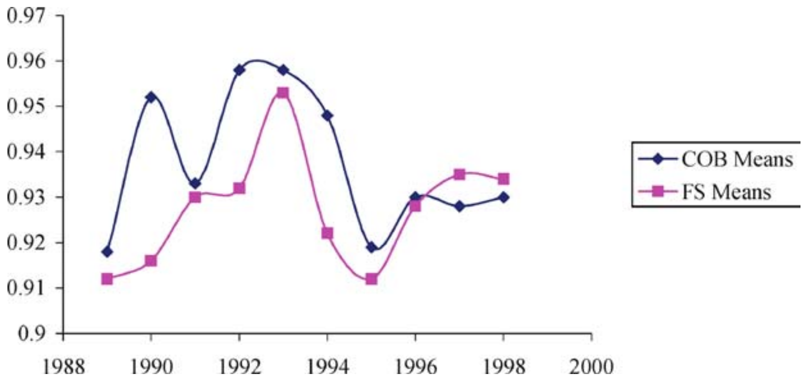

Chart 1. Mean technical efficiency scores (E) for the continuously operating banks (COB) and for the full sample (FS).

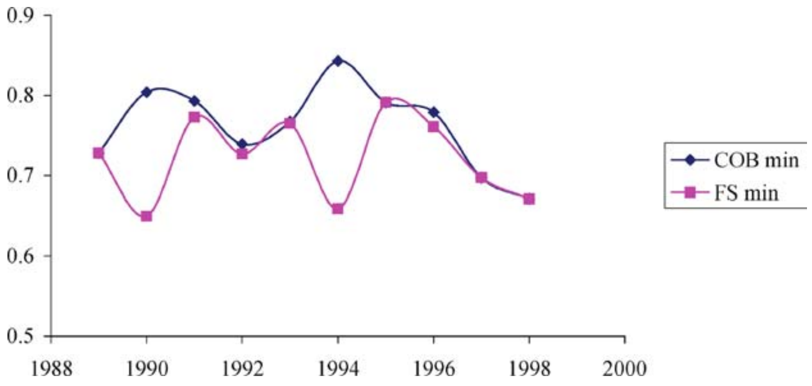

Chart 2. Minimum efficiency scores for the continuously operating banks (COB) and for the full sample (FS).

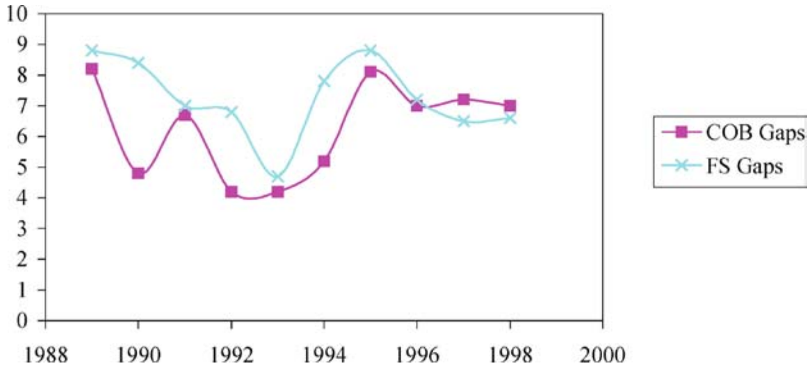

Chart 3. "Efficiency Gaps" for the continuously operating banks (COB) and for the full sample (FS). Gap: (1-mean) $*$ 100, indicates the difference between the best practice banks and the average performance of the remaining banks.

a 'long-term' improvement in average efficiency (a narrowing of the "gap"), they also reveal deterioration in the performance of the least efficient banks. This would suggest that for the period as a whole the degree of dispersion in the efficiency of banking operations has increased across the banks included in our sample.

Generalizations about long-term developments are compromised somewhat by the regime shifts caused by the operational and policy changes that were introduced in the mid-90 s. Considering the terminal point observations of the two sub-periods 1989–1993 and 1994–1998, it is apparent that average efficiency has improved for each sample in each sub-period, except for the COBs during the second interval. This pattern is consistent with the performance measures for the least efficient banks. In each instance there have been improvements over the entire sub-periods of the order of 2–4% except for the dramatic deterioration, of some 17%, in the efficiency of the least efficient COB. The competition measures introduced by BNM during the mid-90s may have had a particularly deleterious impact on the weaker COBs.

Unlike the "newcomers" and the stronger COBs, the less efficient COBs may have enjoyed less flexibility in responding to the challenges that were created by the BNM measures with the result that their performance suffered disproportionately. The fact that this deterioration proceeded consistently from year to year throughout the sub-period strengthens this interpretation, as does the fact that this same set of banks had experienced a sustained improvement throughout the sub-period preceding the introduction of the competition measures.

The apparent contribution of the "transient" banks – the banks that did not operate continuously throughout the entire sample period – is interesting. A comparison of the two samples establishes the general impression that they did not improve the efficiency of the banking system in any single year. On no occasion does the least efficient bank of the full sample outperform the corresponding COB. With the exception of the last two years of the decade, average efficiency also falls consistently short of the COB set. However, the transients appear to have made a distinctly positive contribution to the secular development of efficiency, particularly during the second sub-period. While average efficiency deteriorated for the COBs, the full sample shows a sustained improvement. It would appear that the "transients" account for this secular reduction in the "gap" between average and minimal efficiency. Their smoothing influence suggests that they may enjoy larger scope, or display greater willingness, to improve operational efficiency. However, this evidence must be interpreted with caution in view of the small number of "transients" included in the sample.

5.2. PRODUCTIVITY

Results on productivity changes are reported in Tables IV and V. Entries for each year are geometric means of the results obtained for each bank, and the overall means

Table IV. Malmquist index: Summary of annual means (continuously operating banks, COB)

Year	Pure tech. eff. change (ΔP)	*% ch.*	Scale Eff. change (ΔS)	*% ch.*	Change in tech. (ΔT)	*% ch.*	Malmquist index (M_v)	*% ch.*
1989/90	1.022	*2.2*	1.017	*1.7*	0.874	*−12.6*	0.909	*−9.1*
1990/91	0.997	*−0.3*	0.983	*−1.7*	0.973	*−2.7*	0.954	*−4.6*
1991/92	1.002	*0.2*	1.025	*2.5*	0.847	*−15.3*	0.870	*−13.0*
1992/93	1.003	*0.3*	0.996	*−0.4*	1.069	*6.9*	1.068	*6.8*
Mean	1.006	0.6	1.005	0.5	0.937	−6.3	0.947	−5.3
1994/95	0.975	*−2.5*	0.992	*−0.8*	1.127	*12.7*	1.091	*9.1*
1995/96	1.013	*1.3*	0.999	*−0.1*	0.934	*−6.6*	0.945	*−5.5*
1996/97	1.000	*0.0*	0.997	*−0.3*	0.954	*−4.6*	0.951	*−4.9*
1997/98	0.998	*−0.2*	1.004	*0.4*	0.836	*−16.4*	0.837	*−16.3*
Mean	0.996	−0.4	0.998	−0.2	0.957	−4.3	0.952	−4.8

Note. % ch. entries are calculated as [relevant score (ΔP, ΔS, ΔT, M_v) − 1] $*$ 100.

Table V. Malmquist index: Summary of annual means – Full sample

Year	Pure tech. eff. change (ΔP)	*% ch.*	Scale eff. change (ΔS)	*% ch.*	Change in tech. (ΔT)	*% ch.*	Malmquist index (M_v)	*% ch.*
1989/90	1.008	*0.8*	0.994	*−0.6*	0.939	*−6.1*	0.941	*−5.9*
1990/91	1.009	*0.9*	1.010	*1.0*	0.953	*−4.7*	0.971	*−2.9*
1991/92	1.000	*0.0*	1.003	*0.3*	0.911	*−8.9*	0.913	*−8.7*
1992/93	1.019	*1.9*	1.003	*0.3*	1.026	*2.6*	1.049	*4.9*
Mean	1.009	0.9	1.003	0.3	0.956	−4.4	0.967	−3.3
1994/95	0.998	*−0.2*	0.995	*−0.5*	1.097	*9.7*	1.090	*9.0*
1995/96	1.015	*1.5*	1.002	*0.2*	0.933	*−6.7*	0.949	*−5.1*
1996/97	1.002	*0.2*	1.004	*0.4*	0.913	*−8.7*	0.918	*−8.2*
1997/98	0.999	*−0.1*	0.999	*−0.1*	0.838	*−16.2*	0.836	*−16.4*
Mean	1.003	0.3	1.000	0.0	0.940	−6.0	0.944	−5.6

Note. % ch. entries are calculated as [relevant score (ΔP, ΔS, ΔT, M_v) − 1] ∗ 100.

for the sub-periods are geometric means of the annual means. At first glance, the coexistence of positive and negative changes stands out: the decade spanned by our investigation clearly was not characterized by tranquility and stability of the banking sector in Malaysia that would be conducive to the consolidation of productivity gains. None of the determinants of banking productivity exhibit a steady trend throughout the entire sample period. For the two sub-periods, however, two series stand out by virtue of the consistent direction of year-to-year change: scale efficiency (ΔS) of COBs deteriorated steadily during the second interval until 1997/98 while pure technical efficiency (ΔP) improved steadily for the entire sample during the initial interval. This annual improvement was shared by COBs except for the 1990/91 reporting period. Note, however, that the improvement is generally stronger for the full sample, suggesting that the transient banks are dominant in the active pursuit of technical efficiency.

Secondly, it appears that changes in the Malmquist Index are dominated by technical change. Large negative percentage changes in technology (ΔT), that is, technological regress, offset positive effects of adjustments in resource utilization (ΔP) and improvements in scale efficiency (ΔS) on productivity. For instance, mean productivity declined by 5.3% during the first sub-period (Table IV). This change seems to have been driven by the adverse effects of technological change (−6.3%), moderated in approximately equal parts by improvements in pure technical efficiency (+0.6%) and in scale efficiency (+0.5%). Qualitatively, the productivity experience is replicated during the second sub-period: Mean productivity deteriorated by a further 4.8%, dominated by adverse technological change ($\Delta T = -4.3\%$), but now **reinforced** by deteriorations in both, technical efficiency ($\Delta P = -0.4\%$) as well as scale efficiency ($\Delta S = -0.2\%$).

The picture looks somewhat less gloomy in the first period when the full sample is used. According to the results shown in Table V, mean productivity deteriorated in this period by 3.3%, again dominated by the deterioration in technology that was moderated by improvements in technical and in scale efficiency. However, in the second period the decrease in productivity accelerated to 5.6%. But on this occasion the measured deterioration in technology was counteracted by an improvement in technical efficiency while scale efficiency did not make any contribution to the change in mean productivity. This observation reinforces the potential importance of the "transient" banks for promoting technical efficiency in banking after the introduction of the competition measures in Malaysia.

The foregoing observations are consistent with the empirical findings from the truncated sample (or "modified sample" – see Appendix Table A2). The orders of magnitude of the constituent components of productivity change are slightly smaller, and the scale effect is more persistent throughout each sub-period. As a result, improvements in scale efficiency counteract technological deterioration for the truncated COB sample during the second sub-period without, however, exerting a decisive influence on the mean performance.

The upshot of the above discussion is that productivity of Malaysian banks has decreased over both periods in which gradual liberalization and technical changes have been occurring. Such a productivity decline during periods of deregulation accords with international experience. Griffell-Tatje and Lovell (1996) observed that the productivity of Spanish savings banks declined at an annual rate of 5.5% over the 1986–1991 post-deregulation period. They cite similar results from four other studies at footnote 15, p. 1292. In a survey of the efficiency of financial institutions Berger and Humphrey (1997) conclude that the ability of deregulation to improve the efficiency of financial institutions has yielded mixed findings.

Finally, we try to shed some tentative light on the efficiency and productivity implications of the Asian crisis of 1997. The large declines (in the order of 15 and 16%) in total factor productivity (Malmquist) indices observed in Tables IV–VII for 1997/98 may be seen as an indication of the adverse productivity effects of the crisis. To explore this conjecture we recalculate the Malmquist indices for 1996, 1997, and 1998 relative to the stable pre-crisis year of 1995 rather than as year-on-year change. These resulting scores strongly support the conjecture and identify technological regress as the main source of the productivity decrease that appears to have been associated with the financial crisis in Asia (Table VIII).

5.3. ECONOMETRIC ESTIMATES

The preceding DEA analysis has emphasized the composite nature of productivity change. Further insight into the nature of productivity change can be gleaned by exploring potential drivers of productivity.[14] Aside from direct characteristics of bank production such as specialization and portfolio size, facets of industrial and market structure – for instance, bank size and market power, respectively – that

Table VI. Malmquist index: Summary of annual means – *modified COB sample*

Year	Pure tech. eff. change (ΔP)	*% ch.*	Scale eff. change (ΔS)	*% ch.*	Change in tech. (ΔT)	*% ch.*	Malmquist index (M_v)	*% ch.*
1989/90	1.016	*1.6*	1.023	*2.3*	0.861	*−13.9*	0.895	*−10.5*
1990/91	1.007	*0.7*	0.982	*−1.8*	0.974	*−2.6*	0.963	*−3.7*
1991/92	0.983	*−1.7*	1.031	*3.1*	0.849	*−15.1*	0.860	*−14.0*
1992/93	1.019	*1.9*	1.008	*0.8*	1.021	*2.1*	1.048	*4.8*
Mean	1.006	0.6	1.011	1.1	0.923	−7.7	0.939	−6.1
1994/95	0.985	*−1.5*	0.987	*−1.3*	1.135	*13.5*	1.103	*10.3*
1995/96	1.002	*0.2*	1.004	*0.4*	0.921	*−7.9*	0.926	*−7.4*
1996/97	0.999	*−0.1*	1.021	*2.1*	0.920	*−8.0*	0.938	*−6.2*
1997/98	1.005	*0.5*	0.990	*−1.0*	0.854	*−14.6*	0.850	*−15.0*
Mean	0.998	−0.2	1.001	0.1	0.952	−4.8	0.95	−5.0

Note. % ch. entries are calculated as [relevant score $(\Delta P, \Delta S, \Delta T, M_v) - 1] * 100$.

Table VII. Malmquist index: Summary of annual means – *modified full sample*

Year	Pure tech. eff. change (ΔP)	*% ch.*	Scale eff. change (ΔS)	*% ch.*	Change in tech. (ΔT)	*% ch.*	Malmquist index (M_v)	*% ch.*
1989/90	1.023	*2.3*	0.989	*−1.1*	0.931	*−6.9*	0.941	*−5.9*
1990/91	1.001	*0.1*	1.000	*0*	0.955	*−4.5*	0.956	*−4.4*
1991/92	0.997	*−0.3*	0.998	*−0.2*	0.911	*−8.9*	0.907	*−9.3*
1992/93	1.015	*1.5*	1.016	*1.6*	1.02	*2.0*	1.052	*5.2*
Mean	1.009	0.9	1.001	0.1	0.953	−4.7	0.963	−3.7
1994/95	1.003	*0.3*	0.993	*−0.7*	1.111	*11.1*	1.108	*10.8*
1995/96	1.014	*1.4*	1.005	*0.5*	0.922	*−7.8*	0.939	*−6.1*
1996/97	1.001	*0.1*	1.029	*2.9*	0.876	*−12.4*	0.902	*−9.8*
1997/98	1.004	*0.4*	0.979	*−2.1*	0.865	*−13.5*	0.850	*−15*
Mean	1.006	0.6	1.001	0.1	0.939	−6.1	0.945	−5.5

Note. % ch. entries are calculated as [relevant score $(\Delta P, \Delta \mathrm{S}, \Delta T, M_v) - 1] * 100$.

are susceptible to the liberalization regime pursued by the Malaysian authorities are of particular interest. Mukherje et al. (2001) cite some studies that identify specialization as an empirically relevant variable in the present context. For example, Ferrier et al. (1993) observe that banks have diseconomies of diversification, although the supporting evidence seems to be weak. The effect of specialization on productivity growth is ambiguous: to the extent that diversification (less specialization) reduces bank risk it may attract deposits into the bank. Conversely, to the extent that specialization reduces costs such as screening and monitoring associated

Table VIII. Productivity during the asian crisis malmquist index: Summary of annual means

Year	Pure tech. eff. change (ΔP)	*% ch.*	Scale eff. change (ΔS)	*% ch.*	Change in tech. (ΔT)	*% ch.*	Malmquist index (M_v)	*% ch.*
				Continuously operating banks (COB)				
1995/96	1.013	*1.3*	0.999	*−0.1*	0.934	*−6.6*	0.945	*−5.5*
1995/97	1.013	*1.3*	0.996	*−0.4*	0.838	*−16.2*	0.845	*−15.5*
1995/98	1.010	*1.0*	1.000	*0*	0.750	*−25.0*	0.757	*−24.3*
				Full sample				
1995/96	1.015	*1.5*	1.002	*0.2*	0.933	*−6.7*	0.949	*−5.1*
1995/97	1.017	*1.7*	1.007	*0.7*	0.830	*−17*	0.854	*−14.6*
1995/98	1.015	*1.5*	1.006	*0.6*	0.730	*−27*	0.746	*−25.4*

Note. % ch. entries are calculated as [relevant score (ΔP, ΔS, ΔT, M_v) − 1] ∗ 100.

with loans, it promotes the production of more output (loans) with a given level of inputs (Mukherje et al., 2001).

We represent the specialization variable (SPECIAL) as a Herfindahl index of outputs, i.e. as the sum of the squared shares of each output in total output. Market power (POWER) is measured by the natural log of deposits. For bank size (TA) we use the natural log of total assets. Loan to asset ratio (LOANTA) is simply computed as total loans divided by total assets. Since loans are a major source of income, a higher loan to asset ratio might indicate higher efficiency (Mukherje et al., 2001). The summary statistics are reported in Table IX.

In the present context, panel data models can be estimated by using either a fixed effects estimator or a random effects estimator (feasible GLS). The former estimates a different constant for each bank. Since the intercept terms vary across banks, they are indexed by individual bank. Coefficients are computed by running OLS on transformed data, which are obtained by subtracting the time or "within group" (cross section specific) mean from each variable to eliminate the fixed effects from the regression. In the random effects models it is assumed that the intercept consists of two parts: a constant, which is the same for all cross sectional units, and a time-invariant *random* variable.

We conducted experiments with both specifications and ultimately chose the fixed effects specification on the basis of Hausman test results.[15] Accordingly, we estimate the following model:

$$y_{i,t} = \alpha_i + \mathbf{x}'_{i,t}\beta + \varepsilon_{i,t}$$

where $y_{i,t}$ is the dependent productivity variable (Malmquist indices calculated from original samples), α_i are fixed effects, $\mathbf{x}_{i,t}$ is the vector of regressors identified previously, and β is a vector of parameters excluding the constant. i indexes S cross sectional units (banks). Each bank is observed over $t = 1 \ldots T$ time periods.

Table IX. Summary statistics for the variables used in regressions

	Malmquist indices	SPECIAL	POWER	TA	LOANTA
Banks operating continuously, COB (1989–1993)					
Mean	0.958	0.440	9.783	10.067	0.593
S.D.	0.146	0.033	1.279	1.328	0.097
Minimum	0.579	0.362	7.458	7.672	0.352
Maximum	1.419	0.558	12.483	12.958	0.807
Observations	64	80	80	80	80
Banks operating continuously, COB (1994–1998)					
Mean	0.964	0.436	10.569	10.982	0.595
S.D.	0.158	0.027	1.212	1.235	0.099
Minimum	0.645	0.391	8.000	8.373	0.299
Maximum	1.464	0.562	13.0480	13.568	0.789
Observations	64	80	80	80	80
Full sample (1989–1993)					
Mean	0.975	0.439	9.528	10.164	0.564
S.D.	0.127	0.031	1.876	1.296	0.164
Minimum	0.777	0.362	3.501	7.672	0.008
Maximum	1.423	0.558	12.483	12.958	0.807
Observations	72	90	90	90	90
Full sample (1994–1998)					
Mean	0.956	0.436	10.577	10.75	0.912
S.D.	0.153	0.026	1.202	1.295	0.670
Minimum	0.645	0.391	8.000	7.960	0.299
Maximum	1.425	0.562	13.048	13.568	3.449
Observations	72	90	90	90	90

Notes. SPECIAL: Specialization is measured by a Herfindahl index of outputs, i.e. sum of the squared shares of each output in total output.
POWER: Natural log of deposits, indicating market power.
TA: natural log of total assets.
LOANTA: Loan to asset ratio.
All variables are expressed in thousands of 1995 ringgit.

The error term is assumed to be free of autocorrelation. Heteroskedasticity is allowed, but corrected in the estimations by using the robust variance covariance matrix.

We have used the Dynamic Panel Data (DPD) package of Doornik et al. (1999). Together with the results from one-step estimates, we report the tests for the absence of first- and second-order serial correlation in the first-differenced residuals, AR(1) and AR(2) respectively. When AR(1) is negative and significant and AR(2) is insignificant we can accept the null hypothesis that the disturbance terms are not serially correlated in these specifications.[16]

Table X. Regression results (standard errors in parentheses)

Period	1989–1993		1994–1998	
variable	COBs	Full sample	COBs	Full sample
SPECIAL	−0.748 (1.276)	0.258 (0.940)	−3.555 (1.141)***	−2.982 (1.188)**
POWER	0.613 (0.259)**	0.431 (0.250)*	−0.203 (0.058)***	−0.174 (0.062)***
TA	−0.563 (0.308)*	−0.405 (0.262)	−0.143 (0.086)	−0.207 (0.058)***
LOANTA	−1.335 (0.529)**	−1.074 (0.361)***	−0.793 (0.397)	−0.056 (0.092)
Time Dummies	NO	NO	NO	NO
Wald (joint)	20.28 (4)	16.44 (4)	35.16 (4)	35.31 (4)
AR(1)	−2.627***	−2.670***	−1.867	−2.450**
AR(2)	−0.758	−2.021**	−2.038**	−0.835
Observations	64	72	64	72
Number of banks	16	18	16	18

***Significant at 1% level; **Significant at 5% level; *Significant at 10% level.

Notes. Dependent variables are Malmquist indices (calculated from original samples) These are one-step estimations obtained by using DPD's within option (robust variance-covariance matrix).

COB: Bank operating continuously.

SPECIAL: Specialization is measured by a Herfindahl index of outputs, i.e. sum of the squared shares of each output in total output.

POWER: Natural log of deposits, indicating market power.

TA: Natural log of total assets.

LOANTA: Loan to asset ratio.

Wald (joint): A test for the joint significance of all regressors. We report the Chi-square statistic and degrees of freedom (in the parentheses next to each statistic).

AR(1) and AR(2) are tests for first- and second-order serial correlation, which are distributed as N(0,1) under the null of no autocorrelation.

In Table X we report the results from estimating the model by fixed effects estimator. Our experiments with random effects models consistently indicated the existence of autocorrelation. Accordingly, our inferences are strictly conditional on the particular banks included in the sample. It should be noted, however, that our full sample contains approximately four-fifths of all the banks in Malaysia.

It appears that the explanatory power of the coefficient of market power is relatively robust across all samples and time periods. Note, however, that two sets of regression results are impaired by autocorrelation (1989–1993, full sample and 1994–1998, COBs). Market power affects the Malmquist index positively in the first period but negatively in the second period. Size consistently exerts a negative effect to suggest that larger banks experience a stronger productivity *decrease* compared to smaller banks. Specialization and loan to asset ratios seem to have negative effects on productivity change. The switch in sign of market power between the two sub-periods may reflect institutional and market conditions that lie beyond the control of banks such as the change in the regulatory regime and the substantial interest escalation induced by the crisis.[17]

Even though the regression results display some shortcomings it would appear that our explanatory variables do possess some power. Furthermore, the performance of our estimating equation improved dramatically for the later sub-period. The results for the full sample of 18 banks carry substantial explanatory power for the changes in productivity during the period 1994–1998, and the diagnostics are satisfactory except for indications of second-order autocorrelation in two of the models. Both, market power and size of an institution are found to exert a strong (negative) influence on its productivity, as does the degree to which a bank specializes. Apparently, the increase in risk exposure that comes with reductions in business diversification dominates the information gains and associated cost savings. These findings could be interpreted to support a decentralized banking system where many relatively small banks are engaged in vigorous competition.

6. Conclusions

Our investigation suggests that productivity of Malaysian banks has deteriorated during the decade 1989–1998. Estimates of the productivity decline range between 3.3 and 5.6%. In view of the liberalization and technological innovation during the sample period, this evidence suggests circumspection in advocating the benefits of such innovations.

Second stage regressions of Malmquist indices suggest that larger banks experience faster productivity decline compared to smaller banks. Productivity change varies with market power, positively during the first sub-period and negatively during the second sub-period. Productivity varies negatively with specialization and with the loan to asset ratio. These findings have to be interpreted with some caution in view of the indications of serial correlation in some of our experiments.

Subject to these reservations, it appears that best practice banks in Malaysia have been producing less from a given level of inputs so that the frontier has shifted progressively inwards. This finding can be interpreted in several ways. It could indicate that the Malaysian banks in our sample were not able to exploit the potential benefits from important technological developments such as constructing ATM networks, at least not during the initial phase of implementation. It could also reflect on the fact that the Malaysian banking sector is somewhat insulated from foreign competition by virtue of the restrictions on the operation of foreign banks in the country. The isolation of a protected environment may contribute to the deterioration of banking sector productivity.

A productivity decrease indicates that output grows at a slower pace than inputs grow. The data in Table II show that interest expense on average has grown at very high rates in both sub-periods. For instance, continuously operating banks incurred a 148% increase in interest expense. For the full sample the corresponding rate of increase was 152%. In all cases the rates of increase of output fell short of the rates of increase of interest expense. Since personnel expense grew slower than output, the erosion of productivity appears to be associated with a reduction in the labor intensity of banking activity.

Another factor that contributed to the modest productivity performance could be regulatory distortions such as the priority lending requirements. If banks cannot find suitable people or companies to lend to, or if the designated priority groups are not willing or capable to take advantage of the financial opportunities offered to them, then the funds earmarked for priority sectors would remain unused, creating excess capacity. The immediate policy implication of our finding is that the benefits from reforms and liberalization of the monetary policy regime may be held back by the persistence of micro distortions of the conduct of banking business.

Appendix

A.1. COMPOSITION OF SAMPLES

The identity of the banks constituting the various samples is provided in Appendix Table AI.

Table AI. Composition of the alternative samples

	1989–1993	1994–1998
Original samples:		
• COBs	16 banks: #1, 2, 3, 4, 5, 7, 8, 9, 10, 12, 13, 15, 16, 17, 18, 19	
• Full sample	18 banks: COBs plus #22, 23	18 banks: COBs plus #11, 21
Modified or “truncated” samples:		
• COBs	13 banks: original COBs less #2, 4, 8	
• Full sample	15 banks: original full sample less #2, 4, 23	16 banks: original full sample less #4, 8

Some information about the individual banks included in the original samples is provided in Appendix Table AII. Information about the inputs and outputs for the additional banks in the two individual sub-periods appears in Appendix Table AIII.

Table AII. Details of the banks included in the study and their representation in the various samples

Bank no		Data availability	Sample	Change in status
1	BN	89–98	all	
10	BN	89–98	all	
11		94–98	P2	Classified as Bank 35 before 1995.

(*Continued on next page*)

Table AII. (*Continued*)

Bank no		Data availability	Sample	Change in status
35	BN	No data		Classified as Bank 11 in P2 sample.
12	BN	89–98	all	
13	BN	89–98	all	
14		96–98		Classified as Bank 41 before 1997.
41		No data		Classified as Bank 42 before 1994.
42		No data		Foreign bank. Name of the bank was changed to that of Bank 41 in 1994.
15	BN	89–98	all	
16		94–98	all	Classified as Bank 40 before 1994.
40	BN	89–93	all	Classified as Bank 16 in all samples.
17	BN	89–98	all	
18	BN	89–98	all	
19		94–98	all	Classified as Bank 39 before 1996.
39	BN	89–93		Classified as Bank 19 in all samples.
2	BN	89–98	C, P1, P2, P2m	
20		95–98.		Classified as Bank 31 before 1994.
31		No data		Foreign bank.
3		92–98	all	Classified as Bank 36 before 1992.
36	BN	89–91	all	Classified as Bank 3 in all samples.
4	BN	89–98	all	
5		96–98	all	Classified as f Bank 38 before 1997.
38	BN	89–96	all	
6		96–98		Bank 6 completed a series of mergers between 1997 and 1999. In 1997, the merger between Bank 22 and Bank 43 was completed to form Bank 6, and in 1998, the merger with a finance company was finalized. In 1999, the merger with Bank 44 was finalized.

(*Continued on next page*)

Table AII. (*Continued*)

Bank no		Data availability	Sample	Change in status
22	BN	89–93, 95, 96	P1, P1m	Merged with Bank 43 in 1997.
43	BN	95, 96		Merged with Bank 22 in 1997.
44				Classified as Bank 23 before 1996.
23	BN	89–95	P1	Reclassified as Bank 44 in 1996.
32				Formed in 1999 by the merger of non-Islamic section of Bank 7 with Bank 21.
7	BN	89–98	all	Non-Islamic section of the bank was merged with Bank 21 in 1999.
21		91–98	P2, P2m	Formed after the merger of banks 33 and 34 in 1991.
33	BN	No data		Foreign bank. Merged with bank 34 in 1991.
34	BN	89, 90		Merged with bank 33 in 1991.
8	BN	92, 93, 95–98	C, P1, P1m, P2	Classified as Bank 37 before 1994.
37		89–92		Classified as Bank 8 in all samples.
9	BN	89–98	all	

Notes. BN – indicates the 21 *domestic* banks that are listed in Bank Negara Malaysia (1989). Banks 22, 23, 33, 34, 35, 43 are not included in the sample of banks operating continuously because of data problems noted in the table.
C – sample of banks operating continuously (COB).
P1, P1m – original and modified period 1 (1989–1993) samples, respectively.
P2, P2m – original and modified period 2 (1994–1998) samples respectively.
'all' – indicates that the bank was included in modified COB samples as well as in C, P1, Pm, P2, P2m.

Table AIII. Mean levels of inputs and outputs for the additional banks in periods 1 and 2 (thousands of 1995 Ringgit)

	Investments	Loans	Deposits	Interest expenditures	Personnel expenditures
Bank 22 (period 1)	284.86	285.63	44.64	15.96	4.39
Bank 23 (period 1)	15673.42	63884.82	72883.24	5354.66	1332.09
Bank 11 (period 2)	5846.93	27999.42	20839.47	2433.23	220.29
Bank 21 (period 2)	19226.88	99501.63	108847.60	8003.85	790.01

A.2. DATA

Appendix Table AIV gives detailed information about the adjustments that had to be made to the data

Table AIV. Adjustments made to the data

Bank no.	Problem with the data	Solution
2	All data for 1991 are missing due to a change of financial year in that year	In all cases the missing values were interpolated by using average growth rates
4	All data for 1989 are missing	
4	Personnel expenditures for 1998 are missing	
8	All data for 1994 are missing due to a change of financial year in that year	
23	All data for 1990 are missing due to a change of financial year in that year	

Note. We use these adjusted data only for the banks that are included in the original samples. We then modify the original samples by deleting the banks mentioned here to check the sensitivity of our results to the adjustments made.

Notes

1. In their comprehensive survey, these authors note that only 66 out of the 116 single-country studies they examined dealt with US financial institutions.
2. Throughout this section we include foreign banks in the discussion.
3. Hire Purchase Lending enables the borrower to pay for a commodity by regular installments while having full use of it after the first payment.
4. Net Non Performing Loans are Gross NPLs adjusted for interest-in-suspense and specific provisions for doubtful and bad debts. In September 1998 BNM changed the NPL classification standard from three months to six months. NPLs in arrears for three months but less than nine are classified as "sub-standard"; those in arrears for nine months but less than 12 months are classified as "doubtful"; and those in arrears for more than 12 months as "bad". It should be noted that NPL data come from financial statements that are based on book value rather than on market value. Bank managers carry loans at book value on their statements without publicly acknowledging the deterioration of their loan portfolio in order to maintain accounting solvency and to avoid recognizing economic insolvency. As a result, NPL indicators are likely to be significantly biased and provide only a lower bound for economic losses during recessions and economic crises.
5. In mid 1998, BNM and the government took certain measures to restructure the banking sector and to help banks overcome the bad debt difficulties they had been experiencing. Three institutions were created for the purpose: Danaharta, Danamodal, and CDRC (Corporate Debt Restructuring Committee). Danaharta's main task is to acquire NPLs, Danamodal's is to provide fresh capital, and CDRC's is to arrange the restructuring of large corporate loans.

6. A BNM survey shows that many key services had been computerized by 1995: deposit handling, financial management, loan products, and electronic delivery systems. Newly introduced products included electronic home banking, the use of cards for electronic transactions, savings accounts combined with insurance products, deposit-cum-standby facilities, and fixed deposit accounts that are incorporated into (or combined with) endowment insurance and/or unit trust products (BNM, 1999).
7. To illustrate, after the 1985–1986 recession BNM bailed out three banks (Sabah, United Asian, and Perwira Habib). BNM replaced the capital lost by these banks and changed their boards of directors and top management. During this period BNM also assumed control of The Oriental Bank (BNM, 1994).
8. Our methodology relies heavily on the approach developed by Grifell-Tatje and Lovell (1996) and Wheelock and Wilson (1999).
9. For inputs the formal definition is: if y can be produced from x, then y can be produced from any $x^* \geq x$. For outputs it is: if $y \in P(x)$ and $y^* \leq y$ then $y^* \in P(x)$ (Coelli et al., 1998, p. 62).
10. For example, data for the financial year June 1994-June 1995 appear as 1995 data in our data set.
11. The rapid acceleration after 1996 in the growth of interest expense seems to be largely attributable to the decisive posture of BNM in the face of the Asian crisis. The BNM raised interest rates in defense against incipient speculative attacks and, in the wake of the crisis, to protect real interest earnings from increasing inflationary pressures (BNM, 1999).
12. References to the relevant literature are provided by Favero and Papi (1995) and Avkiran (2000).
13. The results from these exercises are available on request.
14. As mentioned earlier, because of data deficiencies we had to limit our sample to banks that existed throughout our sample period. This might create a bias in the second stage analysis. If the excluded banks are more inefficient, then their exclusion should not affect the frontier of best-practice banks. However, the exclusion of failing banks would inflate the calculated average efficiency scores. This could potentially affect the second stage regression analysis which links efficiency to bank characteristics.
15. Hausman tests (using STATA) reject, at the 5% level of significance, the null that differences in the coefficient estimates obtained under the two alternative specifications are not systematic.
16. According to the DPD manual: "If the disturbances $v_{i,t}$ are not serially correlated, there should be evidence of significant negative first order serial correlation in differenced residuals, (i.e $\hat{v}_{i,t} - \hat{v}_{i,t-1}$), and no evidence of second order serial correlation in the differenced residuals. These tests are based on the standardized average residual autocovariances which are asymptotically $N(0; 1)$ variables under the null of no autocorrelation" (Doornik et al., 1999, p. 8).
17. The regulatory framework may influence the mode of competition. If banks are unable to compete on price (interest rates) as was the case during the first sub-period, then they are likely to compete through non-price channels, by providing additional services to their customers, for instance. If successful, the observed increase in bank output (deposits and, hence, market power) for seemingly given factor inputs would be interpreted as an increase in productivity. In the second sub-period, after deregulation, banks competed also by offering higher interest rates. Depending on the extent to which input costs are pushed up by such competition, the measured productivity may well decline.

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