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TOTAL FACTOR PRODUCTIVITY GROWTH, TECHNICAL CHANGE, AND TECHNICAL EFFICIENCY IN ASEAN COUNTRIES

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ABSTRACT

This paper analyzes productivity growth in five ASEAN countries over the period 1978-1990. A Malmquist-Data-Envelopment Analysis (DEA) method as introduced by Färe, Grosskopf, Norris, and Zhang (1994) is used to calculate indices of productivity change and its components, technological change, technical efficiency change, and scale efficiency change. Results suggest that, on average, ASEAN countries productivity growth had been declining at a negative rate of 0.5 percent over the study period, mainly due to deterioration in efficiency with which existing technology is utilized rather than a lack of innovation or technological change. The results also show that Singapore is the most efficient economy in the region, while Philippines is the least efficient.

ABSTRAK

Kertas ini menganalisa pertumbuhan produktiviti di lima negara ASEAN meliputi jangkamasa 1978-1990. Kaedah 'Malmquist-Data-Envelopment Analysis (DEA)' seperti yang diperkenalkan oleh Färe, Grosskopf, Norris, and Zhang (1994) digunakan untuk mengira indeks perubahan dalam produktiviti dan komponennya, perubahan teknologi, perubahan kecekapan teknikal, dan perubahan kecekapan skala. Keputusan kajian menunjukkan bahawa, secara purata, pertumbuhan produktiviti telah menurun pada kadar negatif 0.5 peratus di sepanjang jangkamasa kajian, terutamanya disebabkan oleh kemerosotan kecekapan dalam penggunaan teknologi sedia ada dibandingkan dengan kekurangan innovasi atau perubahan teknologi. Keputusan kajian juga menunjukkan bahawa Singapura mempunyai kecekapan ekonomi yang paling tinggi di rantau ASEAN manakala Filipina adalah sebaliknya.

INTRODUCTION

The economic success story of the ASEAN economies prior to the current financial crisis has been well documented.[1] However, the issue of much interest is whether this outstanding economic growth can be sustained in the event of a negative shock to the economy. The economic crisis in the mid-eighties and the recent financial crisis provide a litmus test for the much debated question on the resilience of the economy to withstand such shocks. If the recent performance were taken as evidence, ASEAN economies have failed, suggesting the need for policy makers to reevaluate their development strategies. Undoubtedly, the need for strengthening competitiveness and hence efficiency, is very important to ensure sustainable economic growth in the long run. Most of the existing studies on ASEAN countries have found that the growth rate of productivity is negligible, if not negative, as opposed to the outstanding growth in their income levels. For example, in a series of papers by Young (1992, 1993, and 1995), he concluded that the growth rates of total factor productivity in ASEAN economies are not as spectacular as their growth rates of output. This inferior Total Factor Productivity (TFP) growth is further documented by, among others, Austria and Martin (1995) and Tham (1995), which show that total factor productivity grew at negative rates of 0.6 and 1.2 percent in Philippines and Malaysia, respectively, while negligibly grew at 0.46 percent in Thailand (Limskul (1995)) although Singapore shows a promising rate of 2.6 percent, Rao and Lee (1995).[2]

Various factors were given to explain the poor performance of total factor productivity growth in ASEAN. Among others, low labor productivity, low levels of R&D, and inefficient use of resources due to public sector interference in resource allocation. Based on this rationalization, various policy recommendations were suggested.[3]

However, despite the numerous existing studies of total factor productivity growth in ASEAN countries, the possibility of a meaningful cross-country comparison of TFP growth is limited for two reasons. First, the methodology used in the existing studies of TFP growth in ASEAN countries requires the specification of input expenditure shares for various inputs used in production (in the case of the growth accounting method) or requires the specification of a production function (in the case of the econometric estimation method). The results of these studies are sensitive to the specification employed. Second, most of the studies on ASEAN countries are done on single countries. As a result, comparing TFP growth based on these individual country studies are unlikely to be reliable since they employed different sets of assumptions.[4]

By employing the approach of Färe, Grosskopf, Norris, and Zhang (1994) and a set of panel data on selected ASEAN countries, this study will not only solve the problem of specifying factor shares/production function and the problem of differing methodology to make reliable comparison among countries but also allows the possibility of decomposing TFP growth into efficiency change and technical change components. The ability to separate these two components is very important, since focussing only on TFP growth alone as a guide for policy actions can be misleading.

Hence, this paper contributes to the studies in ASEAN TFP growth in two ways: i) empirically comparing the productivity growth among the ASEAN countries and relating it to the country's performance during the mid-eighties economic crisis; and ii) using the Malmquist-Data-Envelopment Analysis (DEA) method as introduced by Färe, Grosskopf, Norris, and Zhang (1994) to calculate indices of TFP change, technological change, technical efficiency change and scale efficiency change.

The rest of the paper is organized as follows. Section 2 explains the importance of distinguishing between the concept of technological progress and efficiency change. Section 3 provides a brief explanation of Malmquist productivity index as a measure of TFP growth, technical change, and efficiency change. Section 4 deals with the methodological issues. Section 5 describes the data and discusses the empirical results. Finally, section 6 summarizes the main findings.

TECHNOLOGICAL PROGRESS AND EFFICIENCY CHANGE

In studying the productivity performance of developing economies, the distinction between technological progress (innovation or adoption of new technology) and changes in technical efficiency (catching-up) is very pertinent. Given a level of technology, appropriate resource allocation may be required to reach the 'best practice' level of technical efficiency over time. There is considerable evidence that productivity gain due to such 'technological mastery' is substantial in developing economies, and may outweigh gains from technological progress (Nishimizu and Page, 1982). It is therefore important to know how far one is off the technological frontier at any point in time, and how quickly one can reach the frontier.

Since TFP growth is the sum of the rate of technological progress and changes in technical efficiency, low rates of technological progress (due to failure in adopting new technology) can co-exist with improving technical efficiency (due to the ability to master existing technology), resulting in the low or often observed negative overall rates of TFP growth. On the other hand, relatively high rates of technological progress can co-exist with deteriorating technical efficiency. Policy actions intended to improve the rate of TFP growth might be badly misdirected if focussed on accelerating the rate of innovation for example in circumstances where the cause of lagging TFP change is a low rate of mastery or diffusion of best practice technology. Hence, the idea that TFP growth can be decomposed into technical progress and changes in technical efficiency provides an avenue to distinguish the two analytically distinct concepts, hence leading to more meaningful policy recommendations.

METHODOLOGY

This section describes the method used to compare the economic performance of countries using measures of productivity growth and its decomposition into technical progress (innovation or adoption of new technology) and efficiency change (catching-up) components. The output-orientated productivity measures focus on the maximum level of output that could be produced using a given input vector and a given production technology relative to the observed level of outputs.[5] Each country's efficiency is measured relative to the performance of other countries observed during the year as well as relative to the best-practice technology available during a "base year." The year and "base-year" technical efficiency scores are used to construct the Malmquist productivity index first introduced by Caves, Christensen, and Diewert (1982) and later extended by Färe, Grosskopf, Norris, and Zhang (1994) to allow for inefficiency in production . By explicitly recognizing the possibility of inefficient behavior, the frontier Malmquist productivity index allows productivity changes to be decomposed into measures of "catching-up" and "true" technological changes as proposed by Nishimizu and Page (1982).

To illustrate the difference between technological change and efficiency change, first we need to define production technology and output distance functions.

Production Technology, Distance Function, Technical Efficiency and Technical Change

One can describe a multi-input, multi-output production technology without the need to specify a behavioral objective (such as cost-minimization or profit maximization) by using distance functions. An output distance function characterizes the production technology by looking at a maximal proportional expansion of the output vector , given an input vector.

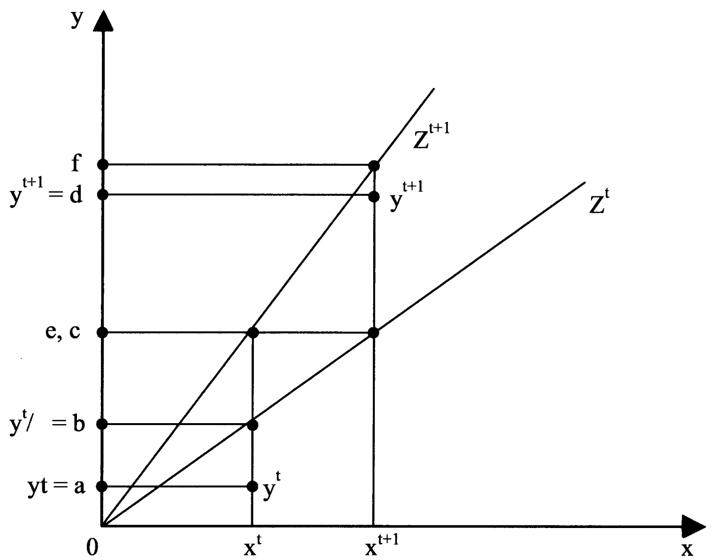
A production technology, satisfying standard axioms, may be defined using the output set, Z, which represents the set of all output vectors, $y \in R^N$, which can be produced using the input vector, $x \in R^N_+$. That is,

$$Z(x) = \{(y: x \text{ can produce } y\} \quad (1)$$

The output distance function is defined on the output set, Z(x), as:

$$D(x,y)=\min\{\delta:(y/\delta)\in Z(x\} \quad (2)$$

Figure 1
Malmquist Productivity Indices and Output Distance Functions



The output distance function, D(x,y), will take a value which is less than or equal to one if the output vector, y, is an element of the feasible production set, Z(x). Furthermore, the output distance function will take a value of unity if y is on the boundary of the feasible production set or frontier of the technology. In this case, the production is technically efficient in the terminology of Farrell (1957).[6] This can be shown in Figure 1. In Figure 1, y^t is not technically efficient since observed production at t is interior to the boundary of technology at t. The distance function seeks the reciprocal of the greatest proportional increase in output, given input such that output is still feasible. In the diagram, maximum feasible production given x_t, is at (y^t/δ). Hence, the value of the distance function is $y^t/(y^t/\delta) = \delta = oa/ob \leq 1$.

Technical change has occurred between time period t and t+1 since the set of feasible production in t+1 is greater than the set of feasible production at t i.e., $Z^t \subseteq Z^{t+1}$. Technical efficiency also appears to have improved from time period t to t+1 as well since y^{t+1} is relatively closer to the boundary of Z^{t+1} than y^t is to the boundary of Z^t.

Malmquist Productivity Index and its decomposition

The Malmquist TFP index came to prominence through the work of Caves, Christensen, and Diewert (1982) and it measures the TFP change between two data points by calculating the distances of each data point relative to a common technology. Following Färe, Grosskopf, Norris, and Zhang (1994), the Malmquist output-oriented productivity index is defined as:

$$M^{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) = \{[D^t(x_{t+1}, y_{t+1}) / D^t(x_t, y_t)]\,[D^{t+1}(x_{t+1}, y_{t+1}) / D^{t+1}(x_t, y_t)]\}^{1/2} \quad (5)$$

The productivity index is the geometric mean of a pair of ratios of output distance functions. The first ratio compares the performance of data from period t and t+1 relative to the production possibilities existing in period t, and the second compares the performance of the same data relative to production possibilities existing in period t+1. Equation (5) can be rewritten as:

$$M^{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) = D^{t+1}(x_{t+1}, y_{t+1}) / D^t(x_t, y_t)$$
$$\bullet \; \{[D^t(x_{t+1}, y_{t+1}) / D^{t+1}(x_{t+1}, y_{t+1})]\,[D^t(x_t, y_t) / D^{t+1}(x_t, y_t)]\}^{1/2} \quad (6)$$

Equation (6) decomposes the Malmquist productivity index into the product of two terms. The first term is the ratio of the output distance functions involving data and technology from periods t+1 and t, respectively, showing whether production is getting closer (catching-up) or farther from the frontier. It has a value of unity when there is no change in technical efficiency, greater than unity if there is improvement in technical efficiency, and less than unity if there is decline in technical efficiency. The second term captures the effect of technological change. The second term has a value of unity when there is no technical change, greater and less than unity if technical change has improved and worsened respectively.

MEASUREMENT OF MALMQUIST PRODUCTIVITY INDEX, TECHNICAL CHANGE, AND EFFICIENCY CHANGE

To estimate the Malmquist productivity index as in equation (5), we need to calculate the component distance functions $D^t(x_t, y_t)$, $D^{t+1}(x_{t+1}, y_{t+1})$, $D^t(x_{t+1}, y_{t+1})$, $D^{t+1}(x_t, y_t)$. We used the method by Fare et al. (1994) which uses non-parametric programming methods. To calculate the productivity of country i between time period t and t+1, we need to calculate four component distance functions, which involves solving four linear programming (LP) problems. The calculation of $D^t(x_t, y_t)$ and $D^{t+1}(x_{t+1}, y_{t+1})$ involves the calculation of technical efficiency scores for each country in a time period in comparison with all countries in the same time period. Assuming constant return to scale technology, and since output distance function is reciprocal to the output-based Farrell measure of technical efficiency, the output-oriented LPs used to calculate both distance functions, respectively, are:

$$
\begin{aligned}
[D^t(x_t, y_t)]^{-1} &= \max_{\delta,\lambda} \delta \\
\text{s.t.} \quad -\delta y_{it} + Y_t\lambda &\geq 0 \\
x_{it} - X_t\lambda &\geq 0 \\
\lambda &\geq 0
\end{aligned} \tag{7}
$$

$$
\begin{aligned}
[D^{t+1}(x_{t+1}, y_{t+1})]^{-1} &= \max_{\delta,\lambda} \delta \\
\text{s.t.} \quad -\delta y_{it+1} + Y_{t+1}\lambda &\geq 0 \\
x_{it+1} - X_{t+1}\lambda &\geq 0 \\
\lambda &\geq 0
\end{aligned} \tag{8}
$$

Calculation of $D^t(x_{t+1}, y_{t+1})$ and $D^{t+1}(x_t, y_t)$ involves calculation of technical efficiency scores for each country in a time period in comparison with all producers, including itself, in the other time period. The LPs to calculate these distance functions are:

$$
\begin{aligned}
[D^t(x_{t+1}, y_{t+1})]^{-1} &= \max_{\delta,\lambda} \delta \\
\text{s.t.} \quad -\delta y_{it+1} + Y_t\lambda &\geq 0 \\
x_{it+1} - X_t\lambda &\geq 0 \\
\lambda &\geq 0
\end{aligned} \tag{9}
$$

$$
\begin{aligned}
[D^{t+1}(x_t, y_t)]^{-1} &= \max_{\delta,\lambda} \delta \\
\text{s.t.} \quad -\delta y_{it} + Y_{t+1}\lambda &\geq 0 \\
x_{it} - X_{t+1}\lambda &\geq 0 \\
\lambda &\geq 0
\end{aligned} \tag{10}
$$

In LPs (9) and (10), where production points are compared to technologies from different time periods, the δ parameter need not be $\oplus$ 1, as it must be when calculating Farrell efficiencies. The point could lie above the feasible production point. This will most likely occur in LP (9) where a production point for period t+1 is compared to technology in period t. If technical progress has occurred, then a value of $\delta < 1$ is possible. Although it could also possibly occur in LP (10) if technical regress has occurred, this is less likely.

Once these four linear programmings are solved, efficiency scores are inverted and substituted into equation (6) to obtain a decomposition of productivity change into efficiency change and technical change, for each country. Then, the entire procedure is repeated for the set of countries for periods t+1 and t+2 and so on, through time period T-1 and T. Since in our study we have thirteen time periods and five countries, the total LPs to be solved are 240.

DATA AND RESULTS

Aggregate data on output, capital and labor have traditionally been used in estimating total factor productivity whether stochastic frontier functions, data envelopment analysis, or an index number approach were employed. We used the Penn World tables 5.6 (PWT 5.6), which were released in 1994, to obtain data on real GDP and labor employed during 1978-1990. The Penn World Tables present internationally comparable economic data for more than 120 countries. PWT 5.6 is the latest version of the Penn World Tables, and is described in detail in Summers and Heston (1991). Data on real GDP were retrieved from real GDP per capita. This database has been widely used since output per person was measured in 1985, dollars adjusted for purchasing power parity, meaning that this variable is, in principle, not affected by domestic prices of goods and services, relative to both domestic and foreign goods. Similarly, data on labor employed were retrieved from the real GDP per worker. (However, data on capital stock were only available for certain countries in the sample). We refrain from using national sources for estimates of these variables since our main concern is to treat the five countries in the sample uniformly. Hence, we follow the procedure employed by Sarel (1997) in constructing the capital stock using historical data on investment flows from the Penn World Tables database.[7]

Table 1

Average Annual Growth Rate Of GDP, Capital, and Labor : 1978-1990

Country	**GDP growth (%)**	**Capital growth (%)**	**Labor growth (%)**
Indonesia	7.2	2.3	12.8
Malaysia	6.8	9.3	3.2
Philippines	2.7	5.0	2.5
Singapore	7.4	9.2	2.8
Thailand	7.1	7.7	2.4
ASEAN average	6.2	6.7	4.7

The DEA method constructs a best-practice frontier from the data in the sample. Hence, in our case we are constructing an "ASEAN frontier" and comparing individual countries to that frontier. We begin with a summary table of average annual growth rates of output, capital, and labor for ASEAN as a whole as well as for each country in the sample. As seen in Table 1, GDP growth in ASEAN averaged 6.2 percent per year over the 1978-90 period.

This growth rate was very impressive given there was an economic slowdown in the sample period. The annual growth rate of capital and labor are 6.7 and 4.7 percent, respectively. Among individual countries, Singapore had the highest average annual growth rate in GDP of 7.4 percent followed by Indonesia, Thailand, Malaysia, and the Philippines at 7.2, 7.1, 6.8, and 2.7 percent, respectively. Malaysia had the largest growth rate in capital, 9.3 percent, while Indonesia had the largest growth rate in labor, 12.8 percent.

Table 2
Technical Efficiency Scores: All Years

Year	Country					
	Indonesia	Malaysia	Philippines	Singapore	Thailand	Mean
1978	1.000	1.000	0.981	1.000	0.960	0.988
1979	1.000	1.000	0.975	1.000	0.977	0.990
1980	1.000	1.000	0.933	1.000	0.937	0.974
1981	1.000	1.000	0.881	1.000	0.889	0.954
1982	1.000	1.000	0.934	1.000	0.922	0.971
1983	1.000	1.000	0.911	1.000	1.000	0.982
1984	1.000	1.000	0.811	1.000	1.000	0.962
1985	0.978	1.000	0.793	1.000	1.000	0.954
1986	0.922	1.000	0.809	1.000	1.000	0.946
1987	0.841	0.950	0.805	1.000	1.000	0.919
1988	0.769	0.960	0.785	1.000	1.000	0.903
1989	0.748	0.979	0.773	1.000	1.000	0.900
1990	0.746	1.000	0.778	1.000	1.000	0.905

Table 2 reports estimates of technical efficiency scores for the ASEAN countries in our sample. Values of unity imply that the country is on the ASEAN frontier in the associated year; values less than unity imply that the country is below the frontier or technically inefficient. For all years in the sample, only Singapore is consistently technically efficient. This is not surprising, since Singapore is known to have highly productive labor. The Malaysian economy is technically efficient in ten of the thirteen periods under study. Its technical efficiency scores average 99 percent meaning that Malaysia's economy produced about 99 percent of its potential output over the period. This suggests that Malaysia's economy is not that far behind Singapore in terms of efficiency. Thailand's technical efficiency is also quite impressive; it is on the frontier in eight of the thirteen sample periods and averages 97 percent over the period. Meanwhile, Indonesia's technical efficiency scores, averaging 92 percent, are higher than the Philippines, which at 86 percent is the least technically efficient among the ASEAN countries in the sample. While it is not technically efficient in all of the years in the period, the Philippines's economy only produced about 86 percent of its potential level of output. Its efficiency scores fluctuated between 77 and 98 percent.

The estimates of Malmquist productivity indexes as well as the efficiency-change, technical change, and scale-change components for each country in the sample are shown in Tables 3,4,5 and 6. Each country will have an index for every pair of years. If the value of the Malmquist index or any of its components is less then one, that denotes regress or deterioration in performance, whereas values greater than one denote improvement in performance. Also recall that these measures capture performance relative to the best practice in the sample, where best practice represents an "ASEAN frontier."

Table 3

Malmquist Index Of Productivity Change, Technical Change, and Efficiency Change: Average Annual Changes

Country	Productivity change	Technical change	Efficiency change	Pure efficiency change	Scaled efficiency change
Indonesia	0.969	0.993	0.976	1.000	0.976
Malaysia	0.993	0.993	1.000	1.000	1.000
Philippines	0.983	1.002	0.981	0.986	0.995
Singapore	1.022	1.022	1.000	1.000	1.000
Thailand	1.008	1.005	1.003	1.002	1.001
Mean	0.995	1.003	0.992	0.998	0.994

For the entire sample (1978-1990), on average, productivity in ASEAN economies had decreased slightly (Table 3). While the first half of the sample period was characterized by productivity decline, the latter half showed gains in productivity. The Malmquist productivty index had a negative growth of 0.5 percent as a whole. On average, the decrease is mainly due to the deterioration in efficiency with which existing technology is utilized rather than a decrease in the growth of innovation or technical change. We can see from the results that in the years prior to the economic recession in 1986, the productivity growth is declining, confirming findings that it is one of the causes of recession in ASEAN countries. However, improvement in innovation and the use of new technologies (showed by the growth in technical change) in the years 1986 onwards contributes to the productivity gains in the latter half of the period.

Turning to country-by-country results (Table 4), Singapore has the highest total factor productivity change at 2.2 percent followed by Thailand at 0.8 percent, where, in both cases, most of the change is due to innovation or technical change as shown by each year's technical change and efficiency change index in Tables 5 and 6 respectively. In fact, Singapore and Thailand are the only countries that experienced positive growth in total factor productivity over the period. On the other hand, Indonesia had the greatest decline in total factor productivity growth, with a negative rate of 3.1 percent, most of which is due to deteriorating efficiency, although it also experienced a decline in the growth of innovation. In addition to being the least technically efficient among the ASEAN countries in the sample, the Philippines also experienced the largest decline in efficiency. However, a positive growth in innovation helped to overcome greater worsening in its productivity growth. Malaysia experienced a declining growth in total factor productivity of 0.7 percent, all of which is due to decline in the growth of innovation or technical change.

Table 4
Total Factor Productivity Change (Malmquist index): All Years

Year	Country					
	Indonesia	Malaysia	Philippines	Singapore	Thailand	Mean
1978-79	0.976	1.009	0.994	1.017	1.018	1.003
1979-80	0.994	1.026	0.972	1.016	0.974	0.996
1980-81	1.035	0.992	0.960	1.038	0.982	1.001
1981-82	0.888	0.971	0.993	1.007	0.962	0.963
1982-83	0.955	0.961	0.945	1.014	1.060	0.986
1983-84	0.942	0.970	0.875	1.022	0.985	0.958
1984-85	0.934	0.898	0.934	0.937	0.966	0.933
1985-86	0.934	0.914	1.005	0.987	0.993	0.966
1986-87	0.956	0.993	1.051	1.060	1.049	1.021
1987-88	0.979	1.077	1.046	1.079	1.059	1.048
1988-89	1.018	1.065	1.031	1.055	1.033	1.040
1989-90	1.025	1.053	1.000	1.038	1.019	1.027

Table 5
Technical Change: All Years

Year	Country					
	Indonesia	Malaysia	Philippines	Singapore	Thailand	Mean
1978-79	0.976	1.009	1.000	1.017	1.001	1.000
1979-80	0.994	1.026	1.015	1.016	1.016	1.013
1980-81	1.035	0.992	1.017	1.038	1.036	1.023
1981-82	0.888	0.971	0.937	1.007	0.928	0.945
1982-83	0.955	0.961	0.969	1.014	0.978	0.975
1983-84	0.942	0.970	0.983	1.022	0.985	0.980
1984-85	0.955	0.898	0.955	0.937	0.966	0.942
1985-86	0.991	0.914	0.985	0.987	0.993	0.973
1986-87	1.049	1.045	1.056	1.060	1.049	1.052
1987-88	1.070	1.066	1.073	1.079	1.059	1.069
1988-89	1.047	1.044	1.048	1.055	1.033	1.045
1989-90	1.028	1.031	0.995	1.038	1.019	1.022

Table 6
Efficiency Change: All Years

Year	Country					
	Indonesia	Malaysia	Philippines	Singapore	Thailand	Mean
1978-79	1.000	1.000	0.993	1.000	1.018	1.002
1979-80	1.000	1.000	0.957	1.000	0.959	0.983
1980-81	1.000	1.000	0.945	1.000	0.948	0.978
1981-82	1.000	1.000	1.060	1.000	1.037	1.019
1982-83	1.000	1.000	0.975	1.000	1.085	1.011
1983-84	1.000	1.000	0.890	1.000	1.000	0.977
1984-85	0.978	1.000	0.978	1.000	1.000	0.991
1985-86	0.943	1.000	1.021	1.000	1.000	0.992
1986-87	0.912	0.950	0.995	1.000	1.000	0.971
1987-88	0.915	1.011	0.975	1.000	1.000	0.980
1988-89	0.972	1.020	0.985	1.000	1.000	0.995
1989-90	0.997	1.021	1.006	1.000	1.000	1.005

CONCLUSION

The idea that TFP growth can be decomposed into technical change and efficiency change provides a more meaningful avenue for evaluating economic performance across countries, especially in the developing countries, since there is considerable evidence that productivity gain due to technological mastery is substantial and may outweigh gains from technological progress. Our results show that the economic slowdown in the ASEAN countries in the mid-eighties were preceded by a decline in productivity growth. As such, the notion that productivity growth is a prerequisite for sustainable economic growth is supported. On average, ASEAN countries' TFP growth had been declining at a negative rate of 0.5 percent over the study period. The decline is due mainly to the deterioration in efficiency with which existing technology is utilized rather than a worsening in the growth of innovation or technological change. These findings support the evidence that technological mastery/diffusion is important in the growth of TFP in developing countries. This suggests that policies in ASEAN countries should focus on mastering available technology or improving imitation skills to improve the rate of TFP growth. However, based on the individual countries, the results are mixed. While the contribution of innovation or technological change is substantial in the growth of TFP in Singapore, which was the leader in overall TFP growth in the region, the decline in productivity growth in Indonesia is primarily due to deteriorating growth in efficiency. The results also show that Singapore is the most efficient economy in the region since the country is on the ASEAN frontier (implying technically efficient) in all periods of the study, while Philippines is the least efficient.

ENDNOTES

1. ASEAN is the acronym for Association of South East Asian Nations. Its ten member countries are Brunei Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. This study concentrates only on five ASEAN economies due to lack of historical data on the other five.

2. This series of papers was presented at the 20^{th} Federation of ASEAN Econ omic Association Conference held on 7-8 December, 1995, in Singapore.

3. Among the policies recommended were enhancing human resource development such as increasing the number of engineers and technicians, shifting employment from low - to high - productivity sectors of the economy and improving the organizational structure of the economy.

4. Furthermore, all these studies used different time periods. As such, comparison in performance across countries can be misleading without controlling for world economic conditions.

5. Productivity can also be measured using an input-orientated approach. The input-orientated productivity measure focused on the minimum level of input use to produce a given level of output using a given production technology.

6. The output distance function is the reciprocal of Farrell's (1957) measure of output technical efficiency, which calculates how far an observation is from the frontier of the technology: i.e., Farrell's measure of output technical efficiency $F(x,y) = 1/D(x,y)$.

7. The details on how capital stock is being constructed can be found in Sarel (1997).

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