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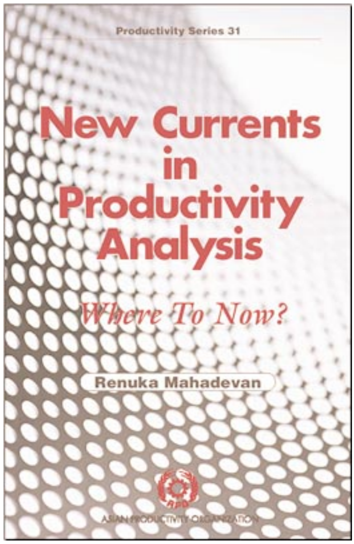
by Renuka Mahadevan



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New Currents in Productivity Analysis

Where To Now?

Renuka Mahadevan

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2003
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John A-A

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Preface

The aim of this book is four-fold. The first is to review the main total factor productivity (TFP) growth measurement techniques and to provide an update on the latest approaches in the continuously expanding research field of productivity measurement. The problems and advantages underlying the measurement and interpretation of TFP growth are also summarized. The view of the author is that productivity is an essential concept for analysis as well as policy orientation in the long term.

The second aim of this book is to discuss the underlying theory of the sources of output growth and TFP growth. The relationship between the partial measures of labor and capital productivity and TFP growth is also examined to make explicit the conceptual links between them. Second, an empirical investigation is undertaken using the recent panel data set of various countries from 1990-99, compiled and published in the 2001 Asian Productivity Organizaiton (APO) publication *APO Asia-Pacific Productivity Data and Analysis*. Great effort was devoted to coordinating and compiling in a single publication data on many variables related to productivity growth for those economies. The present volume provides some empirical analysis based on the compiled data set to understand what drives TFP growth and to analyze the policy implications for sustained growth in the Asia-Pacific region.

The third aim of the book is to highlight the effect on productivity of the "new economy," which is characterized by computers and the era of information technology. For some reason, these have failed to bring about the expected increase in productivity growth, and the issues underlying such a productivity paradox are discussed.

The fourth aim of this book is to suggest how more can be done in productivity research by the APO. This focuses on the importance of various aspects of productivity analysis that have yet to be undertaken.

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Abbreviations

APO	Asian Productivity Organization
DEA	Data Envelopment Analysis
FDI	Foreign Direct Investment
IT	Information Technology
ICT	Information and Communications Technology
MNC	Multinational Corporations
NIE	Newly Industrializing Economy
OECD	Organisation for Economic Cooperation and Development
TFP	Total Factor Productivity

Chapter 1: Total Factor Productivity Growth Measurement

"Productivity isn't everything, but in the long run it is almost everything."

Paul Krugman (1990)

1.1 Introduction

Productivity growth forms the basis for improvements in real incomes and welfare. Economists of all leanings accept this basic relationship between productivity and living standards. It is one of the few relationships economists agree on. The concept of total factor productivity (TFP) gained importance and appeal when it was recognized that output growth could not be fuelled by continuous input growth in the long run due to the nature of diminishing returns for input use. That is, as more and more inputs are used, less and less extra output can be expected from an extra unit of input used. For sustained output growth, TFP growth is essential, and hence TFP growth became synonymous with long-term growth as it reflects the potential for growth. This spurred great interest in trying to obtain improved and more accurate productivity growth estimates, which is an ongoing task in the field of productivity measurement.

This chapter first reviews the concepts of labor productivity, multifactor productivity, and TFP growth. Second, it discusses the use of gross output versus the value-added output measure. Third, it distinguishes between TFP levels and TFP growth rates. Fourth, a brief review of the core approaches and the latest methods for TFP growth measurement are provided. Then a selected survey of some empirical work using these techniques is presented. The last section details the many uses of this measure as well as abuses of the concept and interpretation of TFP growth measures.

1.2 Types of Productivity Growth Measures

One common measure of productivity is the partial measure given by labor and capital productivity calculated as net or gross output per unit of the respective input. Although intuitively appealing and relatively easy to measure, the partial measure only considers the use of a single input and ignores all other inputs, thereby causing misleading analyses. Thus the partial measure does not measure overall changes in productive capacity since it is affected by changes in the composition of inputs. For example, improvements in labor productivity could be due to capital substitution or changes in scale economies, both of which may be unrelated to the more efficient use of labor. Or if a reduction in labor caused production bottlenecks or new capital was not utilized efficiently or intensively enough to pay its way, a labor productivity measure would show an increase even though overall efficiency declined.

However, labor productivity makes a good starting point for analysis as it reflects how efficiently labor is combined with other factors of production. It has also been maintained that partial measures are useful in showing the savings achieved over time in the use of the input per unit of output. From the welfare point of view, labor productivity, which is linked to output per capita by labor force participation and the age structure of the population, ultimately limits per capita consumption. Therefore, this partial measure retains a role in the family of productivity measures relevant to national economic policy. Also, if there are important biases in the estimates of capital stock used to construct measures of TFP growth, then it will be better to rely on measures of labor productivity. Typically, labor productivity moves in the same direction as TFP but it grows at a somewhat faster rate, reflecting the influence of capital deepening.

Unlike the partial measure, the multifactor and TFP measures consider the joint use of the production inputs and mitigate the impact of factor substitution and scale economies. They are given by:

$$\text{TFP index} = Q_1/(aL + bK) \quad (1)$$
$$\text{Multifactor productivity index} = Q_2/(aL + bK + cM) \quad (2)$$

where Q_1 is value-added output, Q_2 is gross output, M is intermediate inputs, and a, b, and c are weights given by input shares.

These measures are the ratio of output to the weighted average of inputs. The distinction between TFP and multifactor productivity is that the latter includes the joint productivity of labor, capital, and intermediate inputs, and the former considers the joint productivity of labor and capital only. Intermediate inputs comprise materials, supplies, energy, and other purchased services, and value added is defined as gross output minus intermediate inputs. The multifactor productivity measure may also include other inputs such as land and other natural resources used in the production process. Most studies do not distinguish between the two indices and they are often used interchangeably.

1.3 Value-added and Gross Output Measures

There are two types of output measures that can be used to calculate TFP growth. One is the value-added output, which is gross output corrected for purchases of intermediate inputs, and the other measure is gross output. For value-added output, single deflation is appropriate, and for gross output, double deflation must be used because there are two components to deflate. Diewert (2000) noted that for comparing TFP growth at the industry level, it is best to use value-added output rather than gross output as the latter includes the purchase of intermediate inputs which may very greatly among industries. Use of the gross output may also bias the results because of substitution in the production process between intermediate goods and labor or capital. In addition, the value-added measure is best used for primary production and for comparing enterprises that produce different product mixes that are vertically integrated to different degrees, or produce outputs of different quality. The value-added output measure remains a useful concept, particularly for international comparisons of productivity, because it is simple, avoids the need for estimates of intra-industry transactions, and bears closer resemblance to primary statistics such as production census and representative firm data.

On the other hand, using value added distorts technology effects in estimating TFP growth because all raw and semi-finished materials, subassemblies, energy, and purchased services are omitted from measured inputs. Often TFP growth based on the value-added measure is greater than that based on the gross output measure due to the upward bias created by the omission of these intermediate goods and services. If the growth rates of value-added output and gross output differed greatly, this would magnify the TFP growth distortion even more. But the choice of the use between gross output and value-added output can easily be determined by testing for the separability conditions for a value-added approach, which means that the intermediate inputs must be weakly separable from the other inputs. In other words, the marginal rate of substitution between capital and labor must be independent of the level of intermediate inputs.

1.4 TFP Levels and TFP Growth Rates

TFP growth compares different points in time while TFP levels compare different points in space. In particular, productivity comparisons between countries or industries must address the tricky issue of currency conversion, while productivity growth measurements avoid this question and constitute a useful starting point for analysis. However, it is far less useful for comparing the relative productivity of different countries. This is because implications drawn from TFP levels and TFP growth rates are quite different. For example, if a country is enjoying high TFP levels, then it can be expected that the potential for high TFP growth would be low as there is little for the economy to catch up given that it has been already doing well and vice versa. Hence, a developing country is likely to have a much more rapid TFP growth than a developed country because it starts from a lower TFP level and is able to enjoy growth by gaining access to technology that it has never used.

The concepts of TFP levels and TFP growth can also be linked to reflect static and dynamic efficiency (Kalirajan and Wu 1999). If an economy's TFP levels for a single year or several years are raised but the underlying TFP growth rate is unchanged, then the economy is said to have experienced a static form of efficiency. To have both static and dynamic efficiency, not only the TFP level but also the growth rate of TFP must increase.

TFP growth can be calculated from TFP levels in the following way:

$$\text{TFP Growth}_{t} = \text{TFP Level}_{t} - \text{TFP Level}_{t-1} \qquad (3)$$

The above equation shows that TFP growth at time t is given by the difference in the TFP levels at time $t-1$ and t. In a way, the rigid distinction between TFP levels and TFP growth is artificial, as the study of growth rates cannot ignore levels that are in effect needed for the calculation of growth rates. Also, the TFP growth calculation as the first difference operation is sometimes said to remove the long-term information in the data, although the literature to date remains divided between using TFP growth rates and TFP levels in cross-country studies.

1.5 Approaches to TFP Growth Measures

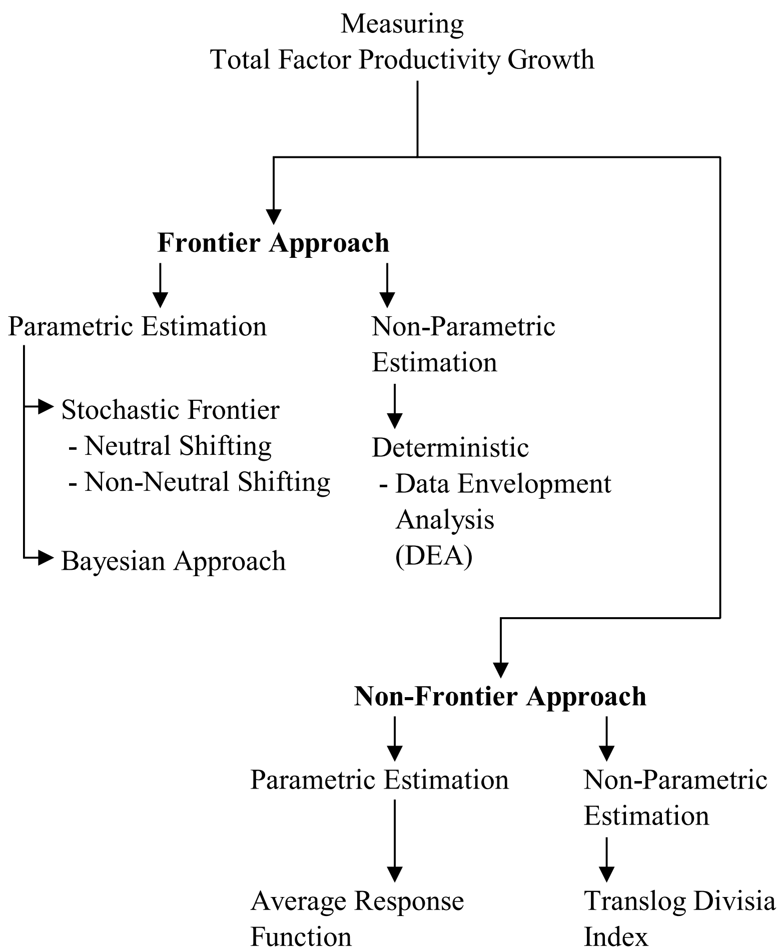
Depending on the reader's background, this section may or may not seem technical but it hopes to be sufficiently general to engage most readers. While it is deliberately kept simple without a large dose of mathematical and technical detail, for a more detailed discussion, see Mahadevan (2003).

The concept of TFP growth dates back to the work of Tinbergen (1942)[1], Abramotivz (1956), Solow (1957), and Griliches and Jorgenson (1966) among many others. While these and a significant number of studies thereafter have often focused on the

[1] Tinbergen's Paper was first written in German and was not published in English until 1959.

non-frontier approach to calculating TFP growth, the frontier approach to TFP measurement was first initiated by Farrell (1957). However, it was not until the late 1970s that this approach was formalized and used for empirical investigation. The literature on TFP growth measurement can be broadly categorized into the frontier and non-frontier approach.

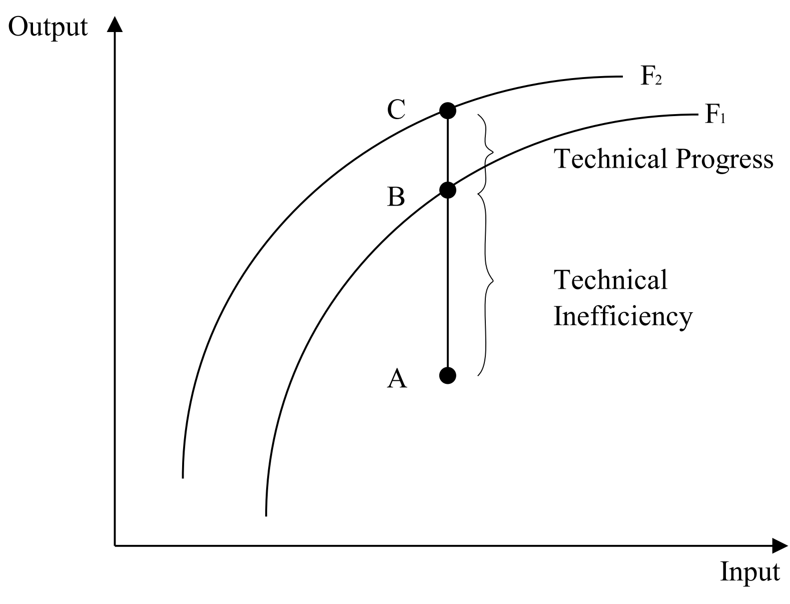
Figure 1.1 Total factor productivity estimation methods



The flowchart in Figure 1.1 shows the main TFP measuring methods under these two approaches. The crucial distinction between these approaches lies in the definition of the word, frontier. A frontier refers to a bounding function, or more appropriately, a set of best obtainable positions. Thus a production frontier traces the set of maximum outputs obtainable from a given set of inputs and technology, and a cost frontier traces the minimum achievable cost given input prices and output. The production frontier is an unobservable function that is said to represent the 'best practice' function as it is a function bounding or enveloping the sample data.

The frontier and non-frontier categorization is of methodological importance since the frontier approach identifies the role of technical efficiency in overall firm performance while the non-frontier approach assumes that firms are technically efficient. Figure 1.2 illustrates this idea.

Figure 1.2 The frontier and non-frontier TFP growth measure



F_1 and F_2 are production frontiers in periods 1 and 2, respectively. Technical efficiency, which is represented by a movement toward the frontier from A to B, refers to the efficient use of inputs and technology due to the accumulation of knowledge in the learning-by-doing process, diffusion of new technology, improved managerial practices, etc. Thus AB shows technical inefficiency in period 1. The absence of technical inefficiency in the non-frontier approach is related to the implicit assumption of long-term equilibrium behavior whereby firms are said to be fully efficient as they have had time to learn and adjust their input and technology use appropriately. Thus the non-frontier TFP growth measure is only made up of the movement from B to C, which represents technical progress due to technological improvements incorporated in inputs. Hence technical progress and TFP growth are used synonymously when the non-frontier approach is used. The frontier TFP growth measure, on the other hand, consists of outward shifts of the production function resulting from technical progress as well as technical efficiency related to movements toward the production frontier. That is,

Non-frontier TFP Growth = Technical Progress (4)

Frontier TFP Growth
= Technical Progress + Gains in Technical Efficiency (5)
(Shifts of the Production Frontier) (Shifts toward Frontier)

However, this is not to say that the non-frontier TFP growth measure would always be lower than the frontier TFP growth measure as gains in technical efficiency may well be negative and cause the frontier TFP growth measure to be lower. In fact, this has been the case for Singapore's manufacturing sector, as shown by Mahadevan and Kalirajan (2000).

Another difference between the frontier and non-frontier approach is that the former is best suited to describe industry or firm behavior. This is due to the benchmarking characteristic of the frontier approach whereby a firm's actual performance is compared with its own maximum potential performance or as defined by the best-practice efficient firm in the sample. Benchmarking has little place in the non-frontier approach, which was first used to obtain estimates of aggregate TFP growth measure for the entire economy and then was progressively used for various sectors or industry-level analysis when disaggregated data became more widely available.

One feature shared by the frontier and non-frontier approach is that they can both be estimated using either the parametric or the non-parametric method. The parametric technique is an econometric estimation of a specific model and since it is based on the statistical properties of the error terms, it allows for statistical testing and hence validation of the chosen model. However, the choice of the functional form is crucial to model the data as different model specifications can give rise to very different results. The non-parametric technique, on the other hand, does not impose any functional form on the model but has the drawback that no direct statistical tests can be carried out for validation.

1.5.1 The Non-frontier Approach

The non-frontier approach uses the standard growth accounting framework that separates the growth of real output into an input component and a productivity component. It is given as:

$$\text{Output Growth} = \text{Input Growth} + \text{TFP Growth} \qquad (6)$$
$$\rightarrow \text{TFP Growth} = \text{Output Growth} - \text{Input Growth} \qquad (7)$$

where input growth consists of the sum of the increases in the use of all factors purchased for production.

Output is thus seen to increase with the increased use of inputs and/or increases in productivity. This framework is able to provide the contribution to output growth of each of the inputs used. Since real data on output and input are available, TFP growth in Equation (7) is estimated as a residual measuring 'everything and anything' of output growth that is not accounted for by input growth. Because the determinants of TFP growth have yet to be proved, this measure is often called a 'measure of ignorance'

(Abramovitz 1956) since it is nothing more than a measure of what we do not know. This idea has often advanced the hypothesis that careful measurement of the relevant input variables should cause this residual to disappear.

However, growth accounting is a step toward a reconciliation of the economic balance sheet as it provides a filing system that is complete in the sense that all phenomena that affect economic growth must do so through input factor qualities and factor intensities. In spite of its above-mentioned limitations, the results from growth accounting have proven to be useful policy parameters, and the residual has provided the theory to guide a considerable body of economic measurement.

Under the non-frontier approach, one can use the non-parametric index number method or the parametric average response function to measure TFP growth. Almost all countries in the Asia-Pacific region have used both these methods. The most commonly used index for productivity measurement is the Theil-Tornqvist index or the Translog-Divisia index. One advantage of the index number method is the ease of computation; it can be calculated with only two data points. But the disadvantage is that the index number method is appropriate only under the assumption of constant returns to scale. This rigid assumption implies that output increases proportionally to input use. That is, if inputs are increased by 50%, then output also increases by 50%. However, in the real world, it is hard to find any market that operates under this assumption.

1.5.2 The Average Response Function

The non-frontier parametric estimation takes the form of the average response function using data from the production or cost side. By far the most important aspect of this method is the selection of an appropriate functional form that ranges from the simple Cobb-Douglas to the more flexible translog form. An example of the former type of production function is:

$$\text{Log } Y = a + b \text{ Log } K + c \text{ Log } L \quad (8)$$

where Y = valued added output
K = capital used
L = labor employed
b = capital share and c = labor share.

The above Cobb-Douglas production function has constant returns to scale technology and thus b + c = 1. Alternatively, Equation (8) can be expressed as:

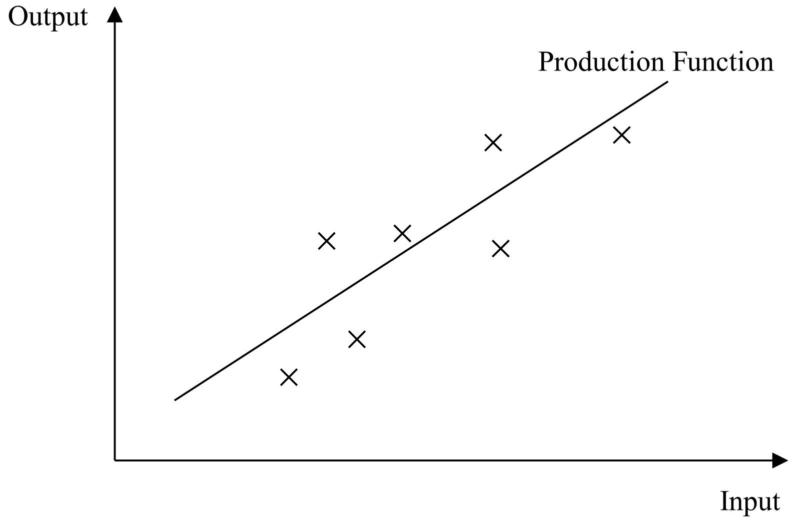
$$\text{Log } (Y/L) = a_1 + b_1 \text{ Log } (K/L) \quad (9)$$

The translog functional form does not impose the constant returns to scale and instead relaxes this assumption by allowing for varying returns to scale. However, there are advantages and disadvantages in the use of both these functional forms.

As a general rule of thumb, in Equation (8), it is perceived that b is about 0.6 and c is about 0.4 for estimations based on aggregate economy data. One can then expect that for the manufacturing sector, the capital share represented by b would be higher than the estimated capital share for the service sector as the latter is likely to be labor intensive. It must be cautioned that these estimates can vary widely depending on the level of economic development in a country. For example, in a predominantly agricultural-based economy such as Nepal, the labor share is likely to be higher than the capital share for its aggregate economy.

An econometric (sometimes known as parametric) estimation of Equation (8) or (9) represent fitting a line through the data set as shown in Figure 1.3. It can be seen that this non-frontier parametric method is the estimation of an average production function. As explained earlier, the assumption is that all firms or industries operate on this estimated average line and do not exhibit any technical inefficiency, unlike the frontier approach.

Figure 1.3 An average response production function



Sometimes, instead of the primal approach of the production function, the dual approach of the cost function is estimated with factor prices and output of a production function. The estimation of the cost function is, however, more demanding as it requires accurate input price data that are difficult to obtain. Here, productivity growth is represented as a downward shift in the cost function. This is because productivity growth can be interpreted as the ability to produce the same level of output using fewer inputs and thus the cost of production decreases with productivity growth, allowing for greater competitiveness.

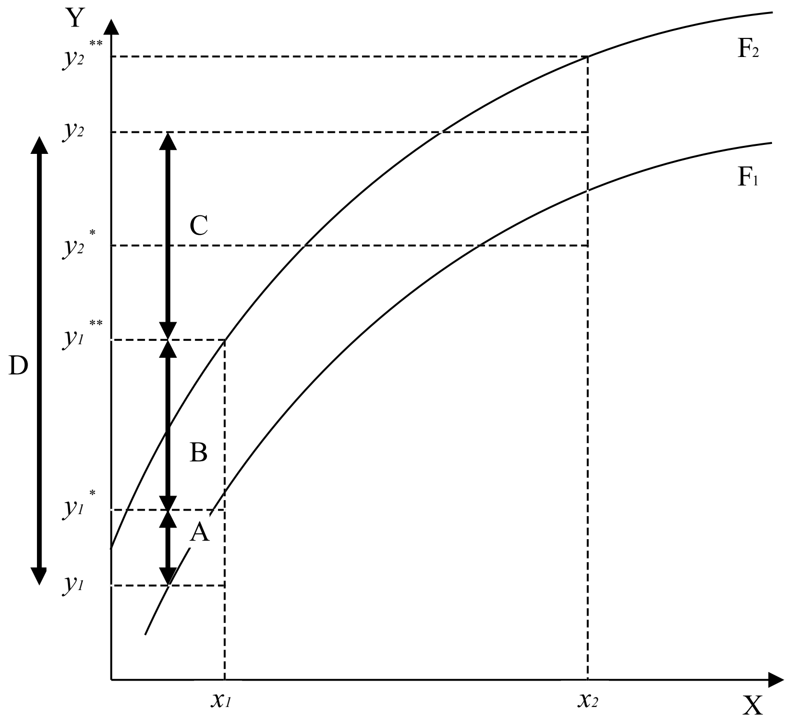
1.5.3 The Frontier Approach

Unlike the non-frontier approach, the frontier approach is able to decompose output growth not just into input growth and TFP growth; it goes a step further to decompose TFP growth into various efficiency components such as technical progress and gains in technical efficiency, as stated in Equation (5). That is, under the frontier approach,

Output Growth = Input Growth + TFP Growth
= Input Growth + Technical Progress
+ Gains in Technical Efficiency (10)

Algebraically, the above can be computed using the framework shown in Figure 1.4. The horizontal axis measures a typical industry's inputs and the vertical axis measures its output. Assume that the industry faces two production frontiers, F_1 and F_2, the 'efficient production technologies' for periods 1 and 2, respectively. In period 1, if the industry is producing with full technical efficiency by following the best-practice techniques, its realized output will be y_1* at the x_1 input level. However, because of various organizational constraints, such as the lack of a proper incentive structure for workers, the industry may not be following the best-practice techniques and therefore may be producing at less than its full technical efficiency. This means that the realized output y_1 is smaller than the maximum possible output y_1*. Technical Efficiency, TE_1, measures this gap by the vertical distance between y_1 and y_1*. Now, suppose there is technical progress due to the improved quality of human and physical capital induced by policy changes, then an industry's potential frontier shifts to F_2 in period 2. If the given industry keeps up with technical progress, more output is produced from the same level of input. Therefore, the industry's output will be y_1** from the x_1 input level, as shown in the Figure 1.4. Technical progress is measured by the distance between two frontiers (F_2-F_1) evaluated at x_1. Now the industry is generally induced to increase its levels of input in period 2. Its maximum possible output is y_2** for new levels of input x_2, and its realized output is y_2. The vertical distance between y_2 and y_2* is measured as TE_2. Therefore, the contribution of the change in technical efficiency to output growth between the two periods is measured by the difference between TE_2 and TE_1. When this difference is positive, it means that there is improvement in the industry's technical efficiency and vice versa. Output growth due to input growth between the two periods can be measured by the distance between y_2** and y_1** along frontier 2.

Figure 1.4 Decomposition of output growth and TFP growth



The decomposition can be mathematically expressed as follows:

$$
\begin{aligned}
D &= y_2 - y_1 \\
&= A + B + C \\
&= [y_1^* - y_1] + [y_1^{**} - y_1^*] + [y_2 - y_1^{**}] \\
&= [y_1^* - y_1] + [y_1^{**} - y_1^*] + [y_2 - y_1^{**}] + [y_2^{**} - y_2^{**}] \\
&= [y_1^* - y_1] + [y_1^{**} - y_1^*] - [y_2^{**} - y_2] + [y_2^{**} - y_1^{**}] \\
&= \{(y_1^* - y_1) - (y_2^{**} - y_2)\} + (y_1^{**} - y_1^*) + (y_2^{**} - y_1^{**}) \\
&= \textbf{\textit{Change in TE}} + \textbf{\textit{TP}} + y_x^* \\
&= \textbf{\textit{TFP Growth}} + y_x^*
\end{aligned}
$$

where $y_2 - y_1$ = production output growth between two periods and

TE = technical efficiency
(shifts toward production frontier)

TP = technical progress
(shifts in the production frontier over time)

y_x* = change in output production due to input growth
(shifts along the production frontier)

Source: Mahadevan and Kalirajan (1999).

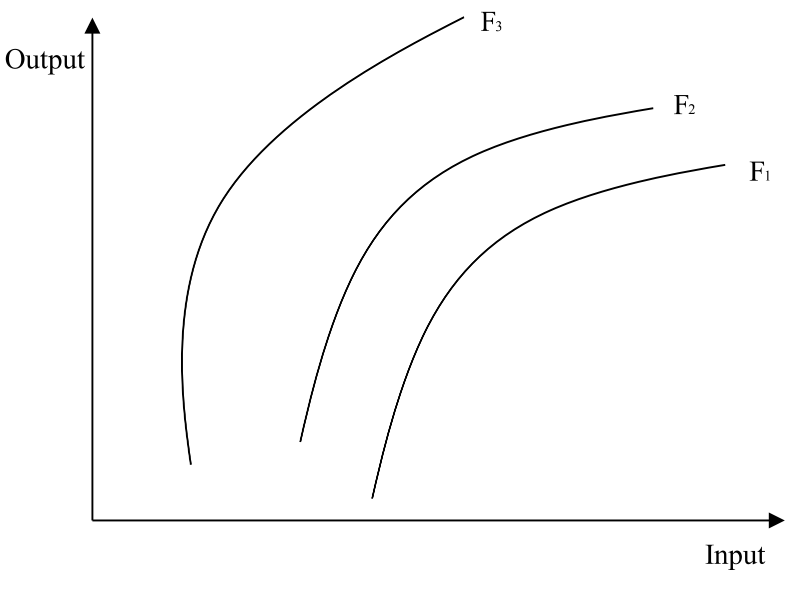
The decompositional framework in Figure 1.4 is important for more accurate policy prescriptions based on the two sources of TFP growth identified as technical progress and technical efficiency. Often studies have considered a host of factors affecting TFP growth to derive policy implications, but such analysis is misguided as the components of TFP growth given by technical progress and technical efficiency are conceptually different and may move in opposite directions, thereby calling for different policies. Table 2.1 clearly illustrates this idea. The non-frontier approach (as seen in Equation (4)), on the other hand, is unable to identify the two main sources of TFP growth. It computes TFP growth as a lump sum, only measures technical progress, and hence does not distinguish between movements toward the frontier and shifts in the frontier over time.

Similar to the non-frontier approach, in the frontier approach one can also use the parametric or non-parametric approach. One attractive feature of the non-parametric estimation using data envelopment analysis (DEA) compared with the parametric method is that unlike the latter, DEA is able to handle multiple outputs and this is crucial for firms with heterogeneous products. The parametric and non-parametric frontier approaches also use different techniques to envelope data more or less tightly in different ways. In so doing, they make different accommodations for random effects and for flexibility in the structure of the production technology. It is these different accommodations that generate the strengths and weaknesses of the approaches. With the parametric method, there exist two types of production frontier for estimation (see Figure 1.5). One is the parallel shifting frontier (F_1 to F_2) and the other is the non-parallel shifting frontier (F_1 or F_2 to F_3). The parallel shifting feature is a special case of the non-parallel shifting frontier which is more realistic as it would be expected that, with the same level of inputs, different levels of output could be obtained by following different methods of application. The parallel shift is rigid as it assumes that the same method of application is used over time.

1.5.4 The Bayesian Approach

The Bayesian approach, which is a relatively recent development in productivity growth analysis, provides robustness to model and parameter uncertainty, thus guarding against drawing

Figure 1.5 Types of parametric production frontiers



strong conclusions from weak evidence. The main advantage is that an interval range for estimates can be obtained and one can say that the estimates are accurate with (usually) 95% confidence. This means that the empirical results using the Bayesian approach can carry weight, but studies have shown that the Bayesian estimates often converge with the estimates of the above approaches if the sample size is sufficiently large and if the data collected are fairly accurate. The Bayesian approach is also not without its limitations. First, it can be computationally burdensome and one needs to be well versed in other econometric techniques to analyze some complex problems inherent in Bayesian-type estimation. For this reason, this technically demanding approach has been used sparingly and is not yet popular in empirical studies.

1.6 Survey of Some Empirical Work

This section highlights and discusses the above different techniques using Singapore and Malaysia by way of illustration. First, TFP growth studies done on Singapore are summarized in Table 1.1. It is clear that most studies on Singapore (like most other economies) have centered on the aggregate economy. As the time periods of coverage regarding data and the construction of the data set are different for the economy, the large discrepancy in the magnitude of the TFP growth rates is not surprising. Undoubtedly this also reflects differences in the methodologies used to obtain the estimates. Apart from Leung (1998) and Mahadevan and Kalirajan (2000), all other studies in the table used the conventional non-frontier approach to measure TFP growth.

Table 1.1 TFP growth estimates for Singapore (%)

Source	Time Period	Overall Economy	Manufac-turing	Services
Bloch and Tang (1999)			Less than 0.05	
Bosworth, Collins & Chen (1995)	1960-92	0.60		
Chen (1977)	1955-70 1960-70	3.62	 3.34	

(Continued to next page)

Table 1.1 (Continued)

Source	Time Period	Overall Economy	Manufac-turing	Services
Collins and Bosworth (1996)	1960-73 1973-84 1984-94	0.90 1.0 3.10		
Department of Statistics (1997)	1973-80 1980-85 1985-90 1990-96	-0.5 -0.6 3.8 1.8		
Drysdale and Huang (1996)	1960-90	0.80		
Kawai (1994)	1970-80 1980-90	0.70 1.60		
Kim & Lau (1994)	1964-90	1.90		
Leung (1997) Leung (1998)	1983-93 1983-93		2-3 4.6	
Mahadevan and Kalirajan (2000)	1976-84 1987-94		0.92 -0.52	
Nehru & Dhareshwar (1994)	1960-69 1960-73 1973-87	-0.80 4.70 1.50		
Owyong (2001)	1960-69 1970-79 1980-89 1990-96	2.87 0.95 1.65 2.87		
Rao and Lee (1995)	1966-73 1976-84 1987-94	1.30 0.60 2.60	 0.40 3.20	 0.90 2.20
Sarel (1995)	1975-90	0.02		
Sarel (1997)	1978-96 1991-96	2.23 2.46		
Tan, Lall, and Tan (2000)	1980-85 1986-91		-0.70 2.27	
Tan and Virabhak (1998)	1976-92 1976-84 1987-92			-0.40 -3.78 -6.00
Takenake (1995)	1970-92	-2.40		

(Continued to next page)

Table 1.1 (Continued)

Source	Time Period	Overall Economy	Manufac-turing	Services
Tsao (1982)	1966-72 1972-80	0.60 -0.90	0.06 2.16	
Tsao (1985)	1970-79		0.08	
Van Eklan (1995)	1961-91	1.80		
World Bank (1993) [a]	1960-90	1.19 -3.01		
Wong and Gan (1994)	1981-85 1986-90		-0.80 4.01	
Young (1992)	1966-85	-0.50		
Young (1994)	1970-85	0.10		
Young (1995)	1966-90 1970-90	0.20	-1.00	

Note: [a] The lower value was obtained using a sample of high- and low-income countries, while the higher value was obtained using a sample of high-income countries only.

It is probably more interesting and sensible to compare results that used entirely the same data set. Two such studies (which were deliberately excluded from Table 1.1) are summarized in Table 1.2. Model 1 is the parallel shifting frontier and model 2 is the non-parallel shifting frontier.

Table 1.2 Comparing parametric frontier models for Singapore's service sector

Period	Output Grows	Input Growth		TFP Growth	
	For Both The Frontier Models	Model 1	Model 2	Model 1 [a]	Model 1 [b]
1976-84	2.70	1.93	3.71	0.77	-1.01
1986-90	1.25	0.54	1.98	0.71	-0.73
1990-94	0.97	0.7	1.89	0.27	-0.92

Note: Since 1985 was a recession year, it was excluded from the above estimation.
a These are computed using results from Mahadevan (2000b).
b These are computed using results from Mahadevan (2002c).

The input growth calculations differ for both frontier models as the input shares obtained were different and hence TFP growth is also different. Although the TFP growth rates in model 2 were negative, both frontier models show that input growth was the main source of output growth and that the TFP growth trend consistently declined over time.While Mahadevan (2002d) has done a comprehensive survey on TFP growth studies on Malaysia, here a comparison of frontier and non-frontier models is shown (Table 1.3). The parametric model is that of the non-parallel shifting frontier and the non-parametric frontier model is that of DEA. Again it is comforting that the conclusions from the parametric and non-parametric models broadly conform in that both frontier models show a decline in TFP growth in the 1990s, although the parametric model provides negative TFP growth rates and the non-parametric model provides positive TFP growth rates over time. It is noteworthy that the decline in TFP growth was found both in the frontier results and in the study by Tham.

Table 1.3 A comparison of TFP growth rates for Malaysia's manufacturing sector (%)

Period	Frontier Models		Non-Frontier Models			
	Mahadevan(2002e) Para. Model	Non-para. Model	Okamoto (1994)	Productivity Report 1999	Tham (1996,97)	World Bank (1989)
1981-84	-0.82	0.40				-1.9
1980-89	-1.06	0.44		2.79		
1986-90	-0.57	0.35	0.3			
1986-91	-0.63	0.38			0.3	
1986-93	-1.18	0.27			0.1	
1990-96	-1.54	0.26		1.6		

Para: parametric; Non-para: non-parametric.

In the above cases of Singapore and Malaysia, it may be pointless to debate whether the benefits of one approach outweigh the costs of another because there is no reason to view the approaches as competitors. The important lesson may well be that it appears sensible to say that no single measure of TFP growth from any particular model should be taken to represent the 'right' value given the advantages and disadvantages of the approaches to productivity measurement (see Mahadevan 2003). However, the possibility of the emergence of empirical irregularities with different methods using the same data should not be ruled out completely. Importantly, as policy formulation is often the ultimate objective in productivity analysis, the trends in TFP growth should be of greater interest and be considered far more reliable than the *magnitude* of TFP growth per se.

1.7 Problems and Prospects Underlying the TFP Growth Measure

TFP-A Truly Fruitful Possibility or Totally False Proposition?

One of the pressing problems of TFP growth calculation has always been the underlying measurement issues. First, is the product mix in measuring output. Hardly any firms produce one homogenous product but often change their product mix over time. Differences in output characteristics will affect the number and type of inputs required. Unless output differences are controlled, different input requirements must be accommodated. The problem is compounded when making inter-industry or international comparisons. Any real index of real output must also account for quality. Market prices in the base period are often taken to reflect relative values that capture quality differences, but when quality changes are not associated with increases in production costs, productivity will be underestimated.

With services, the output measure is fraught with more problems than with industrial output. An example that draws attention to the analytical significance of the distinction between a product and a service is that a movie on a videocassette if purchased is a product but if rented is a service. To some extent, the determination of what is a service and what is not is a statistical artifact. This is particularly pronounced with the development of computer and information technology and the growth of producer services. The word 'services' is often used loosely to mean an intangible product or defined as all economic activities that are not agriculture, mining, or manufacturing. There is no universally acceptable definition or classification of services; there are almost as many definitions as researchers who have written on the subject.

The measurement of service outcomes is especially intractable. For example, there is very little information on the contribution of services to health, learning, or utility. Health outcomes from development are not included in the output of the health care industry even when changes in health status are clearly the result of resources devoted to and actions taken by that industry. As with government services, the difficult problem of valuation has led to a largely underestimated measure of output in these areas by the common use of the cost of inputs that go into the production of such services. The uniqueness of services also makes aggregation of service output more difficult. As discussed above, the problem of considering quality changes is more pronounced in service output. For example, how do you take into account faster transport, a more effective communications system, and an increased array of financial services?

The common way to measure the quantity of labor is to use number of hours worked or number of workers employed. Often, the former is preferred to the latter as it accounts more accurately for part-and full-time employees in terms of actual hours worked. However, even the total number of hours worked is not a satisfactory measure if a mix of skilled and unskilled workers is employed. Hours of work by highly skilled workers generally contribute more to production than those of unskilled workers. Thus, to incorporate the quality of the labor input, in addition to skill level, the composition and demographic characteristics should be considered by constructing employment matrices cross-classified by sex, education, employment status, and in some cases, regional status of workers.

The measurement of capital services is less straightforward than labor services because the employer of a capital service is usually also the supplier of the service. In reality, as capital input is not used with a constant intensity over time, it should be adjusted for capital utilization since the use of capital is subject to cyclical factors such as in a recession or boom. In a recession, due to excess capacity, the residual TFP growth will be understated. However, there is now renewed interest and progress in the measurement of improvements in capital goods. This is necessary as the capital used in 1970 would be less productive than the capital used in the 1990s.

In general, quality changes in both capital and labor inputs have to be accounted for an unbiased TFP growth measure. This is to avoid the gains from quality changes in inputs to be suppressed in the contribution of inputs toward output growth.

The second problem underlying the TFP growth measure has been the interpretation of a specific TFP growth value as it encompasses far too many things that defy proper explanation. Some of the sentiments of the critics in this regard are as follows:

- Abramovitz (1956) referred to TFP growth as a 'measure of ignorance.'
- Felipe (1999) claimed that by definition we cannot explain what we do not know, namely, residual TFP.
- Hulten (2000) believed that a static residual TFP measure does not capture the induced effects of technology on growth.
- Griliches (1988) stated that, 'Despite all this work, there is still no general agreement on what the computed productivity measures actually measure, how they are to be interpreted and what are the major sources of their fluctuations and growth.'

The TFP measure is sometimes termed a statistical mirage. Although the TFP framework itself does not furnish a clear explanation, it remains unclear whether this shortcoming reflects problems inherent in the character of the residual or problems inherent in the data to which the TFP framework is applied. Generally speaking, the contention is that past productivity work was not completely futile as today we know more about the nature of productivity and output growth than we did five years ago. The first steps, however shaky or inaccurate, need to be taken to lead us closer to the truth. Thus instead of engaging in the discussion of the possible abuse and misuse of TFP growth measures, we should appreciate the wealth of insight into and analysis of production economics and technical change that have accumulated over time, take the relevant criticisms in stride, and continue working toward better measures of productivity growth and more accurate interpretation of them.

Recently, attempts to explain or solve the productivity puzzle have been directed at understanding the effect of computers and information technology on the economy. This leads one to wonder if TFP growth explanations are becoming murky because of the strong temptation to link the explanations to factors that are themselves rather blurred conceptually and hence difficult to measure. Perhaps this is due to a rush to develop exciting new fields of research, but 'doing more' in this sense may leave us wiser but with much of the original productivity puzzle still intact. The importance of TFP will always be a matter of ongoing controversy. Clearly, the continued strong interest in the measurement and explanation of productivity and efficiency changes is due to the development of new and better theoretical models, the availability of new and better data and estimation techniques, and the advent of large-scale computers. These have made possible the testing of refined hypotheses that have widened the scope and scale of applications in the framework of productivity analysis. Despite the controversies and criticisms underlying the TFP growth measure, the utility and significance of the concept of TFP are considerable and appealing, as demonstrated by the many case studies undertaken in empirical research.

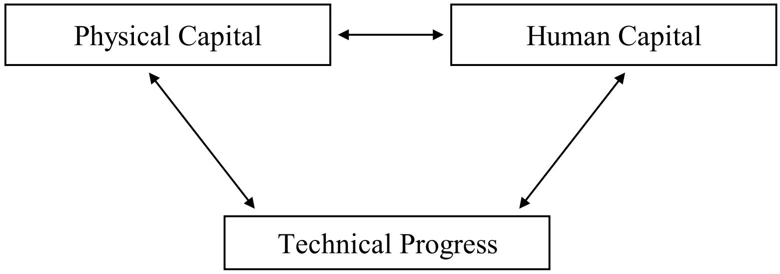
Chapter 2: Sources of Output Growth and TFP Growth

The central role of productivity in determining income levels and economic performance has created much interest in developing sophisticated and more accurate measurement techniques. But this does not answer the most interesting and important question of why productivity and efficiency rates have changed over time. This second equally important question has led to an extensive body of literature on factors influencing productivity growth. These factors are neither inputs to the production process nor outputs of it but nonetheless exert an influence on producer performance. The following approach broadly captures this concept.

2.1 The Three-pronged Approach

Research on the determinants of economic growth and productivity growth suggests that there is a three-way complementarity between physical capital, human capital, and technical progress in the growth process (Figure 2.1). All are necessary ingredients for improved output and productivity growth performance.

Figure 2.1 The three-pronged approach to output growth



For example, new equipment invested in requires a well-trained workforce for efficient operation. While human capital in the form of general education is a key factor for developing countries, the effect of this is expected to be less strong for more developed countries, as they already have relatively high levels of general education and the marginal productivity of an additional year of primary-level schooling is quite low. For developed economies, human capital is made more productive through better skills and in-company training. An increase in the quality of workers would allow increased efficiency in capital use and in turn increase output growth. Another issue is that some types of capital may matter more than others. Some studies have suggested that investment in machinery and equipment is more important than investment in buildings and structures, while others have argued that investment in infrastructure is an important prerequisite for productivity growth and have attributed high payoffs to investment in such capital stock.

Technical progress is another major determinant as new technologies allow the automation of production processes that have led to many new and improved products, allow for better and closer links between firms, and can help improve information flows and organization of production. At the same time, technical progress can be embodied in new equipment, and trained workers can only be fully productive if they have the appropriate equipment with which to work. Increases in physical capital are clearly necessary as there are spillovers from capital investment to productivity growth. Thus it is not appropriate to consider physical capital, human capital, and technology as separate factors since their contributions are closely linked. It is the combination of these three factors and the way in which they are organized and managed within the firm that will determine the extent of productivity growth. For sustained output growth, it is also important that a balance between the three main factors be maintained. The three-pronged approach to increasing output growth has implications for both private-sector action and public policy, as discussed below.

2.2 The Role of Government and Institutions

There are basically two opposing views on the role of government and institutions. One advocates the free market mechanism whereby the government takes on a less directive role to enable firms to respond to market signals quickly. This is the 'market friendly' view or the 'Washington consensus,' which hinges on the argument that governments are bureaucratic and red tape inhibits flexibility and efficiency. Heavy government involvement on the production side would also encourage overcrowding if the private sector cut back production due to excessive and unfair competition from the public sector or if government expansion drove up interest rates, making it expensive for the private sector to borrow. Often the case of Hong Kong's success has been used in support of minimal government intervention.

On the other hand, the revisionist theory or the 'developmental state view' considers the problem of market failure to be pervasive in developing countries. According to this view, there is a need for government to intervene to guide and coordinate entrepreneurial activity. Under this approach the government employs a variety of policy instruments such as tariffs, subsidies, direct finance or credit, and regulation of investment and capital flows to achieve its development goals. In the literature, sometimes the governments of Singapore and the Republic of Korea have been chided for being too heavily involved.

The key responsibility of government is basically to ensure that the actual GDP growth approaches its potential, and this is possible with the creation of an appropriate macroeconomic and microeconomic environment. However, economists differ on which macroeconomic conditions lead to a favorable economic environment. There is the belief that balanced budgets, declining government debt, and price stability are essential as such conditions promote investment by improving business confidence and lowering interest rates. Other economists place more emphasis on demand-side policies to increase spending as the key to keeping the economy on its potential growth path.

With microeconomic policy, appropriate action can foster private-sector productivity performance. Broadly defined, the microeconomic policy environment refers to all policies that affect behavior at the firm level. This includes monetary and fiscal policies, trade policy, tax policy, industrial policy, competition policy, and policies on privatization, intellectual property rights, regulation, and foreign ownership.

The other type of microeconomic policy consists of programs that directly affect the three-pronged determinants of private-sector productivity performance, namely, physical investment, human capital investment, and technological change and innovation. For example, better public infrastructure such as roads, airports, public transit, sewage facilities, and in a more indirect manner, hospitals and educational facilities, can improve the operational efficiency of business. In the area of technical progress and innovation, government can increase direct spending on science and technology but must monitor this by carefully reviewing the cost-effectiveness and relative priorities of these expenditures. Tax incentives could also be given for innovation. Finally, to help diffuse technology, the government must provide business information to assist in the acquisition and implementation of technology and best-practice techniques by providing hands-on technical assistance if necessary.

The broad category of factors and the various determinants in each category influencing productivity growth are shown in Figure 2.2. Inevitably, factors in one category are related to (by causing or being affected by) those in another. For obvious reasons, management decisions pertaining to investment in plant and equipment are affected by external factors such as investment tax credits as well as internal factors such as worker behavior or response to upgrading machinery. Appropriate data are often used as proxies for the measurement of the factors in empirical investigations to choose among policy options for enhancing productivity and efficiency.

Differences in institutions other than the government can also influence productivity growth as effective institutions not

Figure 2.2 Determinations of productivity growth

National, Social, Economic, Defence, Trade and Technology Policies
R&D and investment tax credit
Corporate and personal taxation
Defence procurement practices
Research and development funding
Regulation of industry and trade

Macroeconomic Environment
Business cycle
Saving, investment and interest rates
International trade and exchange rates

Industry Characteristics
Market Structure/Reguration
Product Cycle
Import and export competition
Technology Diffusion

Management Decisions
Technology adoption
R&D expenditures
Investment in plant and equipment
Human resource policies
Quality Control

Worker Behaviour
Responds to:
Technology adoption
Human resource policies
Workforce structure

Plant-level productivity

Product Quality

Profitability and Competitiveness

Source: Norswarthy and Jang(1992)

only lower transaction costs but also play a role in improving incentives, efficiency, and rates of innovation, as in the case of the patent system, and in the definition and protection of property rights more generally. For example, high rates of piracy would discourage the establishment of a flourishing software market or any IT-related industry. Also, in designing institutions, there may sometimes be trade-offs between economic efficiency and other goals, including distributional concerns. For example, the Malaysian government's favored policy toward indigenous Malays (bumiputras) may hinder resource allocation and hence output and efficiency growth in the economy.

Financial development is another aspect of institutional structure that can affect the average size of firms, growth in the average size of firms, and growth in the number of firms where the allocation of capital is concerned. Major financial centers such as Singapore and Hong Kong, which have developed venture capital fund markets, would clearly have more to offer to firms needing loans. In countries with more highly developed financial sectors, it has been observed that a greater share of investment is allocated to relatively fast-growing sectors in the economy. A point to note is that financial underdevelopment often reflects a lack of political will. A more developed financial sector may make subsidies more transparent and this suggests that financial underdevelopment may be due partly to the economic well-being of interest groups. This is illustrated by the case of large conglomerates such as the chaebols in Korea. Although not necessarily a sound policy, strong financial regulation by the government has enabled the *chaebols* to expand, enjoy economies of scale, and become successful multinational corporations.

2.3 A More Focused Approach to Determinants of Productivity Growth

While the above section dealt with general factors that affect TFP growth, this section closely examines the factors that can affect two components of TFP growth, technical progress, and gains in technical efficiency. As explained above, the decompositional framework underlying the frontier approach highlights the importance of identifying the sources of TFP for more accurate policy analysis (see Table 2.1).

Table 2.1 Possible impacts of determinants on TFP growth

Technical Progress	Strength of Effect	Technical Efficiency Change	TFP Growth
↑		↑	↑
↑	>	↓	↑
↑	<	↓	↓

As technical progress and technical efficiency are conceptually different, the impact of a common factor may have different impacts on each of these components of TFP growth. The overwhelming influence of the stronger effect would then determine the final impact. Therefore, appropriate policies to improve both technical progress and technical efficiency must be undertaken to maximize and sustain TFP growth. The discussion below details some of the key factors that can influence technical progress and technical efficiency.

High Capital Intensities

It was hypothesized that industries with higher capital intensities are likely to use resources more efficiently because they cannot afford the rental cost of unused capital and thus have the incentive to economize on the cost of capital to the extent possible. However, there is also the possibility that if the cost of capital becomes relatively cheap due to subsidised credit at low interest rates, then industries may accumulate more capital than is required and underutilize it, thereby lowering technical efficiency. In addition, if higher capital intensities are reflected in higher expenditure on capital pertaining to the purchase of more advanced and better capital equipment, this would have an effect on technical progress.

Interestingly, Mahadevan (2000a) postulated that high capital intensity in Singapore's manufacturing sector has only served to increase technical progress, but not technical efficiency, as the rate of transformation in the economy from labor-intensive to capital-intensive manufacturing operations enabled the use of embodied technology to increase output significantly. This could have led to sufficient profits so that there was little incentive for industries to use the technology efficiently. Also, to qualify for various incentives from the Singapore government, many industries may have accumulated capital that they did not have enough knowledge to use efficiently.

Foreign Direct Investment

Foreign direct investment (FDI) is another important determinant of productivity growth. Dunning (1988) explained that FDI often stems from ownership advantages like specific knowledge of the use of resources due to R&D experience and/or exposure to international competition. Thus FDI can be expected to have a positive effect on technical efficiency as well as on technical progress as the import of more advanced technology embodied in capital often accompanies FDI. In general there is mixed empirical evidence on the effects of foreign ownership on the host country. However, for Malaysia, Mahadevan (2002a) showed that FDI did not improve technical progress or technical efficiency between 1987 and 1992 and that for Singapore, FDI was found to be an insignificant determinant of technical efficiency (Mahadevan 2000a).

Size of the Firm

The size of the firm as a measure of economies of scale has often been found to have an effect on the two components of TFP growth. With economies of scale, firms will be able to take advantage of the relative savings of inputs that can be achieved from operating at or close to the minimum efficient scale. It has been suggested that larger firms have higher efficiency due to economies of scale with respect to organization and technical knowledge, and perhaps due to growth resulting from past efficiency. There is also the counterargument that small firms adopt more appropriate technology, are more flexible in responding to changes in technology, product lines, and markets, and foster more competitive factor and product markets and thus are able to use resources more efficiently.

Number of Firms

The number of firms in each industry can also be used as a proxy to identify the type of market structure that encourages better use of resources. In the standard industrial organizational paradigm, a high concentration ratio (alternatively, the smaller the firm number) is expected to diminish competitive rivalry among industries with the likelihood of underutilizing the production capacity of resources. But others reason that a high concentration ratio brings about sufficiently more innovation and technological change to offset the adverse effects of high concentration, and that concentrated industries experience less uncertainty of demand than other firms and can plan better for higher utilization of productive capacities. Other factors such as the age of the firm and advertising expenditure have also been found to have a significant effect on technical progress and technical efficiency.

Education and Training

More skilled or better educated workers or an increase in training provided to them can be expected to raise technical efficiency. Such workers contribute effectively to the acquisition and combination of productive resources and they are more receptive to new approaches to production and management.

X-Efficiency

The quality of management has a significant effect on productivity growth. This is referred to as X-efficiency in the industrial literature. A firm where management has state-of-art knowledge in areas such as financing, marketing, and innovation has an obvious competitive advantage over firms in which knowledge in these areas is lagging behind. Thus the level of management training is an important factor differentiating an innovating and non-innovating firms; in the long term, it is the former that experience growth.

R&D

The level of R&D undertaken within an economy reflects its absorptive capacity. With increasing R&D expenditure, better technology becomes available or existing technology can be modified. Mahadevan (2000b), however, found that for Australia, R&D did not affect gains in technical efficiency significantly but it had some positive effect on technical progress. The direct effects of R&D on annual growth rates are only a few tenths of a percent even if one applies 40% to 50% rates of return to the real R&D stock (Kendrick 1990). Yet R&D is often deemed necessary to adopt and adapt borrowed technology in the long term.

Macroeconomic Policy

Policies such as trade liberalization, trade orientation related to import substitution, or export orientation can also affect TFP growth. Incentives such as tax holidays and subsidies or technical advice provided by the government to induce firms to export more can be productive. The success stories of Singapore and the Republic of Korea are proof. Another form of trade liberalization is the reduction of government protection given to an industry. Based on the infant industry argument, governments provide support to domestic firms on the grounds that they are unable or not ready to compete in the international market.

Mahadevan (2002b) showed empirical evidence of trade liberalization in Australia: a decrease in the effective rate of protection of the manufacturing industries only significantly improved technical progress, but not technical efficiency.

Chapter 3: Empirical Analysis of Productivity Growth

This chapter draws on data compiled by the APO (2001) comprising many different categories of information for various countries from 1990–99. The main aim is to use these data to draw some policy implications (within limitations of the data) for selected countries in the Asia-Pacific region.

3.1 APO (2001) Data

At the outset, the nature of the data compiled and hence the inherent limitations in the empirical investigation undertaken in this chapter should be acknowledged. First, the data are in current-year prices calculated using the domestic currency of the country concerned. This means that inflationary effects have not been removed, and for countries such as Indonesia and the Republic of Korea that have had very high inflation rates, the figures are inflated. In addition, no exchange rate movements were considered in the data compilation. This means that a country in which the currency appreciated would have found importing more expensive and thus may have cut back production. It thus would be inaccurately judged as not being as productive as another country in which an exchange rate depreciation occurred.

Due to these reasons, it was not possible to pool or combine the data as a rich source of panel data comprising cross-country and time-series information in an appropriate model to consider more in-depth empirical analysis. Nevertheless, an attempt is made to use the simple correlation coefficients between two pairs of data for each country to highlight features of the economy that need to be considered for appropriate policy formulation in the long term. The correlation coefficient is computed as a ratio that varies between +1 and −1. While the sign indicates the direction in which the pair of variables moves in relation to each other, the magnitude indicates the strength of the relationship. Thus, a positive relationship means that as one variable increases in value, the other also increases. Generally, a ratio of more than 0.5 indicates a strong relationship. The drawback is that the ratio does not indicate which variable is the cause and which the effect, and the correlation analysis is unable to determine which of the factors more significantly affects productivity growth. Thus the word "significant" in the subsequent text should not be interpreted as "statistically significant." It has been loosely used to indicate a certain level of importance.

3.2 Cross-country TFP Growth Performance

Without replicating the data and figures that are clearly illustrated by the APO (2001), it can be observed that the Asia-Pacific countries except for the Republic of China and India experienced a declining trend in their TFP growth in the 1990s. During that time, Taiwan's performance was fairly stable at an average annual TFP growth rate of about 1.2%, while India's TFP growth rate averaged about 1.85% annually. Interestingly, the developed countries such as the US, UK, and Australia experienced an increasing trend in their productivity performance, especially in the late 1990s, with TFP growth rates of 2.74%, 2.18%, and 1.94%, respectively.

One possible reason for the similar trend among economies within the Asia-Pacific region could be that the region is becoming increasingly more integrated with regard to trade and foreign direct investment. Together with Japan, the newly industrializing economies (NIEs) of the Republic of Korea and Singapore have spread their wings to invest abroad (Table 3.1), and much of that investment was in the Asia-Pacific region.

The NIEs have progressed from being labor-abundant economies focusing on labor-intensive operations and are now usiing their own expertise and knowledge in low-level manufacturing activities gained in their own countries in the 1970s and

1980s to engage in similar activities in the neighboring region to take advantage of the cheaper labor available there. The Republic of Korea, Malaysia, the Republic of China, Indonesia, and Thailand had shown signs of difficulty before the onset of the 1997 Asian financial crisis. The contagious effect of that event might have also affected their productivity performance.

Table 3.1 FDI outflows (US$ million)

Year	Japan	South Korea	Singapore
1990	39,303	2,301	9,835
1991	42,276	3,328	11,414
1992	34,975	4,426	14,049
1993	37,333	5,442	17,299
1994	41,886	7,472	24,267
1995	52,676	10,233	35,334
1996	49,719	13,828	41,039
1997	54,735	16,821	45,300
1998	39,854	20,263	NA

Source: APO (2001)
NA: not available.

The Asia-Pacific region and the US, UK, and Australia are at different stages of economic development and hence exhibit different patterns of TFP growth. Thus the output growth in the developed countries was TFP growth driven rather than input driven and in the NIEs and the less-developed countries in the Asia-Pacific region output growth is fuelled by input growth. One strong argument in support of the 'mythical' growth of the Asian NIES is that input growth is not sustainable for output growth in the long run. But the developed countries also experienced the phase of being input growth driven until their economies matured. Thus, diminishing returns on increasing inputs is not relevant at this stage for most Asian-Pacific countries. More importantly, input growth with increased technical efficiency, that is, better use of resources and technology, can lead to increased TFP growth. In addition, if input growth means using better-qualified workers and more advanced technology in capital equipment, then technical progress and hence increased TFP growth will occur. The concepts of technical progress and technical efficiency underlying the frontier approach were discussed in Chapter 1.

3.3 Industrial Hollowing Out

The hollowing out of the industrial sector occurs when the industrial sector shrinks and other sectors of the economy expand. This is the natural course of economic development, since the industrial sector first expands at the expense of the agricultural sector, and then the service sector grows, the industrial sector contracts, and the agricultural sector becomes insignificant. But for countries such as Hong Kong and Singapore, the agricultural sector was virtually nonexistent to start with.

In the literature, the simultaneous contraction of the industrial sector and the expansion of the service sector has often been a worry for two reasons: the displacement of workers from the industrial sector; and the relatively slower productivity growth of the service sector (compared with the industrial sector). However, even though the share of output of the industrial sector is decreasing, if the move from a low capital-intensive base to a high capital-intensive base is successful, then the increase from higher value-added manufacturing activities has spillover effects in the economy and industrial hollowing out gives little reason for worry.

The sectoral productivity growth in a group of countries in which the service sector has been increasing in importance is shown in Table 3.2. For both time periods, except for India and Taiwan, and Singapore and the Republic of Korea during 1990-94, all other pairs of observations show that service-sector productivity growth was lower than that in the industrial sector.

Table 3.2 Average sectoral productivity growth using value added (%)

Countries	Industrial Sector (1990-94)	Industrial Sector (1995-94)	Service Sector (1990-94)	Service Sector (1995-94)
Taiwan	4.91	4.41	8.80	7.02
South Korea	8.71	8.92	9.02	8.41
Singapore	9.52	10.53	11.73	9.65
Japan	5.94	3.00	2.70	2.55
Thailand	11.73	9.65	8.90	6.03
Malaysia	20.16	17.83	10.72	9.95
India	6.91	6.85	7.07	8.80

Source: Computed from APO (2001)

Is an expanding service sector with slow productivity growth a concern? Not if the growth of the service sector is linked to improving productivity in the industrial sector. Table 3.3 shows the evidence for various countries.

Table 3.3 Correlation between value-added productivity growth of the service and industrial sectors

Countries	Correlation coefficient
Taiwan	0.08
South Korea	0.82
Singapore	0.49
Japan	0.95
Thailand	0.62
Malaysia	0.59

Source: Computed from APO (2001)

There are some positive linkages in the productivity performance of the two sectors, except in the Republic of China which is characterized by small and medium enterprises that rarely outsource or rely on the services of other firms. The APO (2001) highlighted the problem of industrial hollowing out in the Republic of China, where the manufacturing sector is undergoing structural changes with the rapid outflow of FDI and gradual move toward high-technology, highly capital-intensive industrial activities.

Similarly, for agricultural-based economies such as Nepal, India, and Pakistan, if the growth of the agricultural sector positively affects that of the industrial sector, then policies to boost output and productivity growth in the agricultural sector will have beneficial spillover effects on the performance of the industrial sector. Hence successful implementation and outcome of the policies undertaken would clearly raise the overall productivity growth of the economy. On the other hand, a negative relationship between the productivity growth of the two sectors as in the case of Mongolia and Bangladesh means that there is a need to devise separate policies to induce productivity growth in the two sectors of agriculture and manufacturing.

3.4 Factors Affecting Productivity Growth

Ideally, regression analysis of selected factors would reveal which are significant or insignificant. Unfortunately, this type of analysis was not undertaken as there were only 10 observations per country. Statistically speaking, for such regression analysis to carry any weight, there must at least be 15 degrees of freedom. For example, to consider six factors, the total sample size must at least have 22 years of annual data. Thus, in this section, the correlation coefficient analysis is continued to distinugish the determinants of productivity growth.

3.4.1 Relationship between Productivity Growth and Economies of Scale

The relationship between productivity growth and economies of scale is related to GDP or output growth and is based on Verdoon's law, whereby an increase in output would enable economies of scale to be enjoyed and cost-cutting measures would result in an increase in productivity growth. Table 3.4 illustrates the case for the Asia-Pacific region.

Table 3.4 Correlation between GDP growth and labor productivity growth

Countries	Correlation coefficient
Taiwan	0.68
South Korea	0.86
Singapore	0.76
Japan	0.93
Thailand	0.54
Indonesia	0.91
Vietnam	0.83
India	0.91
Bangladesh	0.53
Fiji	0.83
Nepal	0.83

Source: Computed from APO (2001)

The economies listed in Table 3.4 support Verdoon's law, indicating that economies of scale are important determinants of labor productivity growth[1]. Thus policies should be aimed at fostering large-scale production. Incentives for output expansion

[1] The results for Malaysia and Philippines were implausible and have not been reported here. It is unclear why this is the case but inaccuracies in data compilation could not be ruled out as awkward results were also obtained with the other empirical analyses based on these two economies.

would help firms to improve their productivity performance. However, the danger is that governments might take it upon themselves to engage in production because, unlike domestic firms, they have the necessary resources. This could lead to bureaucracy and inefficiency within government corporations; for this reason huge government corporations in some countries have been privatized over time.

The above evidence also supports the notion that productivity growth is procyclical, that is, in the expansionary (boom) phase of the business cycle, productivity growth increases since output increases; during a recession when economic output contracts, productivity growth declines. In addition to this relationship, another form of causality also exists: if productivity increases, more can be produced with the same amount of inputs and thus output growth also increases. In this case, as explained at the beginning of this chapter, the correlation coefficient is unable to distinguish between these two effects. Due to the lack of data, appropriate causality tests could not be performed.

3.4.2 Relationship between TFP Growth and Input Productivity Growth

As illustrated in Figure 2.1, in the three-pronged approach inputs are linked with productivity growth. Generally speaking, the more productive the inputs, the higher the TFP growth. Table 3.5 shows the relationship between the relevant variables.

Table 3.5 Correlation between TFP growth and input productivity growth

Countries	Correlation coefficient related to labor productivity growth	Correlation coefficient related to capital
Taiwan	0.56	0.86
South Korea	0.88	0.96

(Continued to next page)

Table 3.5 (Continued)

Countries	Correlation coefficient related to labor productivity growth	Correlation coefficient related to capital
Singapore	0.79	-0.24
Japan	0.98	0.67
Thailand	-0.50	-
Indonesia	0.26	-
Malaysia	-0.42	-
India	0.89	0.70
Fiji	0.97	0.83

Source: Computed from APO (2001)
-, No relationship exists because the correlation coefficient could not be computed.

It is interesting that the correlation between TFP growth and labor productivity growth was high for all economies except for Malaysia, Thailand, and Indonesia (which will be explained below). Typically, labor productivity moves in the same direction as the TFP growth rate, reflecting the influence of capital deepening. This explanation correlates well with the high correlation coefficients between TFP growth and capital productivity growth in the selected countries, except for Singapore.

The negative correlation result for Singapore simply warns against the use of excessive capital in production. It is postulated that since too much capital has been used, capital productivity growth has declined, while TFP growth has increased due to increased labor productivity. But why has too much capital been used in Singapore? This is the result of the overzealous efforts of the government in attracting FDI. The transformation from labor-intensive to capital-intensive and then to highly capital-intensive operations has always been rapid for Singapore and this is further evidenced in the average rate of 13% for its gross domestic fixed capital formation figures, which are higher than in economies such as the Republic of Korea and Republic of China when they were in a similar developmental stage. Also, with too much capital, there has been a shortage of labor in Singapore since the early 1980s. Thus the policy lesson for Singapore is that there is a need to slow down in terms of capital accumulation and concentrate on increasing the quantity and quality of labor.

How do we explain the poor correlation between TFP growth and labor productivity growth and the lack of a relationship between TFP growth and capital growth for Malaysia, Thailand, and Indonesia? First, it must be acknowledged that the level of development of these economies is quite similar. They are often termed the second-tier NIEs aspiring to join the first tier, comprising the Republic of Korea, Republic of China, Singapore, and Hong Kong. There are two implications of the result for the second-tier NIEs. One is that they need to focus on capital deepening because insufficient investment in capital has not allowed any spillover effects on TFP growth. But it must be forewarned that the type of capital investment undertaken is also crucial. Like Singapore, these economies have jumped on the bandwagon to attract FDI, but the nature of FDI must clearly be defined and not focus on merely absorbing unskilled labor. The move to capital-intensive manufacturing operations has yet to be successful in these economies as they are still heavily involved in low-level manufactured products. The second implication is that their labor quality needs to be upgraded to ensure that labor productivity feeds TFP growth.

The lack of a strong positive relationship between capital and labor productivity is seen for Singapore, Malaysia, Thailand, and Indonesia in Table 3.6. While the labor skills in these economies are not commensurate with the capital in place, the other economies seem to have better compatibility between the productive use of capital and labor. The mismatch between capital and labor has major repercussions on TFP growth, which is essential for long-term sustainable growth and development.

Table 3.6 Correlation between capital productivity growth and labor productivity growth

Countries	Correlation coefficient
Taiwan	0.69
South Korea	0.71
Singapore	0.31
Malaysia	-
Thailand	-
Indonesia	-
India	0.63
Fiji	0.67

Source: Computed from APO (2001)
-, No relationship exists because the correlation coefficient could not be computed.

3.4.3 Relationship between Productivity Growth and Education

It has been well established that the dramatic increase in the average level of formal education over the past decades has greatly raised labor quality and contributed to aggregate productivity growth. This rests on the simple argument that education enables workers to pick up things readily, be more open to adopt and adapt new methods of production, read and remain up to date, and hence be more aware of how things can be done best. Of all the factors discussed, education is a major factor worth investing in as an economy's own people are key resources waiting to be harnessed.

However, it is interesting to note that unlike the Republic of Korea and Republic of China (where most who obtain an education overseas return to their homeland), Singapore is trying to combat the problem of brain drain. Although Singapore has boosted its efforts to attract skilled Singaporeans back home as well as relaxed the work rules for foreign spouses of Singaporean women, this has met with little success. India is another country that has yet to stem the outflow of its skilled IT professionals who are lured to better-paying jobs in the USA, Japan, and Singapore. The Chinese are still leaving China to settle in countries with better job prospects and different lifestyles.

Thus educating more people needs to be balanced by efforts to retain them by providing jobs and creating a conducive environment to obtain the full benefits of increased productivity. Although countries such as Malaysia and Thailand have come a long way in raising the educational level of their citizens, they are now grappling with the inflow of unskilled workers from neighboring countries. While this solves the problem of demand for unskilled labor (as the educated shun blue-collar jobs), it also creates a continuous pool of unskilled labor that attracts a significant amount of FDI for either labor-intensive or low-level capital-intensive operations. This retards growth in the economy as the move to high-tech industries with higher valueadded activities, sacrificing sustainable productivity growth.

While many studies have confirmed the importance of education for productivity growth, it was found (but not reported here) using APO (2001) data that the correlation coefficient between education (such as number of primary school graduates, number of secondary school graduates, and number of tertiary graduates) was not particularly significant for any Asia-Pacific country. This insignificant relationship can be explained by the following possibilities. First, to assess a factor like education accurately, 10 years of data are insufficient as there is a time lag for the benefits of education to become apparent in the computed values of productivity growth. Second, the data on education are not specific to the labor force but are based on the total population. Thus not all graduates are necessarily working, and some may continue with higher studies. The data must be based on all those employed. For example, in 1991, although the Philippines had 353,000 tertiary graduates and Singapore had only 104,000, Singapore's unemployment rate of 4.6% was much lower than the 9.4% in the Philippines. The quality of education in those two countries varies significantly, and hence the impact on productivity growth can be expected to be different. Third, a decline in the number of graduates is not necessarily a concern as it may be due to the small number attending schools, as in Japan since the 1990s. Thus data from the APO (2001) could not be used directly to identify the effectiveness of education. The fourth reason why education was not found to be significant is due to the possible existence of brain drain. When an economy continues to lose its skilled workers, there is often job-hopping among the skilled workforce in the economy, which may prevent employers from providing worker training to upgrade or improve their skills in an attempt to minimize investment in employees who may choose to leave.

However, the empirical evidence on the correlation between education and productivity growth (not reported here) showed an interesting pattern. Although the correlation ratios are small, they are higher between certain types of educational level and productivity growth. For example, in Bangladesh, the coefficient is higher for secondary education than for primary and tertiary education. In the Republic of China, the Republic of Korea, and Singapore, the coefficient for primary education is the lowest, while in Pakistan and Nepal, primary education had the highest coefficient, indicating its relatively greater effect on productivity growth. Thus the effect of education on productivity growth is dependent on the level of economic development and the main type of economic activity. Primary school enrollment rates are not important for Singapore as the skills required for productivity growth are now at a higher level than in the 1960s. The reverse is true for agriculture-based eonomies.

The ratio of public expenditure on education (Table 3.7) may indicate government commitment to raising the educational level among its people. This is somewhat lacking in Indonesia and Malaysia, because the ratio over the past decade was generally stagnant at around 1% and 2%, respectively. Pakistan and the Republic of China, on the other hand, showed a decline in their ratios in the late 1990s, while India's ratio declined consistently throughout the decade. The efforts of Thailand and Bangladesh were noteworthy. It is difficult to determine the forms of educational expenditure, although this is important for the quality of education provided.

Table 3.7 Ratio of public expenditure on education to GDP

Year	Bangladesh	ROC	India	Indonesia
1990	1.80	4.70	4.34	0.97
1991	2.00	5.14	4.10	1.01
1992	2.76	5.43	4.01	1.01
1993	3.10	5.62	3.90	1.08
1994	2.61	5.42	3.79	0.80
1995	2.42	5.23	3.91	0.74
1996	2.40	5.31	3.80	0.63
1997	2.51	5.05	3.62	0.75
1998	2.48	4.82	NA	0.85
1999	2.52	4.88	NA	0.75

Year	ROK	Malaysia	Nepal	Pakistan
1990	4.70	2.10	1.73	2.10
1991	4.70	1.50	1.92	2.20
1992	5.10	1.30	2.42	2.20
1993	5.30	1.20	2.29	2.20
1994	5.30	1.90	2.31	2.40
1995	5.50	1.72	2.47	2.40
1996	5.80	1.60	2.57	2.50
1997	6.00	1.80	2.59	2.30
1998	6.20	2.00	2.26	2.20
1999	NA	2.00	NA	2.20

Source: APO (2001)
ROC: Republic of China; ROK: Republic of Korea; NA: not available.

(Continued to next page)

Table 3.7 (Continued)

Year	Singapore	Thailand	Vietnam
1990	3.03	2.90	1.63
1991	3.74	3.30	1.47
1992	3.21	3.00	1.69
1993	3.08	3.40	2.23
1994	3.11	3.40	2.57
1995	2.91	3.30	2.78
1996	2.93	3.60	2.49
1997	3.17	4.00	2.78
1998	3.50	4.00	2.69
1999	3.97	5.28	2.59

Source: APO (2001)

In addition, the skill and educational demands on the workforce may have increased substantially so that deficiencies in the area of education and training appear more evident. While education is important, training is equally important to enable workers (both skilled and unskilled) to transfer the educational skills that they have into work skills. In some areas of specialization, this requires training in the form of very specific knowledge. Education in schools or universities is often broad based and does not necessarily cater to industry needs.

To motivate firms to invest in training their workers, it would be encouraging to see the government make a positive move toward providing subsidies for this. While such a scheme is in place in many countries such as Singapore and Malaysia, the amount of subsidies provided needs to be increased. Although this may drain resources from the government, it results in benefits in the long term. This is one area where there are higher rates of return for social subsidy than for private subsidy (that is, when employers bear the cost). Economic theory dictates that in such situations, government intervention and involvement are necessary.

3.4.4 Relationship between Productivity Growth and R&D

The rate of productivity growth is determined by the rate of discovery of product and process innovations and the pace of their diffusion. An indication of the rate of development of innovations can be obtained from R&D spending, on the assumption that there is a positive relationship between resources and discoveries. Here, the correlation coefficient between R&D expenditure as a percentage of GDP and labor productivity growth in manufacturing is examined (Table 3.8). The reason for not choosing TFP growth or aggregate labor productivity growth is that these are aggregate productivity measures and R&D is expected to benefit the manufacturing sector more directly.

Table 3.8 Correlation between R&D and manufacturing labor productivity growth

Countries	Correlation coefficient
Republic of China	0.03
Republic of Korea	0.02
Singapore	0.21
Indonesia	0.11
Thailand	0.24
Malaysia	0.35
Vietnam	0.15
Bangladesh	0.26

Source: Computed from APO (2001)

The correlation coefficients are low for most economies listed in Table 3.8. In Japan, India, Fiji, and the Philippines, the coefficients were even lower. Thus, in general, there is no support for the notion that R&D can improve productivity growth. Why? First, similar to education, there are very long time lags before any R&D benefits can be reaped; more than 20 years may be required before a project becomes successful. Second, R&D has huge sunken costs, which means that a significant amount of resources must be invested as start-up costs. Before 1997, except for the Republic of Korea's R&D expenditure of 2.52% of GDP and Japan's 3.24%, none of the Asia-Pacific economies invested 2% of GDP in R&D. Third, most of those economies do not have a cohort of skilled R&D personnel.

Although R&D in the early stage of economic development is an insignificant contributor to productivity growth, it should not be totally disregarded. Rather, R&D expenditure should be increased gradually. This is because R&D reflects the absorptive capacity of an economy to adopt technically advanced equipment. But innovative research is a slow path to success and is dependent on the level of development. Countries such as Singapore have embarked on a slightly different strategy. By wooing foreign talent in R&D as well as providing incentives for foreign multinational corporations (MNCs) to set up headquarters in Singapore, it was hoped that domestic firms would also be motivated to invest in R&D. This appears to have met with little success, however.

A more significant factor for developing economies is first to gain access to advanced technology either by directly importing foreign technology or attracting FDI. While the latter strategy was successfully pursued by Singapore, the former strategy was taken up by the Republic of Korea in its purchase of patents for the use of foreign technology. The access to foreign technology must, however, be balanced by sufficient diffusion of technology so that spillover effects of the advanced technology can be felt throughout the economy.

3.4.4 Relationship between Productivity Growth and Savings Rate

It has been hypothesized that with a high savings rate, government and private enterprises would have a large pool of resources to borrow from. While the government would be able to upgrade existing infrastructure or expand its own production of goods and services, the private sector would be able to obtain loans for investment. However, as shown in Table 3.9, the evidence shows that the savings rate is an insignificant factor for developing economies and the first-tier NIEs, but it is significant in improving productivity growth for the second-tier NIEs. This highlights the need for a growing pool of funds for expanding economies such as Malaysia, Thailand, and Indonesia where savings and investment rates can be expected to be closely correlated. Incidentally, all the economies listed in Table 3.9 were hit by the Asian financial crisis in 1997/98. This implies that prudent bank management and monetary policy related to interest rates (and hence to investment) have major implications for the pattern of savings and its effect on productivity growth.

Table 3.9 Correlation between savings and labor productivity growth

Countries	Correlation coefficient
Republic of China	-0.07
Republic of Korea	-0.16
Singapore	-0.06
Japan	0.02
Thailand	0.59
Malaysia	0.63
Philippines	0.78
Vietnam	0.06
Bangladesh	0.22
India	0.05
Pakistan	0.02
Nepal	-0.11

Source: Computed from APO (2001)

3.4.6 Relationship between Productivity Growth and Openness

The first-tier NIEs have been successful in the shift from import substitution to an export-oriented strategy as it enabled them not only to benefit from economies of scale but also to become more competitive and have greater incentive to upgrade their technology. The historical experience of other countries that initially pursued closed-door policies either by design or inadvertently was usually unsuccessful and associated with slow growth. This prompted India and Fiji together with the second-tier NIEs to begin liberalizing their trade in the mid-1990s. Liberalization or openness can take many forms. One is via increased trade through the reduction of trade or tariff barriers. Proponents of trade liberalization argue that this makes imports cheaper (and hence imported inputs become less expensive) and thus increases competition and promotes productivity growth in the domestic economy. However, some skeptics claim that trade liberalization can retard productivity growth by shrinking the sales of domestic firms, which would in turn reduce the incentive for those firms to increase their technological efforts. The empirical evidence to date remains mixed on this issue.

The relationship between the ratio of exports and imports as a percentage of GDP and labor productivity growth in manufacturing (since most manufactured goods rather than services are traded) is summarized in Table 3.10.

Table 3.10 Correlation between trade ratio and manufacturing labor productivity growth

Countries	Correlation coefficient
Republic of China	0.43
Republic of Korea	0.72
Singapore	0.19

(Continued to next page)

Table 3.10 (Continued)

Countries	Correlation coefficient
Japan	0.69
Indonesia	-0.06
Thailand	0.51
Malaysia	0.73
Philippines	0.69
Vietnam	0.42
Bangladesh	0.15
Fiji	-0.32
India	0.45
Pakistan	0.39
Nepal	-0.54
Mongolia	-0.43

Source: Computed from APO (2001)

The results shown in the table are interesting. The trade factor was significant for most of the economies, with some exceptions. The rather low ratio for Singapore is not surprising as Singapore is already a very open economy and there is little to gain from opening up further. Countries such as Bangladesh, Fiji, Nepal, and Mongolia are also not poised to gain much from opening up. It is likely that these economies are not ready to compete with the world. A gradual process of liberalization is highly recommended, or otherwise their economies will not do well in the long term. Trade openness for Indonesia has not brought benefits as the economy is still grappling with cronyism, under which power has been vested in politicians who are involved in business. The inefficiency in the operations of those businesses would be exposed if the economy opened up. Although liberalization would perhaps be one way of doing away with cronyism, a strong lobby has prevented this.

It must be acknowledged that trade liberalization effects also depend on other parts of the macroeconomic policy package which accompany the trade reform process. For example, a stable and low inflation rate or depreciation of an overvalued exchange rate would clearly help trade. International trade represents a positive-sum game at the economy-wide level as economic exchange among countries is not necessarily rivalrous. The increased interdependence among countries through trade and capital mobility has increased the importance of trade benefits. The principal notion behind comparative advantage is that countries specialize in industries for which the cost per unit of output is relatively low compared with that in other countries.

Another form of openness is in terms of investment opportunities for foreigners. Of late, attracting FDI has become rather fashionable and many Asia-Pacific countries such as Bangladesh, Thailand, Vietnam, Indonesia, and Malaysia have pursued this following the success of Singapore since the late 1970s. Table 3.11 summarizes the relationship between labor productivity growth in manufacturing (where most FDI is directed) and FDI inflow.

Table 3.11 Correlation between FDI inflows and manufacturing labor productivity growth

Countries	Correlation coefficient
Republic of China	0.46
Republic of Korea	0.48
Singapore	-0.01
Japan	0.05
Indonesia	0.36
Thailand	0.22
Malaysia	0.34
Philippines	-0.02

(Continued to next page)

Table 3.11 (Continued)

Countries	Correlation coefficient
Vietnam	0.59
Bangladesh	0.04
India	0.26
Pakistan	-0.14
Nepal	-0.27
Mongolia	0.15

Source: Computed from APO (2001)

As shown in Table 3.11, the FDI results do not look promising except for Vietnam, the Republic of Korea, and Republic of China, which are not as open as their counterparts such as Singapore and Hong Kong. For economies such as Bangladesh, Pakistan, and Nepal, the relationship between FDI and productivity growth is not encouraging. This means they are not attracting enough FDI for benefits in productivity to emerge. The strategy for these economies should be to target FDI that will absorb the abundance of labor in their economies.

The second-tier NIEs show some positive correlation although not strong. This result may be surprising given the fairly significant amount of FDI that these economies have been attracting. Thus it is highly possible that the type of FDI inflow is simply not improving productivity growth. These economies must be careful not to fall into the rut of only attracting labor-intensive FDI that does not contribute to productivity as much as capital-intensive or high-tech activities.

Interestingly, the relatively closed economy of Japan and the rather open economy of Singapore have not benefited from FDI. Japan has always survived well on its own but its resistance to FDI as well as the secular and distinct cultural environment has not made it particularly easy for foreign MNCs to operate in Japan. In the case of Singapore, the insignificant relationship should not be interpreted as meaning that FDI in the past was not successful because the data are only from the 1990s. Rather, the implication is that more FDI from MNCs engaging in high value-added activities is necessary if productivity growth is to improve in a fairly mature economy such as Singapore. The reason why FDI has had no apparent benefit to Singapore is that there has been a major shortage of skilled and unskilled labor, a high turnover among workers, and a unusually rapid rate of transformation in the economy which did not generate any learning-by-doing gains (Mahadevan and Kalirajan, 2000; Mahadevan, 2000a).

What are some of the important lessons for countries attempting to benefit from FDI? First, the type of FDI is an important factor. If it is only involved in low-tech or labor-intensive activities, then there is a limit to how much the host country can benefit. Second, to attract FDI, there must be a conducive environment in the host country. For example, sufficient labor, good worker attitudes, a stable political and economic environment, sound macroeconomic policies, etc. are necessary for the viability of foreign MNCs. There is also a role for government to ensure that tax incentives, designated export-processing zones, and reduced bureaucratic procedures for approving foreign projects exist to lure more FDI. Third, to ensure spillover effects within the domestic economy, domestic firms must work hand in hand with foreign MNCs to provide good outsourcing services. This enhances the forward and backward linkages in the production line. A word of caution is required: overreliance on FDI can be dangerous given the footloose nature of foreign MNCs. In times of domestic recession, they do not hesitate to relocate to another country. Thus to avoid such a situation, the government must be careful to ensure that domestic firms are not too disadvantaged by the presence of foreign competition. Instead, domestic firms must be groomed to compete with and learn from foreign investors.

Although there are advantages and disadvantages of openness, one must be aware that in reality it is difficult to isolate the effects of trade liberalization and FDI on productivity growth as their success is contingent on a host of other factors. Some of those factors are internal, while others are external and not within the control of the country. Hence policies need to be carefully implemented and combined to work well and complement one another so that the maximum possible benefit from export-oriented strategies can be enjoyed.

Chapter 4: Productivity Growth and the New Economy

This chapter reviews one of the important ongoing debates animating the productivity literature in recent years. The much-asked question has been how much or even whether computers contribute to improved productivity. On the surface, what seems most striking is that such a question has even surfaced. Given the marvelous power of modern computing, its reputation in the public mind, and the vast amounts of money spent on IT applications, the economic benefits should be manifest. But the dissemination of information and new knowledge is intangible and spreads without leaving many traces in the sands of data. Robert Solow (1987) was the first to point out the anomaly between productivity growth and computerization and the famous Solow paradox is that computers can be seen everywhere except in the productivity statistics. The fact that many serious and competent scholars can conclude that there have been few net productivity gains attributable to this technology seems sufficient proof that something is wrong.

4.1 The New Economy

The Industrial Revolution started in the last half of the 18th century in the UK where the steam engine and other mechanical innovations increased industrial output. The second wave of industrialization came with mass production methods represented by the automotive industry at the beginning of the 20th century. Then the third industrial revolution (sometimes called the digital or IT Revolution) came during the 1980s driven by technological breakthroughs in the computer industry. The development of the Internet in particular ushered in the the information age.

The debate that centers around the emergence of the 'new economy' and the resulting implications for productivity measurement began in the 1980s. Some skeptics say that there is nothing new in the so-called new economy and they discount the significance of the Internet and IT as revolutionary forces. But what is the 'new economy'? It involves the acquisition, processing, transformation, and distribution of information. The three major components are the hardware (primarily computers) that process the information, the communications systems that acquire and distribute the information, and the software that with human help manages the entire system. Sometimes the new economy is known as the knowledge economy because IT enables an economy based on knowledge to acquire the know-how for production. The IT sector is defined differently by different countries but generally consists of computer hardware, software, and services, office and communications equipment, communications services, and the banking and insurance industry.

In the Asia-Pacific region, especially in Southeast Asia, awareness of IT increased over the last few years of the 1990s (see Table 4.1).

Table 4.1 Main national IT policies in Asia

Countries	Policy	Year
Singapore	IT2000	1992
	Singapore One	1996
	ICT21 Masterplan	1999
	Infocomm21	2000
Hong Kong	Digital21	1998
ROK	Cyber Korea 21 Vision	1997
Malaysia	Multimedia Super Corridor	1996
Thailand	IT2000	1995
	The Greater Phuket Digital Paradise Project	2000
Indonesia	Nusantara21	1997

(Continued to next page)

Table 4.1 (Continued)

Countries	Policy	Year
Philippines	IT21	1997
Vietnam	IT2000	1995
Japan	National IT Strategies for 2005	2000

Source: Updated from *Yomiuri Shimbun*, 23 September 2000
ROK: Republic of Korea

The stand taken at the governmental level is reflective of the direction of IT in the economy as a whole. In addition, national information infrastructure in the form of telecommunications systems and networks provides important physical conditions for the development of IT-based industries. Table 4.2 shows that information infrastructure is spreading quite rapidly, although Indonesia, Vietnam, and the Philippines are still at a very early stage.

Table 4.2 Diffusion rates of information infrastructure in 2001

Countries	Per 100 inhabitants			
	Main telephone	Cellularmobile phones	Personal computers	Internet users
Singapore	47.14	72.41	50.83	60.51
Malaysia	19.91	29.95	12.61	23.95
Thailand	9.39	11.87	2.67	5.56
Indonesia	3.70	2.47	1.07	1.86
Philippines	4.02	13.70	2.20	2.59

(Continued to next page)

Table 4.2 (Continued)

Countries	Per 100 inhabitants			
	Main telephone lines	Cellularmobile phones	Personal computers	Internet users
ROK	47.60	60.84	25.14	51.07
Hong Kong	57.66	85.46	38.46	45.86
ROC	57.34	96.55	22.32	34.90
Japan	59.69	58.76	34.87	45.47

Source: ITU Telecommunication Indicators
(http://www.itu.int/ti/industryoverview/index.htm)
ROC: Republic of China; ROK: Republic of Korea.

It has often been said that state monopolies in telecommunications service provision leads to high levels of user charges, thus preventing an increase in the demand for services. But Asian countries are committed to opening up their telecommunications sectors to international competition under the 1997 WTO Agreement on Basic Telecommunications and it is important that they fulfill their obligations to foster IT adoption and use in their economies.

While limited, there is some evidence of the stimulation of economic growth and productivity due to the all-pervasive IT applications in the East Asian NIEs of Hong Kong, Singapore, the Republic of Korea, and Republic of China (Rahim and Pennings, 1987; OECD, 1988; Mody and Dahlman, 1992). Arguments for IT-led development are based on the notion that investments in IT can raise the returns on investment in other capital goods. More recently, using data from 1984-90 from a sample of 12 Asia-Pacific countries, Kraemer and Dedrick (1996) showed that there is a high correlation between IT investment and growth in GDP and productivity.

4.2 The IT-Productivity Debate and Evidence

Expert opinion is solidly divided on the IT-productivity debate. One view is that the IT-productivity paradox exists, and the other is that there is no such paradox. Both views are reviewed to provide an update. Although much of the debate and empirical work on the paradox have hinged on evidence obtained from the developed economies, the issues are also relevant for the Asia-Pacific region, which is expected to embrace IT even more.

First, between 1992 and 1995, investment in office computers in the Canadian service sector rose by 64.2% in real terms but TFP advanced a meager 1.2% (Centre for the Study of Living Standards, 2000). In June 1993, Business Week reported that in the USA, a $1 trillion business investment in IT in the 1980s resulted in only a 1% annual rise in the national productivity rate. Launder (1995) and Hu and Plant (1998) also found little evidence that IT investments raised productivity in the USA. Parham et al. (2001) showed that the adoption of IT only contributed to a 1.1% improvement in Australia's productivity surge in the 1990s. The following quote from the National Research Council (1994) puts some perspective on why the figures are so low: "Everybody's secretary must have a 486 chip in his or her personal computer because it's much faster. And the question becomes, so what? The metrics for measuring this kind of productivity are not very good" (Martin Stein, Vice Chairman, Bank of America).

Before explaining away the economic and profitability shortfall by citing unmeasured customer service improvements, we should at least try to measure those improvements appropriately. For example, what is to prevent the Bureau of Statistics from asking people how much they like the new financial services they are receiving and how much they would be willing to pay to get them back if they were rescinded? The fact that banks and brokers usually supply these conveniences "free" as marketing gimmicks rather than as products with a price tag suggests that the answer would not always be overwhelmingly positive. There is a failure to pick up incremental performance improvements passed along to customers and suppliers. Nor do statistics reflect the "alternative cost" of what would have happened without the IT investments. In some cases, entire businesses and industries could not exist on their present scale and with their present complexity without IT.

Significant effects on productivity can take a long time to wend their way through the crooked corridors of business practice, labor resistance, accounting credit, market growth, acceptance, adaptation, and diffusion. Major benefits of computerization may not have become visible yet as several factors must be in place to harness the full potential of the IT environment. Thus for IT to make the GDP pie bigger, a sufficiently high diffusion rate of technology must be in place so that benefits accrue to entire industries, not just to the individual firms that invest heavily in IT. The latter will only serve to rearrange the share of the GDP pie without increasing its size.

Some economists have compared the IT Revolution to the Industrial Revolution, the building of national rail networks, or the arrival of industrial assembly lines, all of which took many decades to produce dramatic improvements in productivity. A more recent precedent, the exploitation of electricity, was described by Stanford University economist Paul David (1990). Dating the industrial use of electricity from the first dynamo installed by Thomas Edison in New York in 1881, he reported that demonstrable effects on productivity did not appear for more than 40 years, until the 1920s. But when they finally appeared, they were substantial, contributing almost 2.5% per year to a spurt in national productivity growth. He believes that potential gains are difficult to determine until about half of the potential users have adopted a technology. This did not occur with electric motors in manufacturing until around 1920.

Different technologies require different amounts of time to mature. There is no reason why computers should take exactly the same time as electric motors. Therefore the lack of an effect now does not prove that there will not be one sometime. Furthermore, none of the historical analogies, even electric motors, is very helpful because we live in a different world. The rate of change in technology, industry, and patterns of consumption is much faster now than during the revolutions of the 19th century, with vastly different attitudes toward technology.

According to Oliner and Sichel (1994), computers still represent only a small fraction of total capital stock and cannot make a major impact on aggregate productivity, and therefore no productivity contribution has been missed by researchers. Thus a certain threshold level of IT stock needs to accumulate before it is involved significantly in productivity improvements. But perhaps a linear regression model that reveals direct relationship between IT and business productivity simply does not exist at the aggregate level. This shows a lack of attention to the range of intervening variables. If a quadratic equation were to be fitted, a more significant relationship might be obtained.

Others have asserted that the evidence we have considered is simply an accident, or rather an elaborate set of accidents. Perhaps there are genuine and large effects of IT on work efficiency but they are masked by negative influences that have reduced productivity at exactly the same times and places that computers have increased it. For example, the worldwide recession of the mid-1970s was very pronounced in the USA just when productivity growth took a downswing. Recessions cause productivity declines by softening markets, leading to unused but still expensive production capacity.

A more persuasive argument is that the increasing spending on IT provides evidence that businesses are receiving paybacks from their investments. The benefits are occurring, but the productivity returns are lost in a statistical black hole and the mismeasurement problem has increased as product cycles have shortened. The contribution of IT to productivity growth can be greatly underestimated by assuming that the income share is proportional to the contribution. Returns from IT to a specific investment in equipment clearly ignores the wider, potentially transformational effect on work methods and the externalities and synergism from increasing networks formed by computers and other forms of IT. Tallon et al. (1997) directed productivity gains toward a multidimensional assessment combining process-level and firm-level measures across business processes such as customer relations, product/service enhancement, marketing support, etc. Nievelt and Wilcocks (1997) also showed similar evidence using a broad measure of productivity evaluation forIT.

Other strong empirical evidence in support of the benefits of further investment in IT exists. Brynjolfsson and Hitt (1993, 1996) used firm-level evidence and concluded that the productivity paradox had disappeared by 1991, at least in their sample of US firms. They attributed the results to the fact the their present data were more accurate and numerous than those of other researchers. It has been argued elsewhere that from around 1995, it became possible to discern a significant impact of the information and communications technology (ICT) sector on aggregate economic performance, as shown in the US growth resurgence. But the gains observed from the use of IT appear to be mainly gains in labor productivity, rather than reflecting improvements in TFP due to spillovers. The labor productivity gains can be thought of as a consequence of capital deepening, where the new investment is partly driven by changes in the relative prices of ICT goods and services. However, it is unclear if the trends will continue as the remarkably rapid decline in the relative price of ICT may be difficult to sustain.

The role of ICT products has brought to center stage two long-standing questions of price measurement: how to deal with quality changes in existing goods and how to account for new goods in price indices. The distinction between these two issues is blurred because it is unclear where to draw the line between a truly "new" product and a new variety of an existing product. The emergence of new varieties of existing products is a case of horizontal differentiation, quality improvement is a case of vertical differentiation, and the emergence of entirely new goods spans a new dimension in product space. Although the hedonic approach has become a popular tool for quality adjustment, it has its drawbacks in terms of its demands on primary data and econometric methodology.

One view is that the link between ICT and productivity growth results from ICT production, not ICT use. Another view is that countries using ICT stand to gain a lot more than those merely producing ICT equipment. The evidence from studies undertaken in developed countries (the USA, Australia, and the OECD) remains mixed on this issue. However, there are major implications for the Asia-Pacific region. Countries such as Singapore and India that produce an increasing share of ICT equipment may not enjoy "new economy" productivity gains unless firms operating in those countries generate substantial technological advances in ICT production. But as Singapore's service and manufacturing sector are sufficiently ICT intensive, it is likely that there are positive linkage effects in productivity growth. Countries such as Malaysia, with the establishment of its Multimedia Super Corridor, are attempting to pursue a strategy of ICT production. Hong Kong, which does not have a large ICT production sector, has instead relied on importing most of its ICT requirements. Relying on imports in the context of rapidly declining world prices of ICT equipment has produced a terms-of-trade gain in Hong Kong's favor, with all other things being equal, boosting the real incomes of its people. Facilitating the greater use of ICT by creating a flexible environment enabling firms to restructure in appropriate ways to tap the full potential of ICT will generate network economies with increasing returns and spillover benefits that change the way an economy grows. The role of ICT in promoting productivity and output growth is also of considerable interest to the Asia-Pacific region. The US economy is essentially the productivity leader. If a new method to increase productivity growth is found in the USA, countries will follow and ride on a new productivity wave.

4.3 Challenges of IT Adoption for the Asia-Pacific Region

Understandably, IT adoption in the Asia-Pacific region has not been as fast-paced as in developed nations but it is nevertheless picking up, especially in Singapore, the Republic of Korea, and Republic of China. Not surprisingly, Hong Kong has lagged behind those economies because the push for IT development lacked governmental support. Thus there was a delay in creating a community-wide infrastructure for data communications and e-commerce. For economies such as Malaysia, Thailand, Indonesia, and Vietnam, which have been attempting to attract FDI, the prevalent outsourcing and subcontracting that go hand in hand with the use of IT to facilitate coordination and relationships with suppliers (Aoki, 1986) means that they have little choice but to adopt IT. However, there are some aspects of IT adoption which act as barriers.

For example, compared with the prices of typewriters and filing cabinets, computers are expensive, and the initial outlay is compounded by substantial expenses for equipment maintenance, software purchase, customization and updating, operation, and especially training and support. Thus the costs associated with the installation of computer systems may be greatly underestimated, and many smaller companies may be better off not using this "aiding" technology. Also, sometimes the full system is not utilized due to the lack of standardization and excessive complexity of software programs. Without user friendliness, the productivity-enhancing potential of IT cannot be realized.

The phase of technological innovation has not slowed and this has proved to be a double-edged sword. New technologies and applications come into the market, increasing uncertainty about a particular product or business model. The fault does not lie with the technology, but possibly with the lack of skills and a poorly trained workforce. That may constitute a barrier to harnessing the potential of IT. As computers and software increasingly become economic inputs for firms and markets, an overriding feature of IT-intensive firms doing business in a networked environment is close, real-time interactions between suppliers, producers, distributors, and consumers. Interactive processes alone place new demands on firms and open up opportunities only for those that can respond to the need for increased flexibility. Thus organizational structures poorly suited to the effective implementation of IT need to be restructured.

In less developed countries, many workplace activities may not be amenable to productivity improvement through computerization as income is a key factor in diffusion. Table 4.2 shows that countries with higher per capita income have more information infrastructure, allowing the diffusion of IT. In Malaysia, higher-income states also have higher Internet access rates, and IT users are concentrated in metropolitan areas. Policy makers in the Asia-Pacific region should realize that ongoing national IT projects may be restricted to certain people and areas as a gap exists between rich and poor.

There is also a gap between governments and the public. Although personal computers and Internet penetration rates may be high and IT education is reasonably widespread, usage may not necessarily be sufficiently sophisticated to utilize new services. People's awareness, understanding, and computer literacy must be upgraded to bridge the gap between the government and people in countries such as Malaysia and Thailand. This has been recognized under Malaysia's Demonstrator Application Grant Scheme, which encourages Malaysians to utilize the opportunities made available by the ICT industry. In addition, the Strategic Agenda has been formulated to facilitate Malaysia's entry into e-commerce and the knowledge-based economy of the new millennium. Equally noteworthy is Singapore's S$30 million National IT Literacy Programme, initiated in 2001, to train 350,000 people over a period of three years. Singapore was one of the few countries in the Asia-Pacific region to conjure a vision of an "intelligent island" as early as 1992 and its progress in IT adoption and use is a good role model for other countries.

Thailand [1], on the other hand, is grappling with shortcomings in the introduction of IT, citing high telecommunications charges and criticizing the government for a lack of leadership and support. The flotation of the Thai baht in mid-1998 could not have come at a worse time, leading to massive cutbacks in government spending and the suspension or curtailment of many official IT projects. However, attempts to deregulate telecommunications and

[1] See tttp://www.bangkokpost.net/data10y/papges/new2.html

the privatization of the Telephone Organisation of Thailand and the Communications Authority of Thailand may show some results in the future. The establishment of the Software Park Office in 1999 is another effort to be applauded.

In India, IT policies in the 1990s showed a trend of increasing liberalization and globalization but were accompanied by interventionist measures ignoring IT consumption and diffusion. That only served to increase IT production and exports (Harindranath, 1999). In the Republic of Korea, the "cramming" education system has come under fire for being regimented and rigid and therefore not producing the creative workers required by the knowledge-based economy. In Hong Kong, on the other hand, where the government has played a non-directive role, it can be argued that IT adoption by the business community has been slowed since no community-wide infrastructure for data communications and electronic commerce has been provided. The Hong Kong government crafted an IT strategy for its civil service much later than most of its regional counterparts. The Government Data Processing Agency was only upgraded to departmental status in 1989. But the informal, non-standardized, highly centralized nature of the traditional small business culture of Hong Kong also made it difficult to justify major IT investments.

However, it remains unclear whether the extent of IT use is a reflection of a market failure justifying government intervention. In addition, informatization affects social interactions tremendously as information should be freely generated, transmitted, and shared. As information is power, it is a source of control, and sometimes it is necessary for a careful checks-and-balances system to be maintained by the government. Progress in ICT-related sectors, particularly computer software and e-commerce, will depend on better legal frameworks and enforcement related to the protection of intellectual property, the security of commercial information, and privacy safeguards for consumers and companies. As in the OECD countries, appropriate government intervention is required to support knowledge-based activities.

4.4 Conclusions

In spite of the unmeasurable benefits of IT, computers are a boon as they reduce human toil, allow the convenience of 24-hour worldwide banking through automated teller machines, provide greater access to information through the World Wide Web, enable faster and cheaper communications through e-mail, and offer greater job satisfaction arising from the use of IT. Another area of documentable success is in inventory and resource management. Booksellers, for example, have made effective use of International Standard Book Numbers, bar codes, and computers. In manufacturing resource planning, the raw materials, parts, and flexibly assigned labor are all kept track of and marshaled in minimal numbers at just the right time so that capital is not unnecessarily tied up in unused resources.

IT-led development is a promising strategy for Asia-Pacific countries to accelerate the development process. However, it does not guarantee success and the desirable process may differ from country to country because their backgrounds are diverse in many respects. With differing levels of economic development and capabilities for producing and using ICT, countries have different visions of how to develop knowledge-based economies based on varying governmental traditions and styles. At a deeper level, their approaches reflect differences in the social institutions, cultural values, and capabilities that underpin the political and economic systems of individual Asian countries.

It must also be acknowledged that identifying IT impacts and effects is a complex matter and there is a need to examine a range of correlated factors before rushing to a conclusion on the productivity effects of IT. Clearly, a favorable environment is needed for countries to earn a sufficiently high return on IT before they choose to invest more heavily in IT as opposed to other investments. Previous and existing studies on developed countries have also highlighted how macroeconomic studies of IT productivity can mislead and how microeconomic studies of the ways in which individual organizations and markets behave are more helpful. While the period under review is too short to derive any conclusions on whether the IT Revolution will be of long-lasting importance to productivity, in any event we must carefully examine the present progress of the IT Revolution and globalization in developed economies. This will help the Asia-Pacific economies to chart their path in the search for the correct policy mix garnered from the forerunners' experiences.

Chapter 5: Future Directions in Productivity Research

This section hopes to advance the ongoing productivity research carried out by the APO. It should be noted that the discussion here is not meant to criticize the achievements so far. The APO has produced a solid foundation on which to stand and move forward in the field of productivity research. The following areas are suggested for future research.

5.1 Measurement Techniques

All of the productivity growth studies to date by the APO have only used the non-frontier approach, which was shown to have some major flaws in the conceptual framework and thus provide inaccurate TFP growth estimates. As explained in Chapter 2, there are many advantages offered by the relatively recent frontier methodology which can further exploit the interpretation and use of TFP growth measures. While empirical work undertaken by academic researchers has clearly moved in the frontier methodology direction, regional institutions such as the APO, Asian Development Bank, and Economic and Social Commission for Asia and the Pacific have lagged behind. The link between the academic and institutional research remains rather weak. It is important that regional institutions invest their resources and time in coordinating research that would shed light on various economies and, more importantly, bring together these countries to learn jointly from the empirical investigations undertaken by regional institutions.

It was conceded in Chapter 2 that TFP growth measurement is necessary but may not be sufficient to make firm conclusions on economic growth, and make policy prescriptions, much less to predict future growth. Thus, quantitative empirical investigations should be complemented by extensive and more comprehensive qualitative discussions based on surveys and interviews at the disaggregated or firm level. There is clearly a need to work at the micro level to understand better the dynamics of productivity growth at the macro level.

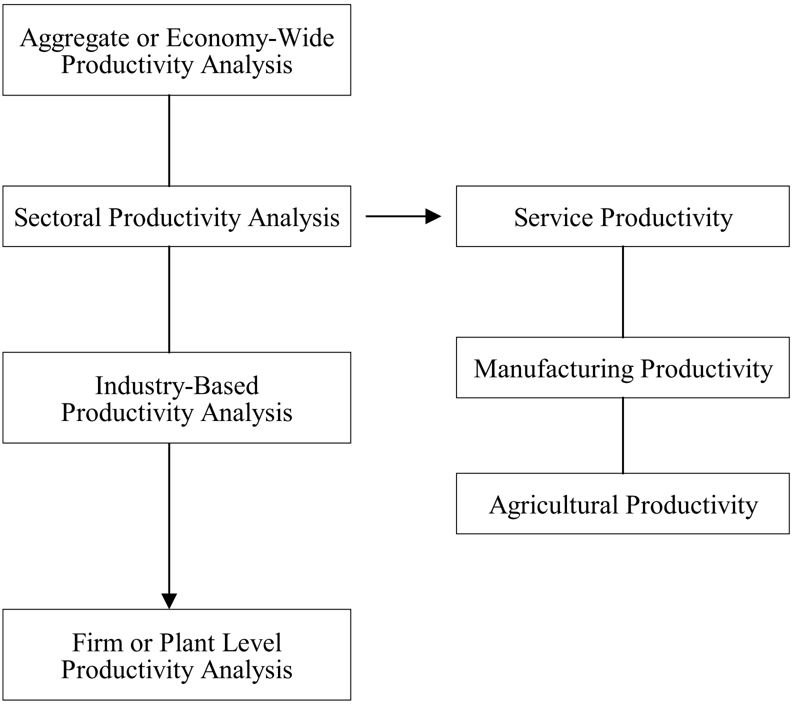
5.2 Micro- and Macro-level Analyses

The current thrust of APO research is centered on productivity growth at the aggregate and sectoral level. Distinctions between these levels of data used for productivity growth measurement are important for inter-country comparisons. For example, Fox (2002) showed that a country may have higher productivity growth than another country in each of the sectors, but it may have a lower productivity growth overall. This has significant implications for the aggregation and disaggregation of productivity growth estimates and the interpretation of productivity convergence studies that use cross-country sectoral data. Basically, the paradoxical result mentioned by Fox hinges on the country's output shares of the various sectors of the economy. It was shown that if country A has relatively more of its total output in a particular sector with lower productivity growth, and country B has relatively more of its total output in a sector with higher growth, then the paradoxical result may occur.

In addition to being aware of the need for the above distinction, there appears another important need to forge a link between micro- and macro-level analysis using more disaggregated data. A schematic representation depicting the links is shown in Figure 5.1.

It is also highly possible that the aggregate productivity of an economy masks productivity trends in the individual sectors such as agriculture, manufacturing, and services. For example, although aggregate productivity growth may be on a rising trend, it may be mainly driven by the increasing productivity growth in the manufacturing sector, while the agricultural and service sector experience decreasing productivity growth. But together, the latter two sectors may exert little or no effect on aggregate productivity

Figure 5.1 Types of productivity analyses



if the productivity growth in the manufacturing sector is strong enough. It is equally important to recognize that industry-level performance within each of the manufacturing and service subsectors can differ significantly given the heterogeneous types of firms within any one sector. For example, within the service sector, the transport and communications industry is different from the banking and financial service industry and within the manufacturing subsector, the electronics industry clearly works differently from the iron and steel industry.

In addition to industry-level analysis, firm- or plant-level data would yield more accurate results for productivity-enhancing policy implications. This is important as the behavior of the industry taken together may be different from that of the individual firms in that industry. Finally, the linkages between the various sectors play an important role because the productivity performance of one affects others, creating ripple effects with significant implications for the economy's growth.

In this regard, a common notion is that as an economy develops, the service sector becomes an increasingly significant contributor to GDP. The implication is that services grow due to increased production of manufactured goods. This is the case when shipping services, advertising, marketing, and commerce thrive because of the need to sell manufactured goods locally or abroad or due to the outsourcing of in-house services by industrial firms. But service-sector growth could also influence growth in the manufacturing sector. For example, the existence of trading companies and their worldwide networks can encourage greater exports of manufactured goods as producers now increasingly rely on such middlemen (who have specific knowledge) to conduct their trade. However, the influence of the service sector on the manufacturing sector is likely to take place in the later stages of economic development.

Relatively little work has been done on international comparisons of service productivity, let alone service-sector productivity within an economy. This is partly because of the complexity of the measurement problems for services. Service productivity is also strongly affected by the institutional organization, the legal framework, and cultural preferences within each country.

However, instead of quibbling about the lack of better-quality data, we should work with what we have and study trends that are far more reliable and worthwhile than trying to obtain a single accurate productivity measure. As is well known, there are many ways of calculating TFP growth, and less time should be wasted in debating which is the best measure.

5.3 Comparable Cross-country Data

As with the OECD inter-country comparison studies, similar comparative analysis for the Asia-Pacific region should be undertaken using purchasing power parity. The underlying theory states that the exchange rate between the currencies of two countries equals the ratio of the countries' price levels. Often, real output and all other variables relating to productivity growth are expressed in the currency unit of a single country. For comparative purposes, it must be converted into a common currency. But the use of exchange rates is not suitable since they are heavily influenced by capital movements and exchange rate adjustments and do not reflect real price differences between countries. As a result, several well-known studies (Kravis et al., 1982; OECD, 1992) have derived purchasing power parities from the expenditure side of national accounts. These underlie the Penn World Tables discussed in Heston and Summers (1991). A comparison of data is provided in Table 5.1.

Table 5.1 Real GDP per capita, 1990 − 92

Countries	Penn World Tables Data (1985 international prices)			APO 2001 (current US$)		
	1990	1991	1992	1990	1991	1992
Singapore	11,698	12,215	12,633	12,401	14,110	15,636
Japan	14,317	14,919	15,095	24,028	27,414	29,856
India	1,262	1,252	1,284	239	249	299
Bangladesh	1,390	1,474	1,509	279	277	277
Indonesia	1,943	2,044	2,104	640	706	754

Source: Heston and Summers, Penn World Table Version 5.6
APO (2001)

It is rather unfortunate that the APO (2001) only reports the above data in current-year prices as these are not adjusted for inflationary movements and prices are known to distort the nominal figures. Interesting differences emerge in the comparison in Table 5.1. The Penn Tables show that Japan's real GDP per capita is about 1.2 times that of Singapore, while in current US$, the ratio is 2 to 1. The ratio of Indonesia's GDP to that of India also shows marked variations in the two data sets. Perhaps the greatest difference is in the comparison of the GDP figures for India and Bangladesh. While the Penn Tables show that Bangladesh's GDP per capita was higher than India's from 1990–92, in current US$ the difference between the two economies seems to be narrowing; in 1992, India's GDP per capita was higher than that of Bangladesh.

However, one drawback of purchasing power parity data is that since industry output comparisons are expressed in terms of producer prices, they may be inappropriate converters for the following reasons. It could be that expenditure prices reflect cross-country differences in wholesale and retail distribution margins and transportation costs, while output prices do not. Expenditure prices also include indirect taxes and subsidies that can vary among countries. The extent to which import and export prices differ from domestic output prices is another factor.

The second type of approach is based on the industry of origin as refined by the International Comparisons of Output and Productivity project, pioneered by Maddison and Van Ark (1988). This approach primarily uses disaggregated or detailed data (up to four-digit level of the international standard industrial classification) from relevant census publications or survey reports. In essence, the output of each industry and for a sector as a whole is first measured by matching comparable products or product groups in each country. Then unit value ratios for each of the matches is calculated based on sales values and quantities of goods and services produced. One drawback is the difficulty involved in matching units or measures of output quantity across countries due to differences in product definitions, product quality, and product mixes at the individual industry level.

5.4 Convergence Theory

Comparisons of productivity performance among countries are central to many of the questions concerning long-term economic growth Are less productive nations catching up to the most productive countries, and if so, how quickly and by what means? The convergence theory is often used to study these important issues. Convergence is defined as low-productivity countries catching up with high-productivity ones. Thus, although an economy may be improving its own productivity performance, it may not be doing well relative to other countries. This draws on the relativity concept of the comparative advantage argument.

The further a country is behind the industrial leader (in the Asia-Pacific region, this would refer to Japan), the greater the potential for catching up. Convergence requires the presence of productivity gaps to create potential and sufficient resources and absorptive capacity on the part of the laggards to narrow the gaps. Presumably, the leaders have greater technological knowledge, part of which is embodied in capital goods, which can be obtained by the less developed countries. Absorptive capacity is indicated by sufficient levels of education and experience, infrastructure, and institutional development to be able to adopt advanced technology, given sufficient savings and investment, access to markets, and favorable macroeconomic policies.

Countries at the same level of development may catch up at different speeds in different industries. This may indicate that structural factors inhibit productivity growth in some sectors. Also, variation in productivity levels and growth rates among countries appears to some extent related to the degree of competition facing industries and sectors in different countries.

A simple measure of the reality of convergence can be confirmed if the standard deviations of real GDP per worker from the mean for the sample countries successively declined over a 20-year period, for example. Other econometric techniques involving regression analysis can also be used to study the convergence issue, which can shed light on the productivity performance of various groups of countries within the Asia-Pacific region, for example, the NIEs or the South Asian countries. Interestingly, evidence from the OECD (1996) showed that although aggregate productivity was converging over time for 14 OECD countries, the sectors showed disparate behavior, with manufacturing showing no signs of convergence while the service sector did. Often in the non-tradable service sector, technological productivity levels converge as the technology for producing similar goods diffuses over time. On the other hand, in the tradable-goods sector of manufacturing, comparative advantage leads to specialization, and to the extent that countries produce different goods, there is no a priori reason to expect the technologies of production to be the same or to converge over time.

5.5 Environmentally Sustainable Production

While there has always been recognition that improved productivity allows sustainable output growth, environmentally friendly production was given new life after the 1996 APO World Conference on Green Productivity in Manila. Environmental protection forms the basis for sustainable development. By taking environmental considerations into account during product planning, design, and development, the negative impact on the environment can be minimized. Those considerations can also involve energy conservation and the reuse and recycling of heat.

The effects of government intervention, particularly environmental, health, and safety regulations, were thought of as adversely affecting productivity growth by raising costs, but the negative effects would be fewer if the benefits of cleaner air and water were captured in real GDP estimates. The present system of national accounts is flawed as it ignores the scarcities of natural resources and does not fully consider the value of environmental systems. Although the United Nations Statistical Office has prepared a framework called the System of Integrated Environmental-Economic Accounting, this has yet to be universally adopted because there is no international consensus on its use.

It is hardly surprising that the depletion of natural resources and the degradation (or improvement) of the environment have traditionally not been integrated into the TFP framework. Clearly, there needs to be a shift in thinking today to broaden the concept of productivity to include such non-market resources. In particular, there is a dearth of empirical studies attempting to compute measures that can be used to discuss the extent of environmental damage. Cost-benefit analysis should be undertaken to facilitate the comparison of alternatives in terms of the monetary costs involved and the benefits that can be obtained.

One other empirical method is using computable general equilibrium models to study the macro effects on the economy. These models describe economic relationships of households, the private sector, and the government. They are often used to simulate the macroeconomic effects of various scenarios before drawing appropriate policy implications. For example, a tax imposed on pollution can be used to understand the behavior of polluting industries in terms of output, export, import, or employment effects. The tax can then be used in conjunction with an appropriate subsidy for reducing pollution and the simulated results provide some estimate of what can be expected. Another example is to study the effects of trade liberalization on the environment. Such models require extensive modeling work and some existing models have already been modified to include specific trade or environmental modules as well as to asses multiregional and multicountry effects.

Bibliography

Abramovitz, M. Resource and output trends in the US since 1870. *American Economic Review*, 1956; 46(2): 5-23.

Aoki, M. Horizontal vs. vertical information structure of the firm. *American Economic Review*, 1986; 76(5): 971-983.

Asian Productivity Organization. *APO Asia-Pacific Productivity Data and Analysis.* Tokyo: Asian Productivity Organization; 2001.

Baumol, W., Blackman, S., and Wolff, E. Unbalanced growth revisited: Asymptotic stagnancy and new evidence. *American Economic Review,* 1985; 75(4): 806-817.

Bloch, H. and Tang, S.H.K. Technical change and total factor productivity growth: A study of Singapore's manufacturing industries. *Applied Economics Letters,* 1999; 6: 697-701.

Bosworth B., Collins, S.M., and Chen, Y.C. Accounting for differences in economic growth. Mimeo; 1995

Brynjolfsson, E. and Hitt, L. Paradox lost? Firm-level evidence on the returns to information systems spending. Massachusetts Institute of Technology Center for Coordination Science working paper; 1993.

Brynjolfsson, E. and Hitt, L. Productivity, business profitability and consumer surplus: Three different measures of information technology value. *MIS Quarterly,* 1996; June: 121-142.

Centre for the Study of Living Standards. Trends in productivity and the new economy. Paper prepared for the Economic Policy Institute, September 2000.

Chen, E.K.Y. Factor inputs, total factor productivity, and economic growth: The Asian case. *Developing Economies,* 1977; 15(2): 121-143.

Collins, S.M. and Bosworth, B.P. Economic growth in East Asia: accumulation versus assimilation. *Brookings Papers on Economic Activity,* 1996; 2: 135-203.

David, P. The dynamo and the computer: an historical perspective on the modern productivity paradox. *American Economic Review,* 1990; 80(2): 355-361.

Department of Statistics, Government of Singapore. Multifactor productivity growth in Singapore: concept, methodology and trends. Singapore: Government of Singapore, Occasional Paper Series; 1997.

Diewert, E. The challenge of total factor productivity measurement. *International Productivity Monitor,* 2000; 1: 45-52.

Drysdale, P. and Huang, Y. Technological catch-up and economic growth in East Asia and the Pacific. *The Economic Record,* 2000; 73(222): 201-211.

Dunning, J.H. *Multinationals, Technology and Competitiveness.* London: Allen and Unwin; 1988.

Farrell, M.J. The measurement of productive efficiency. *Journal of the Royal Statistical Society A,* 1957; 120: 253-281.

Felipe, J. Total factor productivity growth in East Asia: a critical survey. *Journal of Development Studies,* 1999; 35(4): 1-41.

Fox, K. Problems with (dis) aggregating productivity and another productivity paradox. Paper presented at the Australasian Econometric Society Meeting, Brisbane, July 7-10, 2000.

Gollop, F.M and Swinand, G.P. Total resource productivity: accounting for changing environmental quality. In: Hulten, C.R., ed. *New Developments in Productivity Analysis.* Chicago and London: University of Chicago Press; 2001.

Griliches, Z. and Jorgenson, J. Sources of measured productivity change: capital input. *American Economic Review,* 1966; 56(2): 50-61.

Harindranathan, G. Information technology policy in India: production, diffusion and trends. In: Tan, F., Corbett, P.S., and Wong, Y.Y., eds. *Information Technology Diffusion in the Asia Pacific: Perspectives on Policy, Electronic Commerce and Education.* Hershey, PA: Idea group Publishing; 1999.

Heston, A. and Summers, R. The Penn World Table (mark 5): an expanded set of international comparisons, 1950-88. *Quarterly Journal of Economics,* 1991; 106(2): 327-368.

Heston, A. and Summers, R. Penn World Table version 5.6, http://pwt.econ.upenn.edu.

Hu, Q. and Plant, R. Does IT spending impact firm productivity and performance? Working paper, University of Miami, Florida, 1998.

Hulten, C.R. Total factor productivity: a short biography. NBER working paper 7471, 2000.

Kalirajan, K.P. and Wu, Y., eds. *Productivity and Growth in Chinese Agriculture.* London: MacMillan Press; 1999.

Kawai, H. International comparative analysis of economic growth: trade liberalization and productivity. *The Developing Economies,* 1994; 32(4): 373-397.

Kendrick, J.W. International comparisons of productivity trends and levels. *Atlantic Economic Journal,* 1990; 18(3): 42-54.

Kim, J. and Lau, L. The sources of economic growth of the East Asian newly industrialised countries. *Journal of Japanese and International Economy,* 1994; 8(3): 235-271.

Kravis, I.B., Heston, A., and Summers, R. *World Product and Income.* Baltimore: Johns Hopkins University Press; 1982.

Kraemer, K.L. and Dedrick, J. IT and economic development: international competitiveness. In: Dutton, W.H., ed. *Information and Communication Technologies.* Oxford: Oxford University Press; 1996.

Krugman, P. *The Age of Diminished Expectations.* Cambridge, MA: MIT Press; 1990.

Landauer, T. *The Trouble with Computers: Usefulness, Usability and Productivity.* Cambridge, MA: MIT Press; 1995.

Leung, H.M. Total factor productivity growth in Singapore's manufacturing industries. *Applied Economics Letters,* 1997; 4(8): 525-528.

Leung, H.M. Productivity of Singapore's manufacturing sector: an industry level non-parametric study. *Asia Pacific Journal of Management,* 1998; 15(1): 19-31.

Maddison, A. and Ark, B.V. Comparisons of real output in manufacturing. Policy, planning and research working paper WPS5, World Bank, Washington, D.C., 1998.

Mahadevan, R. and Kalirajan, K.P. On measuring total factor productivity growth in Singapore's manufacturing industries. *Applied Economics Letters,* 1999; 6: 295-298.

Mahadevan, R. and Kalirajan, K.P. Singapore's manufacturing sector's TFP growth: a decomposition analysis. *Journal of Comparative Economics,* 2000; 28: 828-839.

Mahadevan, R. How technically efficient are Singapore's manufacturing industries? *Applied Economics,* 2000a; 32(15): 2007-2014.

Mahadevan, R. Sources of output growth in Singapore's services sector. *Empirical Economics,* 2000b; 25: 495-506.

Mahadevan, R. How productive is foreign direct investment in the Malaysian manufacturing sector? *Journal of Quantitative Economics,* 2002a; 15(1 & 2) :1-29

Mahadevan, R. Trade liberalisation and Australia's productive performance. *Atlantic Economic Journal,* 2002b; 30(2): 170-185.

Mahadevan, R. A frontier approach to measuring total factor productivity growth in Singapore's services sector.. *Journal of Economic Studies,* 2002c; 29(1): 48-58.

Mahadevan, R. What is and is not measured by the total factor productivity growth studies in Malaysia? *Malaysian Journal of Economic Studies,* 2002d; 39(1) (Forthcoming).

Mahadevan, R. Is there a real TFP measure for Malaysia's manufacturing sector? *ASEAN Economic Bulletin,* 2002; 19(2) (Forthcoming).

Mahadevan, R. *The Economics of productivity in Asia and Australasia.* London: Edward Elgar; 2003.

Mody, A. and Dahlman, C. Performance and potential of information technology: an international perspective. *World Development,* 1992; 20: 1703-1719.

National Productivity Corporation of Malaysia. *Productivity Report 1999.* Kuala Lumpur: National Productivity Corporation; 1999.

National Research Council. *Organizational Linkages: Understanding the Productivity Paradox.* Washington, D.C: National Academy Press; 1994.

Nehru, V. and Dhareshwar, A. New estimates of total factor productivity growth for developing and industrial countries. World Bank policy research paper no. 1313, 1994.

Nievelt, M. and Wilcocks, L. Benchmarking organizational and IT performance. Oxford executive research briefing no. 6, Templeton College, Oxford, 1997.

Norsworthy, J.R. and Jang, S.L. *Empirical Measurement and Analysis of Productivity and Technological Change.* Amsterdam: Elsevier Science Publishers; 1992.

OECD. *New Technologies in the 1990s: A Socio-Economic Strategy.* Paris: OECD; 1988.

OECD. *Purchasing Power Parities and Real Expenditure-EKS Results 1990,* vol. 1. Paris: OECD; 1992.

OECD. *Industry Productivity: International Comparisons and Measurement Issues.* Paris: OECD; 1996.

Okamoto, Y. Impact of trade and FDI liberalization policies on the Malaysian economy. *The Developing Economies,* 1994; 32(4): 460-478.

Oliner, S. and Sichel, D. Computers and output growth revisited: how big is the puzzle? *Brooking Papers on Economic Activity,* 1994; 2: 273-334.

Owyong, D. Singapore. In: *Measuring Total Factor Productivity-Survey Report.* Tokyo: Asian Productivity Organization; 2001.

Parham, D., Roberts, P., and Sun, H. *Information Technology and Australia's Productivity Surge.* Productivity Commission staff research paper, Canberra, Australia, 2001.

Porter, M. *The Competitive Advantage of Nations.* New York: Free Press; 1996.

Rahim, S.A. and Pennings, A.J. *Computerization and Development in Southeast Asia.* Singapore: Asian Mass Communications Research and Information Centre; 1987.

Rao, V.V. Bhanoji and Lee, C. Sources of growth in the Singapore economy and its manufacturing and service sectors. *Singapore Economic Review,* 1995; 40(1): 83-115.

Sarel, M. Growth in East Asia: what we can and what we cannot infer. Paper presented at the Conference on Growth and Productivity, organized by the Reserve Bank of Australia, Sydney, July 1995; also IMF working paper 95/98, 1995.

Sarel, M. Growth and productivity in ASEAN countries. International Monetary Fund working paper 97/97, 1997.

Solow, R. Technical change and the aggregate production function. *Review of Economics and Statistics,* 1957; 39(3): 312-320.

Solow, R. We'd better watch out. *New York Times Book Review,* 12 July 1987.

Takenaka, H. Changing Asia-Pacific and the Japanese economy. Mimeo, Keio University, Tokyo, 1995.

Tallon, P., Kraemer, K., and Gurbaxani, V. A multidimensional assessment of the contribution of information technology to firm performance. *Proceedings of the Fifth Conference on Information Systems,* Cork, 9-12 June 1997.

Tan, R.G.K, Lall, A., and Tan, M.C.H. Singapore. In: *Productivity Growth and Industrial Structure in the Pacific Region.* Tokyo: Japan Committee for Pacific Economic Outlook and Pacific Economic Cooperation Council; 2000.

Tan, L.Y. and Virabhak, S. Total factor productivity growth in Singapore's service industries. *Journal of Economic Studies,* 1998; 25(5): 392-409.

Tham, S.Y. Productivity and competitiveness of Malaysian manufacturing sector. Paper presented at the 7th Malaysian Plan National Convention, Kuala Lumpur, 5-7 August 1996.

Tham, S.Y. Determinants of productivity growth in the Malaysian manufacturing sector. *ASEAN Economic Bulletin,* 1997; 13(3): 333-343.

Tinbergen, J. Zur Theorie der Langfristigen Wirtschaftsentwicklung. *Weltwirtsschaftliches Archiv,* 1942; 55(1): 511-549 (translated as On the theory of trend movements. In: Klassen, L.H., Koych, L.M., and Witteveen H.J., eds. *Jan Tinbergen Selected Papers.* Amsterdam: North Holland; 1959: 82-221.

Tsao, Y. Growth and productivity in Singapore: a supply side analysis. Ph.D dissertation, Harvard University, 1992.

Tsao, Y. Growth without productivity. *Journal of Development Economics,* 1985; 18: 25-38.

Van Eklan, R. Accounting for growth in Singapore. International Monetary Fund occasional paper 119, 1995.

Wong, F.C. and Gan W.B. Total factor productivity growth in the Singapore manufacturing industries during the 1980s. *Journal of Asian Economics,* 1994; 5(2): 177-196.

World Bank. *Malaysia: Matching Risks and Rewards in a Mixed Economy Programme.* Washington, D.C.: World Bank; 1989.

World Bank. *The East Asian Miracle: Economic Growth and Public Policy.* New York: Oxford University Press; 1993.

Young, A. A tale of two cities: factor accumulation and technical change in Hong Kong and Singapore. In: Blanchard, O.J. and Fischer, S., eds. *NBER Macroeconomics Annual 1992.* Cambridge, MA: MIT Press; 1992: 13-63.

Young, A. Lessons from the East Asian NICs: a contrarian view. *European Economic Review,* 1994; 38(3-4): 964-973.

Young, A. Tyranny of numbers: confronting the statistical realities of the East Asian growth experience. *Quarterly Journal of Economics,* 1995; 110(3): 641-680.

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The Author

Renuka Mahadevan obtained her Master's and PhD in economics at the Australian National University. She also holds a postgraduate diploma in education from the then Institute of Education in Singapore. Currently, she is with the Department of Economics at the University of Queensland in Brisbane, Australia, where she teaches and supervises undergraduate and postgraduate economics students. She has also played an important managerial role as one of the executive directors of the Queensland branch of the Economic Society of Australia.

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This book attempts to highlight some developments in the expanding field of productivity growth analysis. First, the various total factor productivity (TFP) growth measurement methods are categorized under the frontier and non-frontier approaches. By way of illustration, a survey of TFP growth studies of Singapore and Malaysia is used for discussion. Skepticism regarding the usefulness of TFP growth measures and their interpretation is also addressed.

Second, a more focused approach to understanding the determinants of TFP growth is explained. One important feature of the book is the preliminary empirical investigation based on data from the publication APO Asia-Pacific Productivity Data and Analysis 2001. This was used to draw policy implications and lessons from various countries for improving productivity growth in the Asia-Pacific region.

As the emergence of the new or knowledge-based economy is already evident in some Asia-Pacific countries, the debate and evidence surrounding the information technology-productivity nexus as well as the challenges in adopting information technology are reviewed. Finally, to raise the APO's profile and spearhead its efforts in productivity research, suggestions are provided as to what and how more can be done in this area.

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