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Growth and Productivity in ASEAN Countries

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Abstract

This study examines the nature of the growth process in the ASEAN countries, and particularly whether it has been generated primarily by more inputs or by productivity gains. It uses internationally comparable data and explores an alternative method for estimating the capital and labor factor shares. The results, contradicting some previous studies, indicate a very impressive growth rate of TFP in Singapore, Thailand, and Malaysia, a relatively strong rate for Indonesia, and a negative rate for the Philippines. This study argues that the results of previous studies were driven mainly by the fact that they relied on national accounts data for measures of various variables and, in particular, the factor income shares of capital and labor.

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Summary

The nature of growth in the ASEAN countries, and particularly whether growth has been generated primarily by more inputs or by greater efficiency, has been much discussed. Some researchers have concluded that growth rates of total factor productivity (TFP) in Asian economies are not nearly as spectacular as their growth rates of output. If true, this would imply that the success of the ASEAN economies may not be sustainable in the future.

This study argues that the results of previous studies were mainly driven by their heavy reliance on national accounts data for measures of various variables, in particular, by the results that were used for the factor income shares of capital and labor. By contrast, this analysis uses internationally comparable data from the Summers-Heston database and explores an alternative method for estimating the capital and labor factor shares, assuming that technological factor shares are determined by the industrial structure of the economy and, possibly, by its level of development. The resulting shares are not necessarily equal to the income shares as measured in the national accounts. Using this new methodology and consistent cross-country methods to estimate growth rates of output, capital, and labor, this study performs a growth accounting exercise for five ASEAN economies and, for purposes of comparison, the United States.

The results of this study for the period 1978–96 show a very impressive growth rate of TFP in Singapore (2.2 percent), Thailand (2.0 percent), Malaysia (2.0 percent), a relatively strong rate for Indonesia (1.2 percent), and a negative rate for the Philippines (-0.8 percent). The estimated rate of TFP growth over the same period for the United States is 0.3 percent. The proportion of output growth per person attributable to TFP growth is not systematically different in the ASEAN economies and the United States.

This is probably a fairly boring and tedious paper, but it is not intentionally so. This paper attempts to provide a new interpretation of the growth process in ASEAN economies to interest the historian, to derive new theoretical implications of the forces behind this process to motivate the theorist, and to draw new policy implications from the subtleties of government intervention in ASEAN economies to excite the policy activist.[2]

I. Introduction

The phenomenal growth rates of many economies in East and Southeast Asia have been documented, dissected, analyzed, and discussed in a countless number of economic research papers, as well as in books and newspapers and at conferences. There is not much purpose in repeating the full set of stylized facts regarding these growth rates. It is enough to mention that many of these economies have continued, even in recent years, to grow at rates that exceed by far the normal historical and geographical experience. During 1980–95, for example, four ASEAN economies (Indonesia, Malaysia, Singapore, and Thailand) more than doubled their real income per person, compared with an increase of only 20 percent in the United States and other industrial countries and even less than that in many other regions of the world.[3]

A major question about the nature of growth in ASEAN economies is whether the growth process is mainly intensive or extensive.[4] This seemingly inconsequential distinction plays a crucial role in determining how we judge the past performance of these economies and how we regard their future growth prospects. For example, one possible explanation for the collapse of the Soviet economy around 1990 is the "extensive growth" hypothesis.

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[2]With apologies to Alwyn Young (1995, p. 641).

[3]ASEAN is the Association of South East Asian Nations and it includes seven members. This study concentrates on five ASEAN economies: Indonesia, Malaysia, Philippines, Singapore, and Thailand (because of a lack of historical data, the study does not cover Brunei Darussalam and Vietnam). The study also includes the United States, mainly as a reference point to gauge the estimated results for the five ASEAN economies. The term "country," as used in this paper, may not refer to a territorial entity that is a state as understood by international law and practice; the term may also cover some territorial entities that are not states but for which statistical data are maintained and provided internationally on a separate and independent basis.

[4]Intensive growth means that the economy grows because it uses new technologies and becomes more efficient, creating more and more output per unit of inputs, while extensive growth means that the economy grows because it uses more resources as inputs, such as more factories, buildings, and machines, and has higher participation rates in the labor force. A mathematical analysis of this distinction is presented in Appendix I.

William Easterly and Stanley Fischer (1994), among others, argue that the Soviet economy ran into inevitable diminishing returns after many decades of extensive growth, caused by a massive accumulation of capital not accompanied by technological progress. This extensive growth hypothesis, if true, raises serious concerns about other economies that invested heavily in past decades, such as many ASEAN economies. The comparison of the Asian economies with the Soviet economy was explicitly made in an essay provocatively entitled "The Myth of Asia's Miracle," by Paul Krugman (1994, p. 70):

> "The newly industrializing countries of Asia, like the Soviet Union of the 1950s, have achieved rapid growth in large part through an astonishing mobilization of resources. Once one accounts for the role of rapidly growing inputs in these countries' growth, one finds little left to explain. Asian growth, like that of the Soviet Union in its high-growth era, seems to be driven by extraordinary growth in inputs like labor and capital rather than by gains in efficiency."

The view expressed by Krugman is primarily based on empirical findings reported in a series of papers by Alwyn Young (1992, 1993, and 1995). In these papers, Young decomposes the growth rates of several Asian countries into an "extensive" component, measured by the rate of factor accumulation, and an "intensive" one, measured by the growth rate of total factor productivity (TFP). His surprising conclusion is that growth rates of TFP in Asian economies are not at all as spectacular as their growth rates of output. Furthermore, he estimates their rates of TFP growth to be lower than in industrial countries, and, at least in Singapore's case, to be virtually zero.[5]

Young's findings, and Krugman's subsequent Soviet analogy, have generated additional economic research and renewed interest in previous studies that analyzed the growth process in East Asia.[6] In general, these other studies produced mixed results. Some of them found support for Young's results (e.g., the study by Kim and Lau, 1994). Most studies,

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[5]The very low TFP growth that Young (1995) estimates for Singapore (0.2 percent during 1966–90) is partly caused by the quality adjustment of labor that he performs. However, even with no such adjustments, the estimated TFP growth we can derive from Young's calculations is still low (0.7 percent).

[6]They also generated many articles and commentaries in the popular press. For example, a whole section in the *Asian Wall Street Journal*, entitled "Dismal Science" (October 9, 1995), was devoted to this topic.

however, found support for the view that TFP growth in East Asia was much stronger than Young's research suggests.[7]

Despite the impressive number of previous studies of the growth process in East and Southeast Asia, at present we still lack a full understanding of this issue. The methodology and the coverage of these previous studies limit the possibility of a meaningful cross-country comparison of the mechanics of economic growth. The main methodological problem of previous studies is that they have relied almost entirely on national accounts data for measures of real output, investment flows, estimates on capital stocks, labor force participation, composition of the labor force, and, most important of all, distributive shares of income distribution to capital and labor. It will be argued below that all these data are likely to be strongly affected by country-specific biases and measurement problems, including those relating to relative prices in the economy (especially the relative prices of investment goods), comprehensiveness of labor market data, demographic composition of the labor force (and also of the population outside the labor force), the government's policies and tax incentives, the industrial structure of the economy (presence of monopolies and labor unions), and other factors that may affect the distribution of income.

With a few exceptions, previous studies have also had a coverage problem. Every study of growth and productivity necessarily makes some strong assumptions about economic structure and relationships among a set of economic variables. Of course, there are no strict rules for making such assumptions, and, in large measure, they depend on the discretion and the judgment of the authors. However, as will be argued below, the estimated values of key results of these studies, including the rate of TFP growth, are very sensitive to the particular assumptions. Therefore, in a study of a particular group of countries, it is crucial to include in the sample the full set of countries to be compared, in order to be able to draw meaningful conclusions on cross-country or cross-regional differences. The implication is that previous attempts to compare TFP growth in Southeast Asia with that in, say, the United States, are unlikely to be reliable because such comparisons are typically based on results from different studies that made different assumptions.

This paper addresses the major problems of previous studies and derives new (and, it is hoped, better) estimates of productivity growth in the ASEAN economies. Country-specific national accounts are used only for the most basic data, and common methodologies are employed to derive almost all of the key variables required. The results obtained are positive in terms of their implications for the nature of growth in ASEAN economies in the past and their growth prospects in the future. These results are markedly different from Young's and

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[7]Numerous studies have examined this issue. Most of them, however, concentrated on one economy only. Wong Fot-Chyi (1995) surveys about a dozen previous studies that had estimated TFP growth for Singapore. Tinakorn and Sussangkarn (1994) have estimated strong TFP growth for Thailand.

do not support the pessimistic conclusions drawn by Krugman. However, most people familiar with the dynamic and vibrant Southeast Asian economies will not find them surprising.

The study conducted in this paper is, essentially, a growth accounting exercise. Accordingly, the structure of the paper follows the design of this exercise. Section II presents the growth accounting framework and prepares three of the building blocks of the exercise: it estimates the growth rates of output, capital, and labor. The next two sections deal with factor shares, the last (and crucial) building block of the exercise. Section III performs a sensitivity analysis with respect to the values of the factor shares. The results of this analysis show the crucial role played by the magnitude of these shares in the results of growth accounting exercises, especially in the case of fast-growing economies. Section IV discusses the main problems with previous attempts at estimating factor shares, develops a new procedure for estimating them, and reports results from applying this procedure. Section V constructs estimates of the marginal product of capital. Section VI puts together all the building blocks from the previous sections and estimates rates of total factor productivity growth. Section VII discusses the outlook for the future, and Section VIII concludes.

II. The Growth Accounting Framework and its Building Blocks

The growth accounting framework, which is the traditional framework used in numerous other similar studies of growth and productivity, is presented in Appendix I. Appendix II prepares the main building blocks of the exercise, estimating the growth rates of per capita output, capital, and labor in five ASEAN countries and the United States, during 1978–96 (trying to ensure, as much as possible, a uniform cross-country treatment). The estimated growth rates are presented in Figures 1-3.

III. A Sensitivity Analysis

This section presents a sensitivity analysis of growth rates and levels of total factor productivity (TFP) with respect to changes in values of capital shares. The purpose of this analysis is to demonstrate the high sensitivity of TFP estimates and to motivate the estimation of capital shares in each country using a consistent cross-country methodology.

For each of the six countries in the sample, the growth rate of TFP during 1978–96, as well as its level at the end of this period, is simulated, using the per capita growth rates of output, capital, and labor that were estimated in Section II. The sensitivity analysis is performed with respect to changes in the capital and labor factor shares (α and $1-\alpha$). We vary the value of α over the range [0.25-0.50], by increments of 0.01, covering the entire spectrum of most estimates of this parameter. Then, we calculate the TFP growth rate as a residual (the

Figure 1 (a)
Five ASEAN Countries and U.S.
Output 1978-96

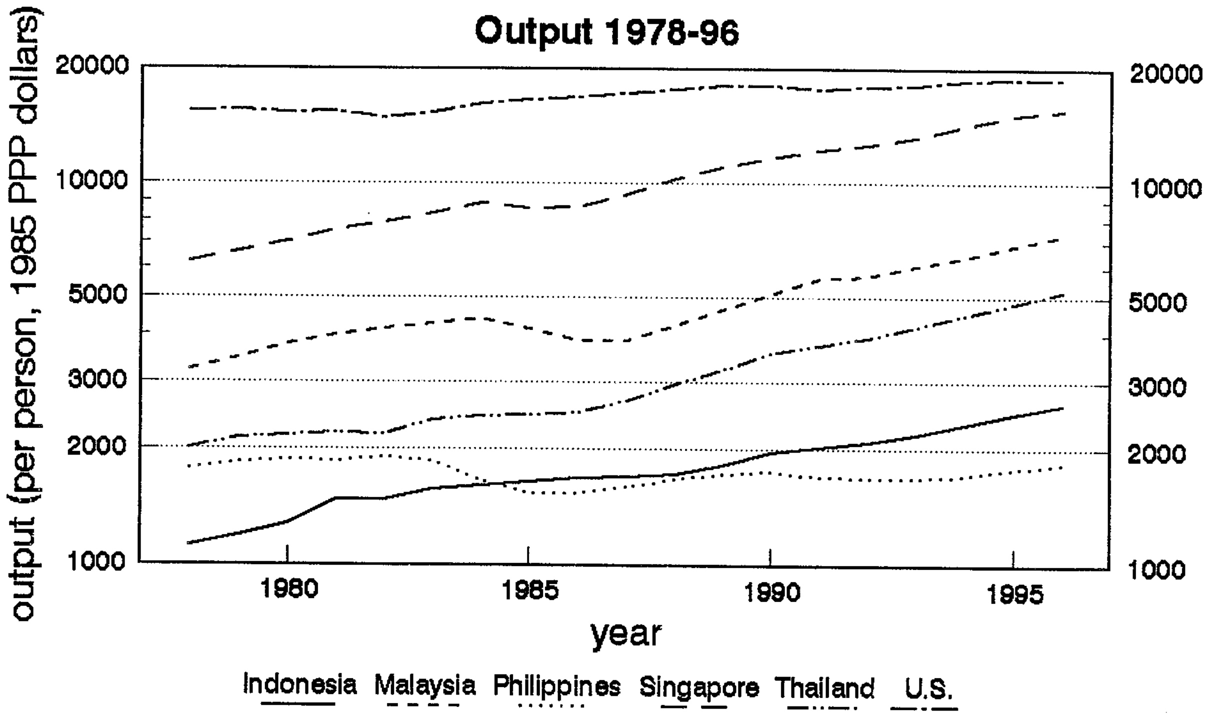


Figure 1 (b)
Five ASEAN Countries and U.S.
Output Growth Rates 1978-96

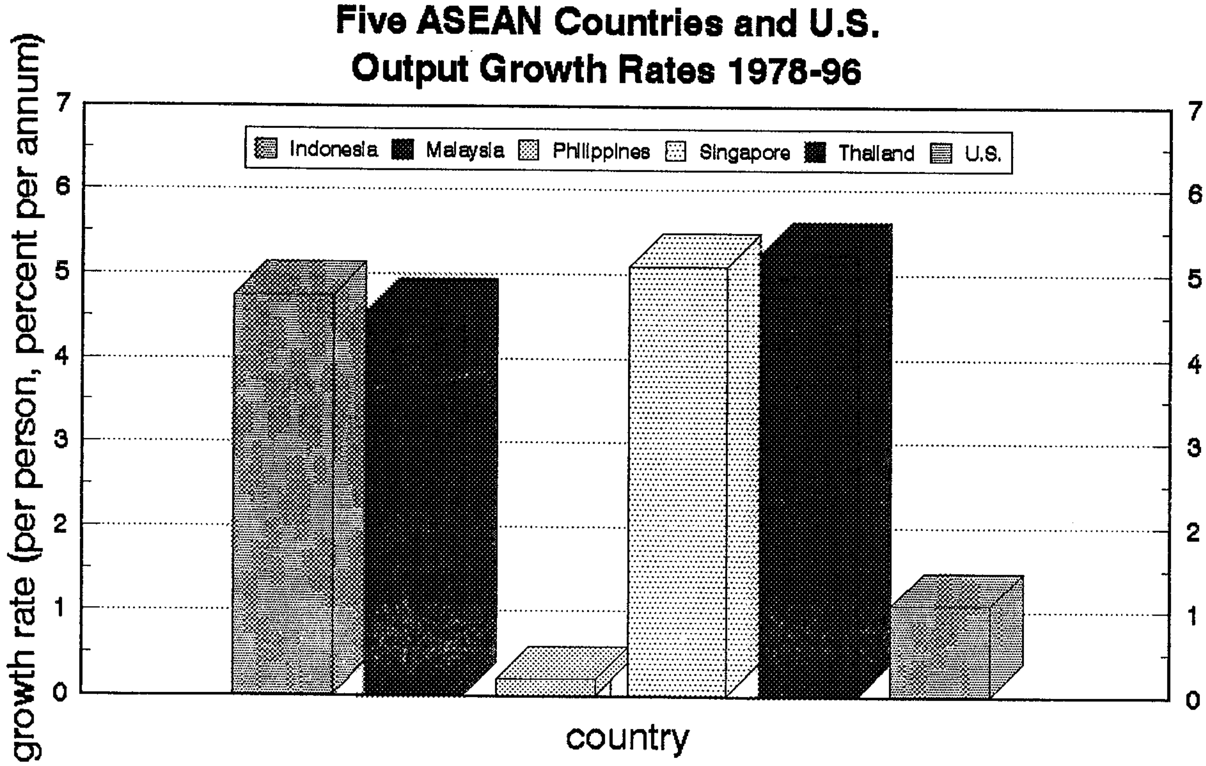


Figure 2 (a)
Five ASEAN Countries and U.S.
Capital 1978-96

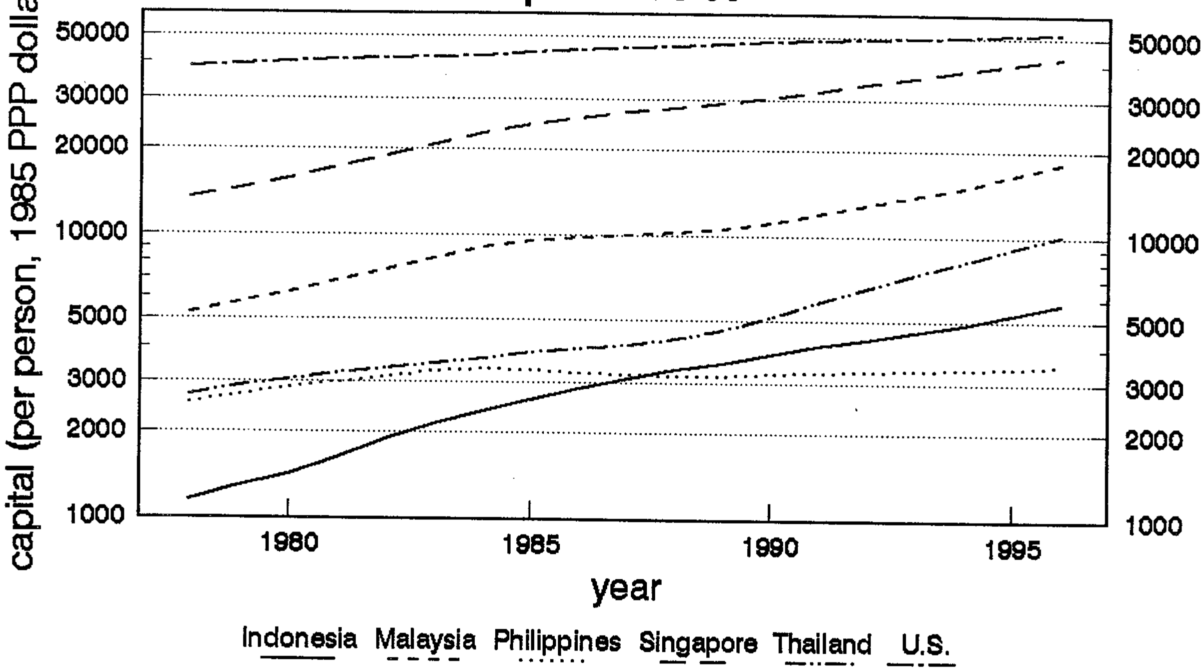


Figure 2 (b)
Five ASEAN Countries and U.S.
Capital Growth Rates 1978-96

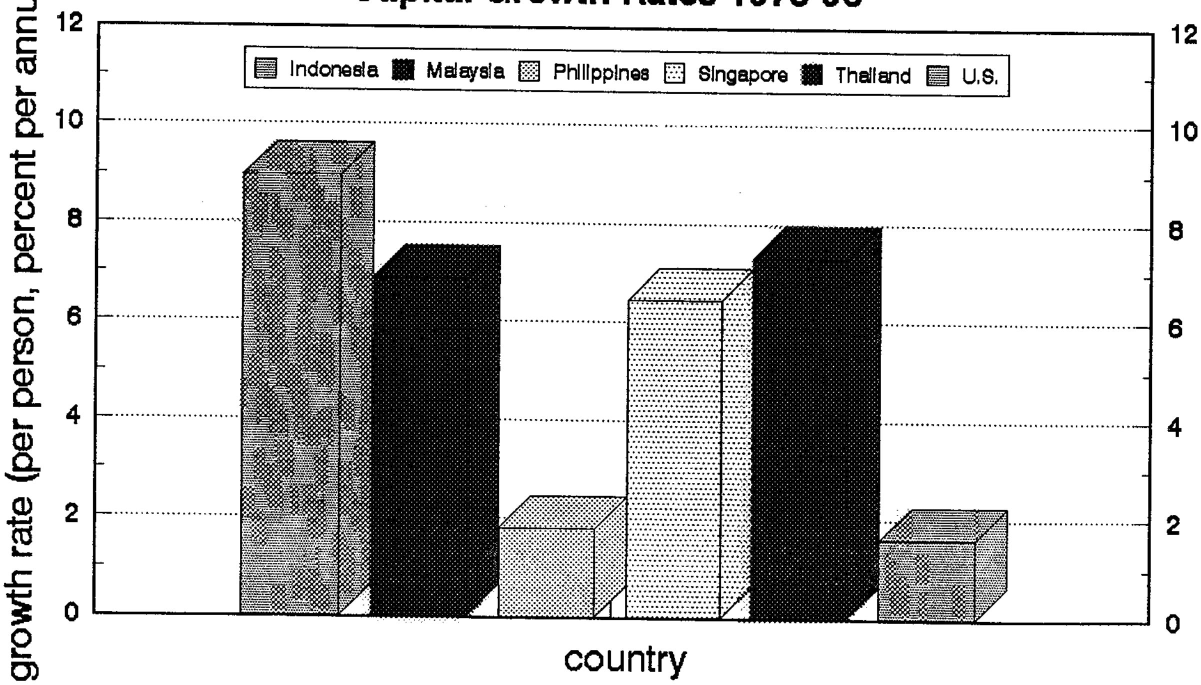


Figure 3 (a)
Five ASEAN Countries and U.S.
Labor 1978-96

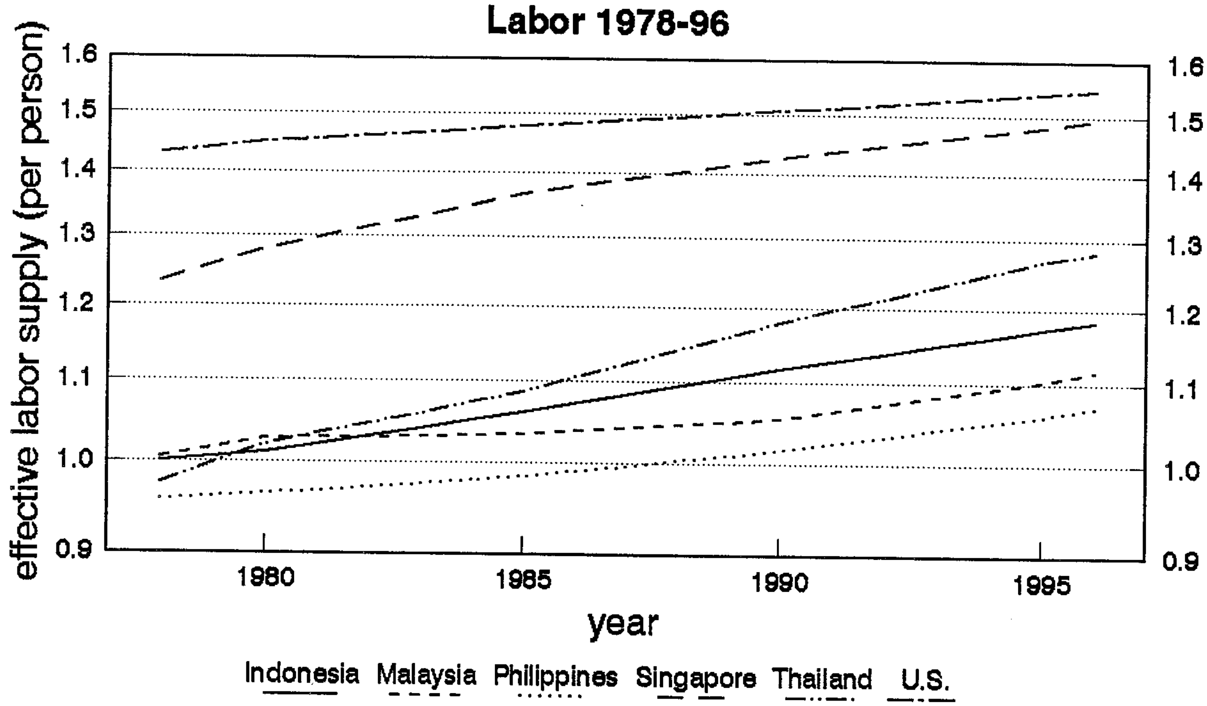
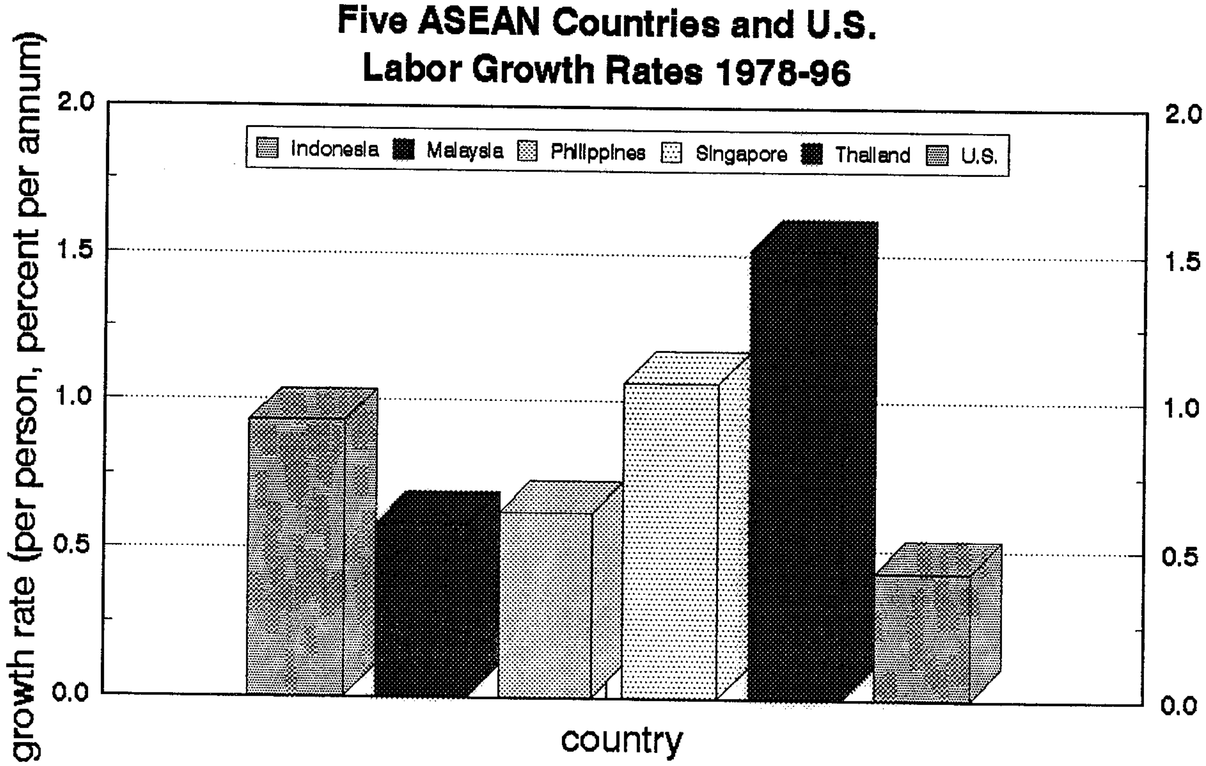


Figure 3 (b)
Five ASEAN Countries and U.S.
Labor Growth Rates 1978-96



part of growth in output that is not accounted for by growth in inputs). We repeat this procedure for the level of TFP in 1996.[8] The results are presented in Figure 4.

The top panel of Figure 4 describes the simulated rate of TFP growth. It demonstrates that the value of α has a large impact on this rate. For example, if α is similar across countries, then Singapore has, for each value of α, an annual rate of TFP growth that is significantly higher than in any other country in the sample. However, if the value for α is 0.45 in Singapore but only 0.30 in Malaysia and Thailand, then the resulting growth rate of TFP will be higher in these countries than in Singapore.[9]

Another interesting exercise is comparing Indonesia with the United States. If the value of α is relatively low in both countries, then the annual rate of TFP growth in Indonesia will be much higher than in the United States; if α is around 0.30, then this difference will exceed a full percentage point. However, if the value of α is relatively high in both countries (close to 0.50), then the rate of TFP growth in Indonesia will fall below the rate in the United States, and its value will even be negative.[10]

The bottom panel simulates the level of TFP in 1996. Here, the value of α has an even more dramatic effect. If α is similar across countries, then the order of the six countries, according to their TFP level, remains constant for every value of α: United States, Singapore, Malaysia, Thailand, Indonesia, and Philippines. However, if α differs across countries, then this order may change. Indeed, every possible permutation of the six countries can be a valid order, resulting from choosing the "right" value of α for each country.

IV. An Improved Method for Estimating Factor Shares

This section discusses the problems associated with estimating technological factor shares and develops a possible solution to these problems. Technological factor shares are derived from production functions and are defined as the elasticities of output with respect to each factor of production. For example, in a standard Cobb-Douglas production function, the

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[8]We assume a Cobb-Douglas production function. See Appendix I for details.

[9]It is important to notice that such differences in estimates of α are not uncommon in TFP studies. For example, Young (1995) uses in his growth accounting exercise the following values of α: 0.37 for Hong Kong, 0.49 for Singapore, 0.30 for Korea, and 0.26 for Taiwan Province of China.

[10]The intuition for this result is that capital growth rates are usually higher than labor growth rates, and capital growth accounts for more output growth when α values are higher. But the capital growth rate in the Unites States was very low (relative to Indonesia), and therefore the TFP calculations for the United States are less affected by changes in values of α than similar calculations for Indonesia or for other countries with high rates of capital growth.

Figure 4 (a)
Five ASEAN Countries and U.S.
Simulated TFP Growth 1978-96

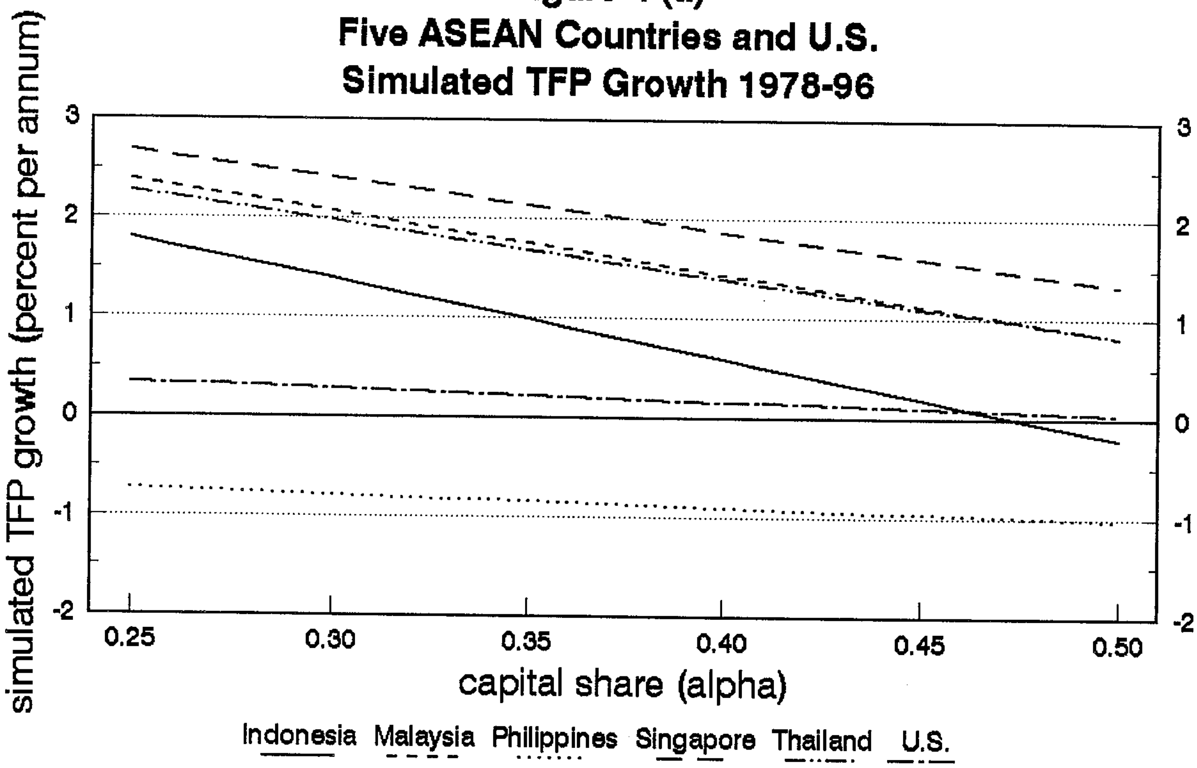
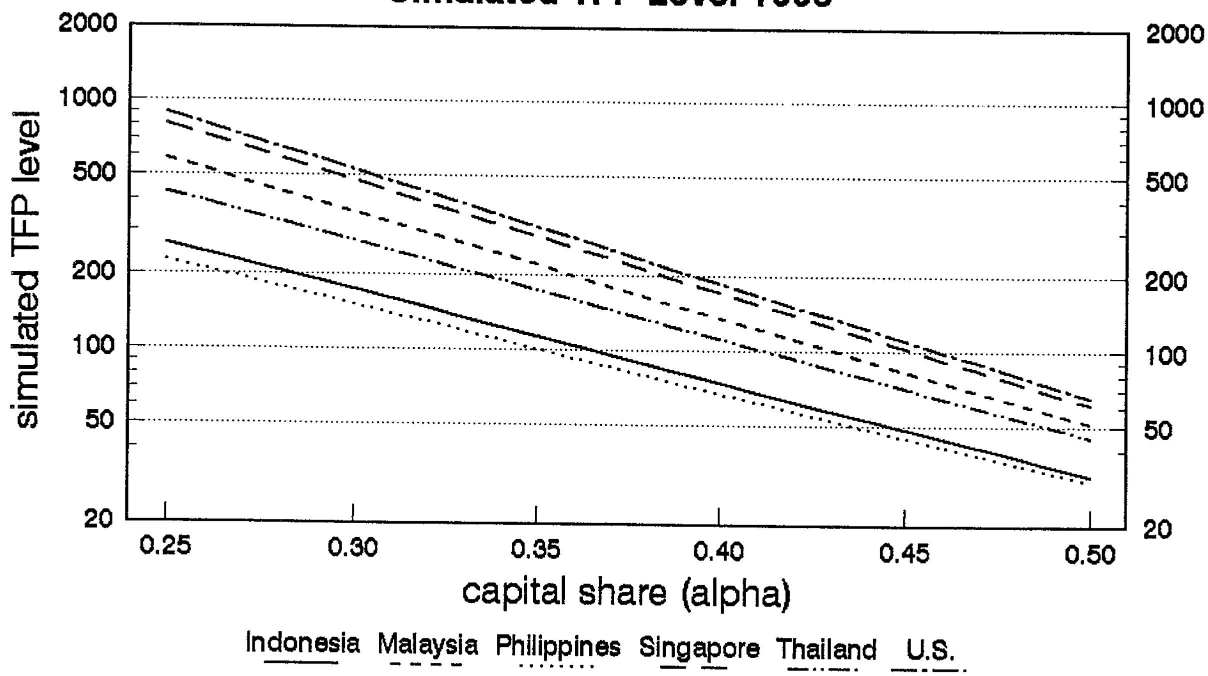


Figure 4 (b)
Five ASEAN Countries and U.S.
Simulated TFP Level 1996



technological factor shares are α (for capital) and $1-\alpha$ (for labor).[11] Estimating these factor shares is a crucial step in the methodology used in growth accounting exercises. This was made clear in the previous section: even small variations in technological factor shares were shown to have powerful effects on TFP calculations. Unfortunately, there is no simple way to observe production functions and directly measure the factor shares. These shares need to be estimated using an indirect approach.

The two methods that are commonly used to estimate technological factor shares are the "regression" approach and the "national accounts" approach. Appendix III reviews these two methods and discusses their main weaknesses. In the remainder of this section, a possible way to improve upon these methods is suggested.

The following outline suggests a new method of estimating factor shares. It is based on the same principles as the national accounts approach, but has the advantage of being free of the problems associated with both the regression and the national accounts approaches. The main idea behind this approach is to ask a basic question: What are the possible reasons for cross-country differences in technological factor shares? In other words, why should the technological factor shares in Indonesia be different, say, from those in Canada?[12] In response to this question, two obvious candidates are:

- differences in the structure of production,[13] and
- differences in the level of development.[14]

Of course, many more factors may affect the income shares, including, among others, government taxes, regulations, and imperfect competition. It is important to notice that all

[11] See Appendix I for details.

[12] The cross-country approach described here can easily be extended to a time-series dimension. For example, we can compare Indonesia in 1980 with Indonesia in 1995. Or, we can compare Indonesia in 1980 with Canada in 1995.

[13] The share of agriculture in the economy, for example, is larger in Indonesia than in Canada, and it is possible that the factor shares in agricultural production are not identical to the factor shares in other major economic activities, such as manufacturing.

[14] The methods of production in each sector of the economy (including in agriculture) may be different, because Canada has achieved a higher development level (e.g., its farmers have access to better, more expensive tractors).

these factors affect the income shares, but not the technological factor shares.[15] In other words, they do not affect the elasticity of output with respect to each factor of production; this elasticity is fully determined by the production technology.

Now, suppose a way is found to control for cross-country differences in both the structure of production and the level of development. It is assumed that, in this case, no additional systematic differences in factor shares would exist.[16] This is not an innocuous assumption. However, it is reasonable, and extremely powerful: it immediately suggests a relatively simple and elegant method for estimating a panel of technological factor shares that are not subject to the problems identified with the two traditional methods. The estimation procedure is based on several specific assumptions:

- Each economic activity is performed according to a standard Cobb-Douglas production function $Y = AK^{\alpha}L^{1-\alpha}$, where α is the elasticity of output with respect to the capital input. Different activities may use different technologies of production (i.e., they may have different α values).

- The technologies (i.e., the α values) are not fundamentally different across countries and over time; where such differences exist, they can be fully captured by controlling for the average stock of capital per person across countries and over time.

- The differences between technological factor shares and income shares are not systematic. In other words, some countries might reward one factor of production more than its technological share, while other countries might reward it less on account of government interventions and regulations, imperfect markets or information, and other reasons. But, on average across countries, the reward that each factor receives in each type of activity approximates its technological share in that type of activity.

The procedure is implemented in three steps:

- For each major type of economic activity, collect data to construct a sample of observations and estimate the intrinsic technological factor shares (possibly as a function of the level of development).

- For each country and for every year in the sample, estimate the relative intensity of each economic activity.

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[15]The problems caused by these factors, and the reasons why they might affect the income shares (rather than the technological factor shares), are discussed in Appendix III.

[16]In other words, it is assumed that no additional factors would affect the factor shares in a systematic and predictable way.

- For each country and for every year in the sample, find the aggregate (economy-wide) technological factor shares.

A. The First Step

The first step, which estimates the technological factor shares of each major economic activity, involves a complex and tedious procedure. The main idea of the procedure is to use a sample of countries for which we have detailed information on both the national accounts and the composition of the labor force to estimate, for each major economic activity, "typical" income shares as a function of the level of development. The details of this procedure are fully described in Appendix IV. The main results are:

- The capital shares were found to be significantly different across economic activities. The estimated shares are described in Table 1.

- The level of development (measured by the average stock of capital per person) was not found to have a significant effect on the capital share in each economic activity.

Table 1. Estimated Capital Share for Each Kind of Activity

	Kind of Activity	Capital Share (α)
1	Agriculture	0.275
2	Quarrying	0.601
3	Manufacturing	0.308
4	Utilities	0.538
5	Construction	0.189
6	Commerce	0.232
7	Transport and communication	0.320
8	Financial and business services	0.604
9	Government and other services	0.081

B. The Second Step

The second step defines the relative intensities of the nine major economic activities as their relative shares in GDP, measured at factor cost. The value generated by each economic activity during 1978–91 is described in the National Accounts Statistics, which are published by the United Nations.[17] The methodology that is used to define and measure each economic activity in this database is not directly comparable with the methodologies used in the various national statistics publications. Using the database from the UN's National Accounts Statistics, we obtain better cross-country comparisons. However, for 1992–96, which is not yet covered by these statistics, we have had to estimate these values using a logarithmic extrapolation of data available for the preceding nine-year period.

C. The Third Step

The third step estimates the aggregate capital share in each country, for every year during the sample period 1978–96. It computes the weighted average of the capital shares in each major economic activity (estimated in the first step), using as weights the relative intensities of these activities (estimated in the second step).

D. The Results

The estimated values of the capital shares are depicted in Figures 5-7; and the averages for the most recent five-year period (1992–96) are described in Figure 8, panel (a). The results are revealing, given the large range of values of α that have been used in previous studies. The full panel of 114 estimates of α (for six countries, over the 1978–96 period) covers, perhaps surprisingly, a relatively narrow range: [0.28-0.35]. Singapore has the highest average estimate, 0.34, while Thailand and the United States have the lowest, 0.29. The results confirm that, as many other studies have estimated, the capital shares in ASEAN economies are, in general, larger than in the United States. The difference, however, is relatively small; and the estimated capital share of Singapore, despite being the highest in the sample, is still much lower than the estimate used by Young (close to 0.50). Another interesting result is the relative stability of the capital shares in each country during 1978–96.

V. Estimating the Marginal Product of Capital

In this section, we estimate the marginal product of capital (*MPK*), for each country and every year in the sample. *MPK* is not directly related to total factor productivity, but it is a key variable in determining rates of return to investment, and, as a result, growth rates of

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[17]Table 1.10: Gross Domestic Product by Kind of Activity, in Current Prices. We use United Nations (1982) to obtain data for 1978–81, and United Nations (1992) for 1982–91.

Figure 5 (a)
Indonesia
Alpha, Y/K Ratio, and MPK 1978-96

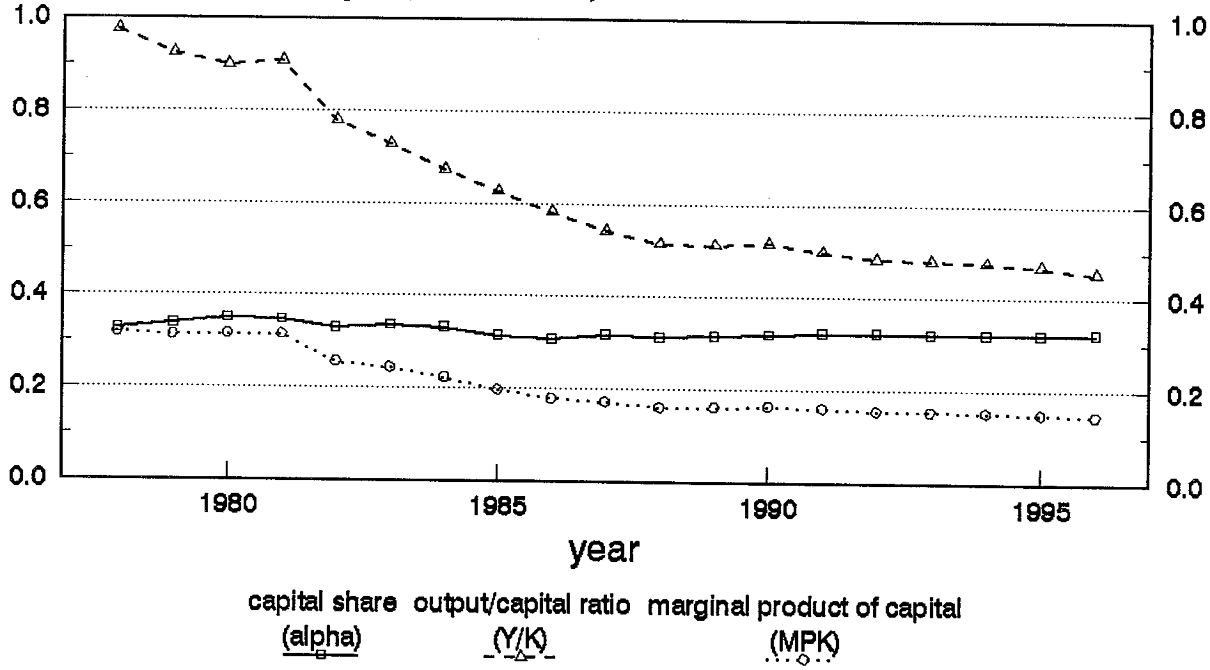


Figure 5 (b)
Malaysia
Alpha, Y/K Ratio, and MPK 1978-96

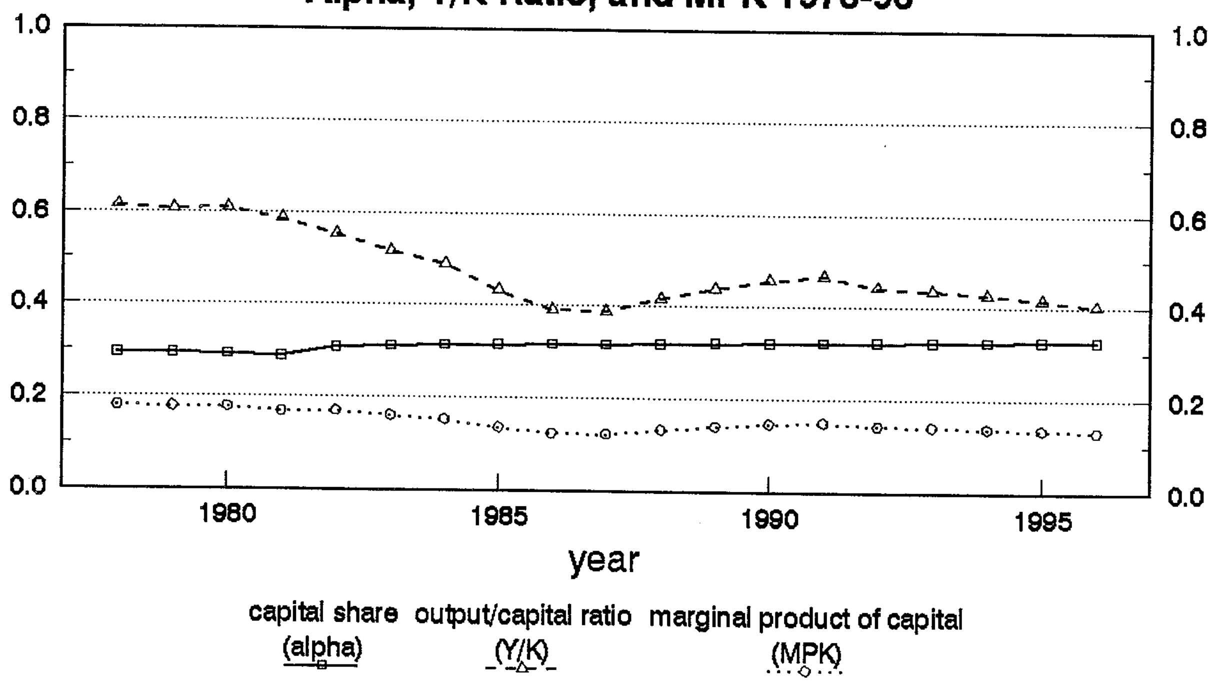


Figure 6 (a)
Philippines
Alpha, Y/K Ratio, and MPK 1978-96

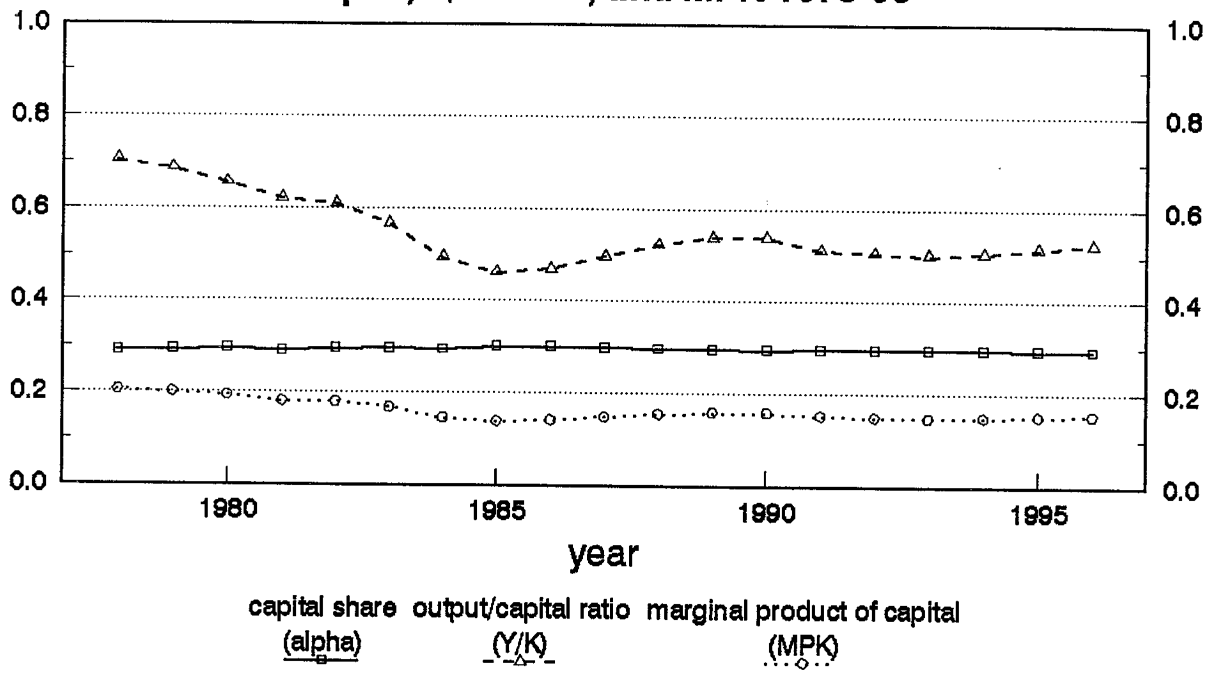


Figure 6 (b)
Singapore
Alpha, Y/K Ratio, and MPK 1978-96

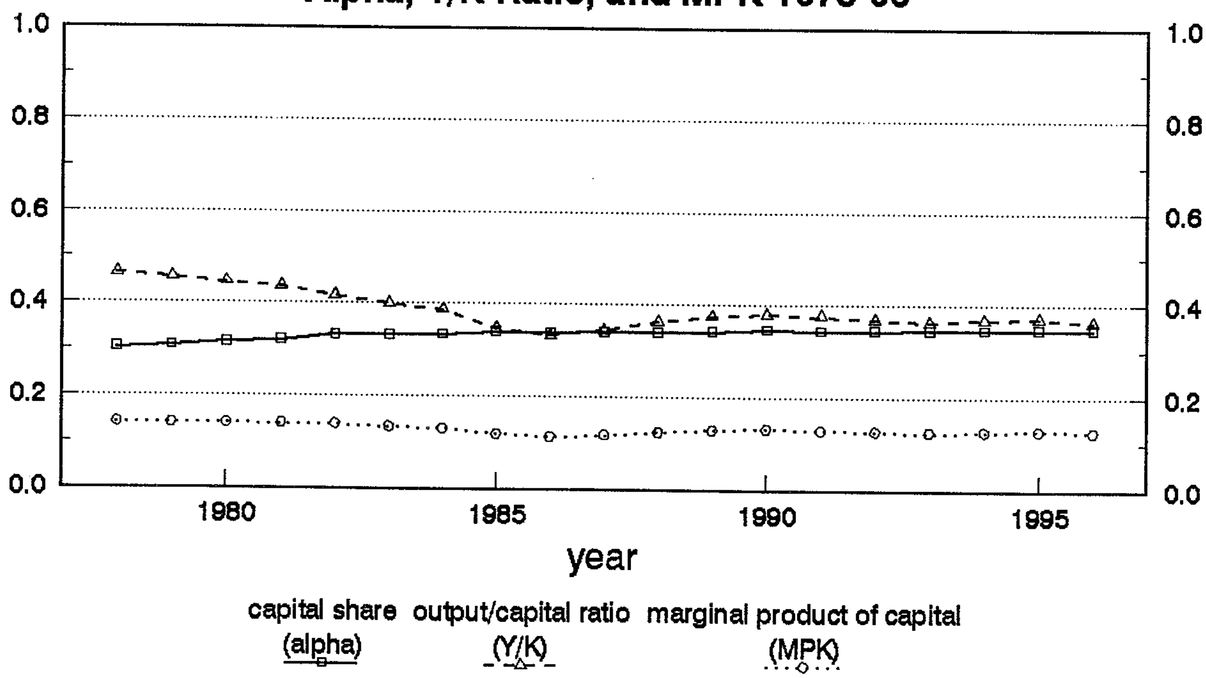


Figure 7 (a)
Thailand
Alpha, Y/K Ratio, and MPK 1978-96

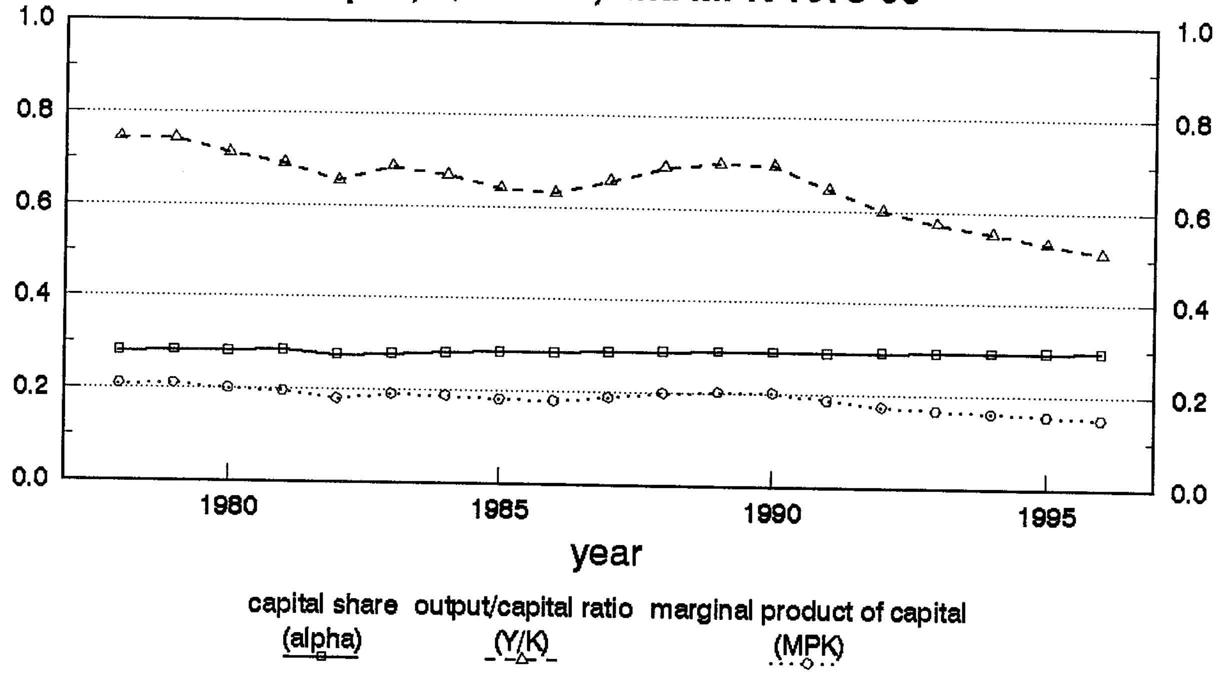


Figure 7 (b)
United States
Alpha, Y/K Ratio, and MPK 1978-96

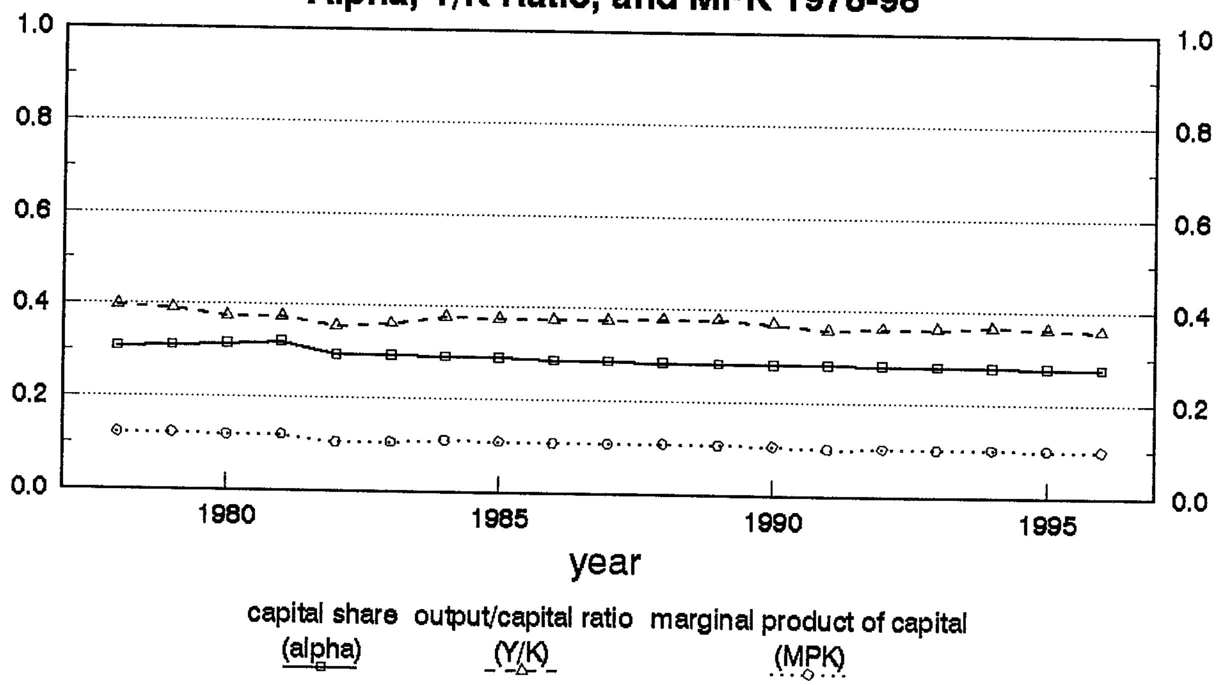


Figure 8 (a)
Five ASEAN Countries and U.S.
Capital Share (Alpha) 1992-96

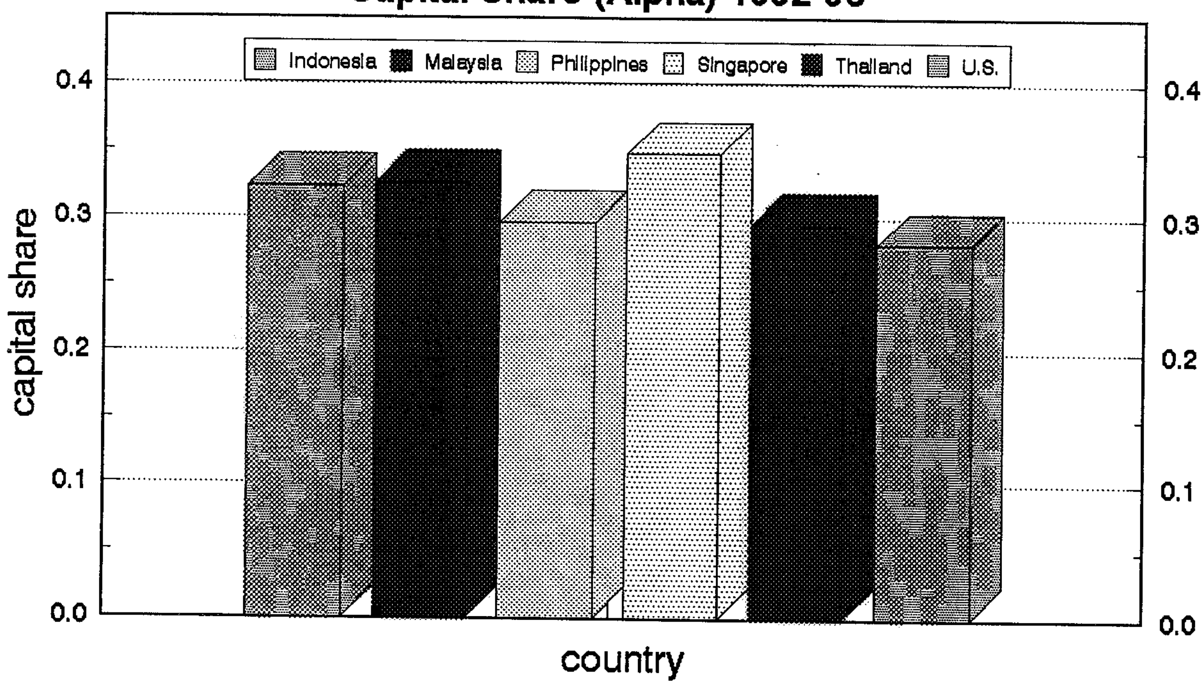
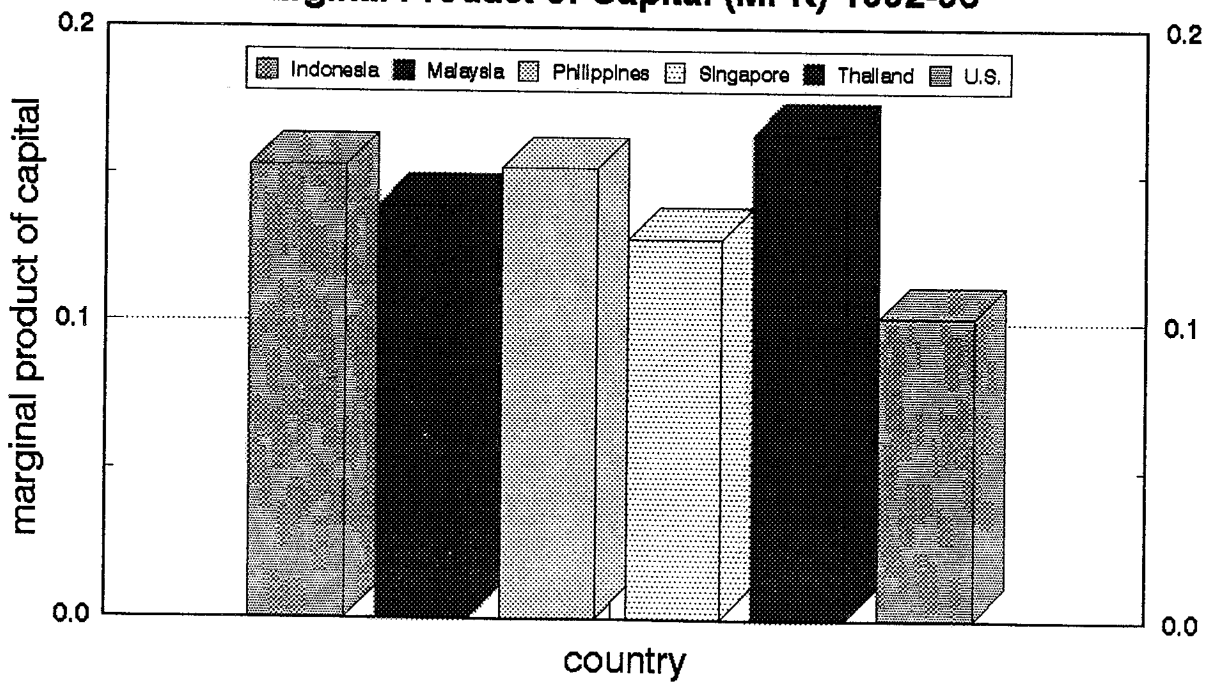


Figure 8 (b)
Five ASEAN Countries and U.S.
Marginal Product of Capital (MPK) 1992-96



capital and output. *MPK* is particularly important in cross-country comparisons because capital tends to flow from place to place to take advantage of relative return opportunities.[18]

We estimated in the previous section the capital shares (α), and in Section II output per person and capital for each person (depicted in Figures 1-2). The ratio of these two series, the output-capital ratio (Y/K) is depicted in Figures 5-7. The two variables (α and Y/K) enable us to estimate the *MPK* series.

Note that the marginal product of capital is equal, by definition, to the partial derivative of a production function $Y(K, \ldots)$ with respect to capital (K). This, assuming a Cobb-Douglas production function (as described, for example, in Appendix I), is equal to the expression α Y/K. The estimated *MPK* values are depicted in Figures 5-7. The average *MPK* values for the most recent five-year period (1992–96) are described for each country in the sample in Figure 8, Panel (b). This figure facilitates a cross-country comparison.

The estimated results indicate a large variation in *MPK* values across countries and also across time in each country; and the main source of this variation is the output-capital ratio, not the capital share.[19] A significant factor that affects both the cross-country and the time-series variation is the level of development of the economy; the output-capital ratio and *MPK* tend to decrease during a country's transition from middle income to high income. This process is a natural result of capital deepening and is in accord with the predictions of the standard neoclassical growth model (see, for example, Sarel, 1994). The only exception is Thailand, whose marginal product of capital is high for its level of development.[20]

VI. The Mechanics of Growth in ASEAN Economies

In previous sections, we prepared all the tools needed to examine the mechanics of economic growth in the six economies covered by this study. For each country and for every year, we estimated per capita growth rates of output, capital, and labor, and factor shares.

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[18]Many other factors affect cross-border investment flows, including the skill level of the workforce, political stability, external relations, property rights, and law enforcement. Still, when all other factors are equal, it is reasonable to expect capital to flow to the country with the highest *MPK*.

[19]The output-capital ratio and the marginal productivity of capital are clearly affected by business cycles: when economic activity is strong, these values are relatively high. However, the variation in these values goes far beyond the effects of business cycles.

[20]However, as a result of rapid capital accumulation, the *MPK* in Thailand appears to be on a declining path.

Using the decomposition of a Cobb-Douglas production function, we now perform a simple two-step growth accounting exercise:

- Calculate the growth rate of inputs, weighted by capital and labor shares:

  [α][growth of capital per person] + [1-α][growth of labor per person].

- Calculate the growth rate of *TFP* as the difference between the growth rates of output and inputs:

  [growth of *TFP*] = [growth of output per person] - [growth of inputs per person].

The results of the growth accounting exercise are depicted, for each country, in Figures 9-11. A cross-country comparison of country averages for the full period and for the most recent five-year period are presented in Figures 12-13. Table 2 summarizes these results, describing contributions to growth during 1978–96 and 1991–96. The results suggest that:

- During 1978–96, the rates of TFP growth were very strong in four of the five ASEAN economies (Indonesia, Malaysia, Singapore, and Thailand). Furthermore, TFP growth accounts for a significant portion of their phenomenal growth rates of output per person. The exception is the Philippines, which experienced a negative rate of TFP growth. Singapore appears to be the best performer in the region in terms of TFP growth rates, followed closely by Thailand and Malaysia.[21]

- During 1991–96, the rates of TFP growth increased strongly (compared with 1978–91) in Indonesia and the Philippines. In these countries, the recent acceleration in the growth of output per person can be fully attributed to faster TFP growth.[22] In the Philippines, the rate of TFP growth is still relatively low, although it improved significantly compared with the earlier period.

A question of particular interest is why our estimate of TFP growth rate in Singapore (2.2 percent) is so much larger than Young's estimate (0.7 percent, assuming no quality-adjustments of labor). The difference reflects mainly the much lower estimate of capital share

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[21]The adjustment of the Singapore data for the presence of foreign workers (described in Appendix II) has only a minimal effect on the estimated TFP growth during 1978–96 (2.2 percent, compared with 2.5 percent when no adjustment is made). It has, however, a significant effect on the estimated TFP growth rate during 1991–96 (2.5 percent, compared with 3.6 percent when no adjustment is made).

[22]Because of the way it is calculated, TFP growth is a strongly procyclical variable. This should not matter much over a long period (such as the 18-year period 1978–96), but can be important over shorter periods (such as the five-year period 1991–96).

Figure 9 (a)
Indonesia
Growth of Output, Inputs, and TFP 1978-96

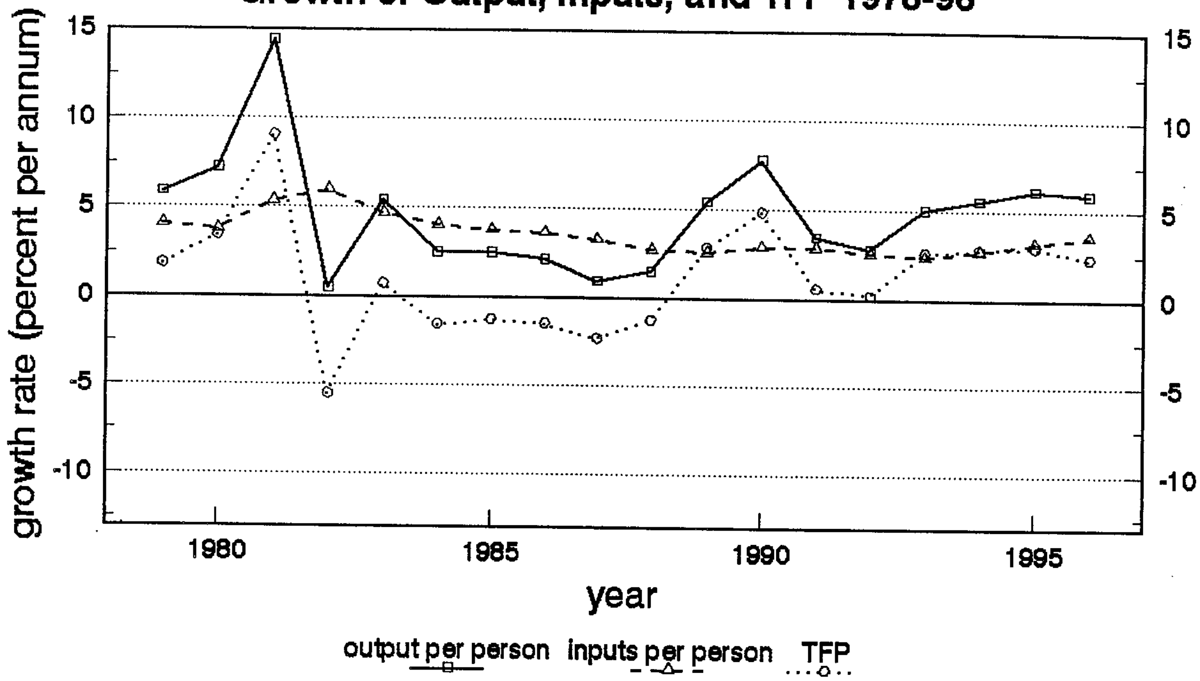


Figure 9 (b)
Malaysia
Growth of Output, Inputs, and TFP 1978-96

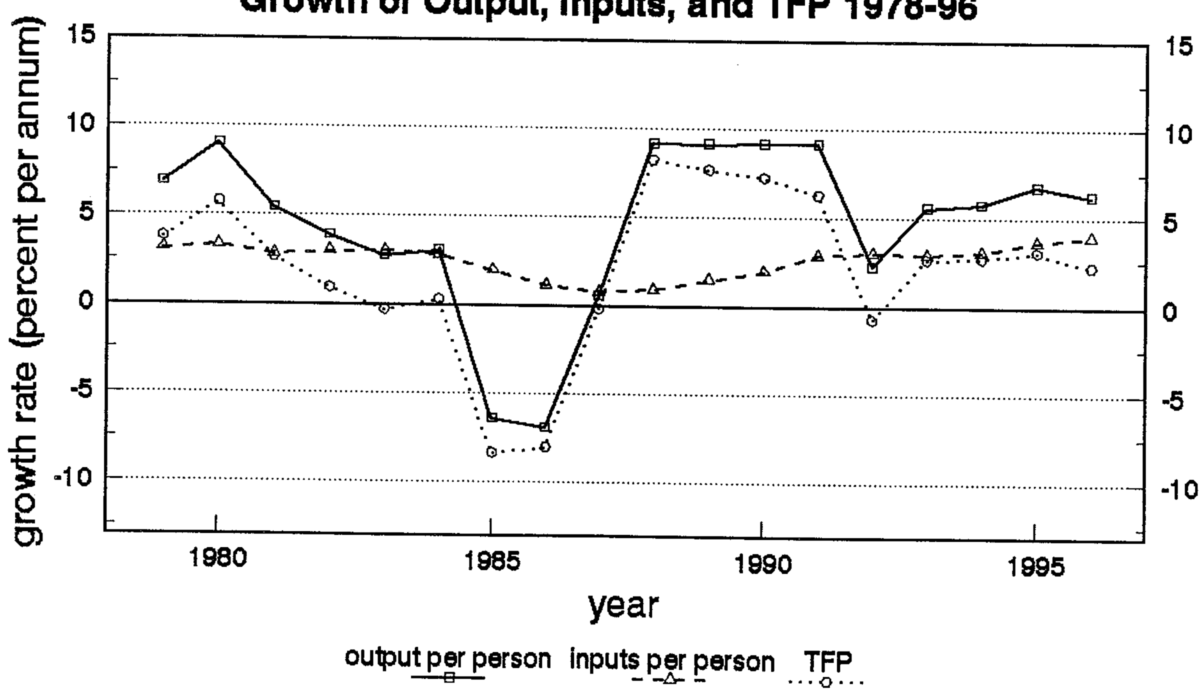


Figure 10 (a)
Philippines
Growth of Output, Inputs, and TFP 1978-96

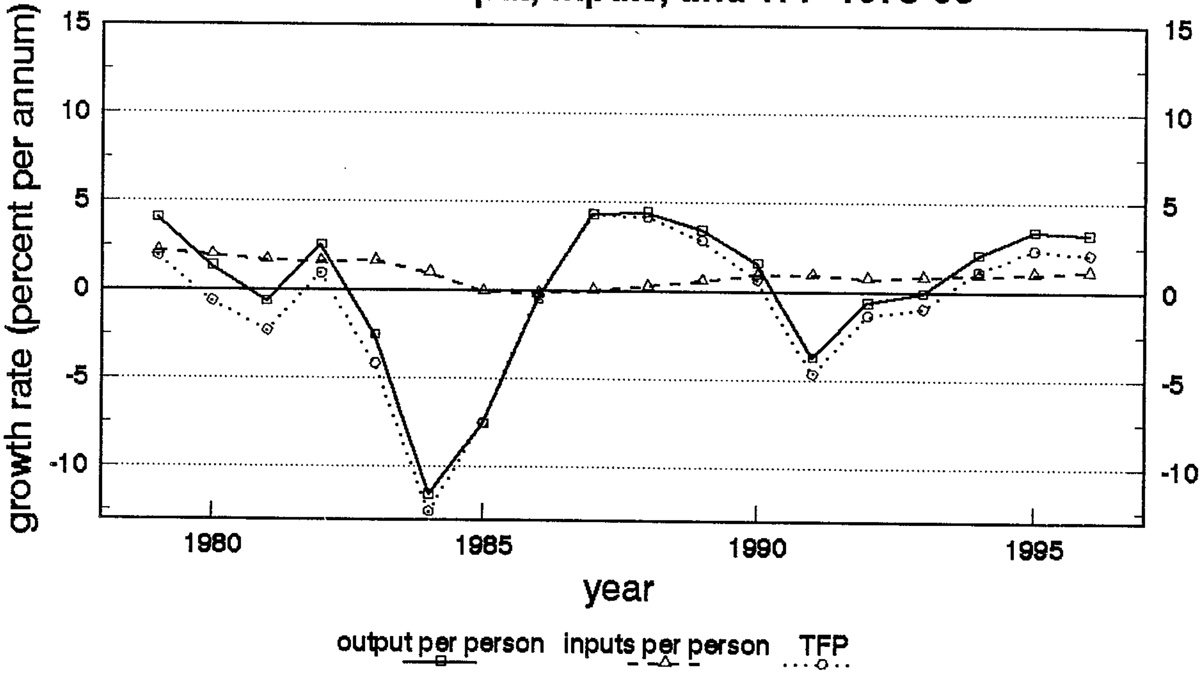


Figure 10 (b)
Singapore
Growth of Output, Inputs, and TFP 1978-96

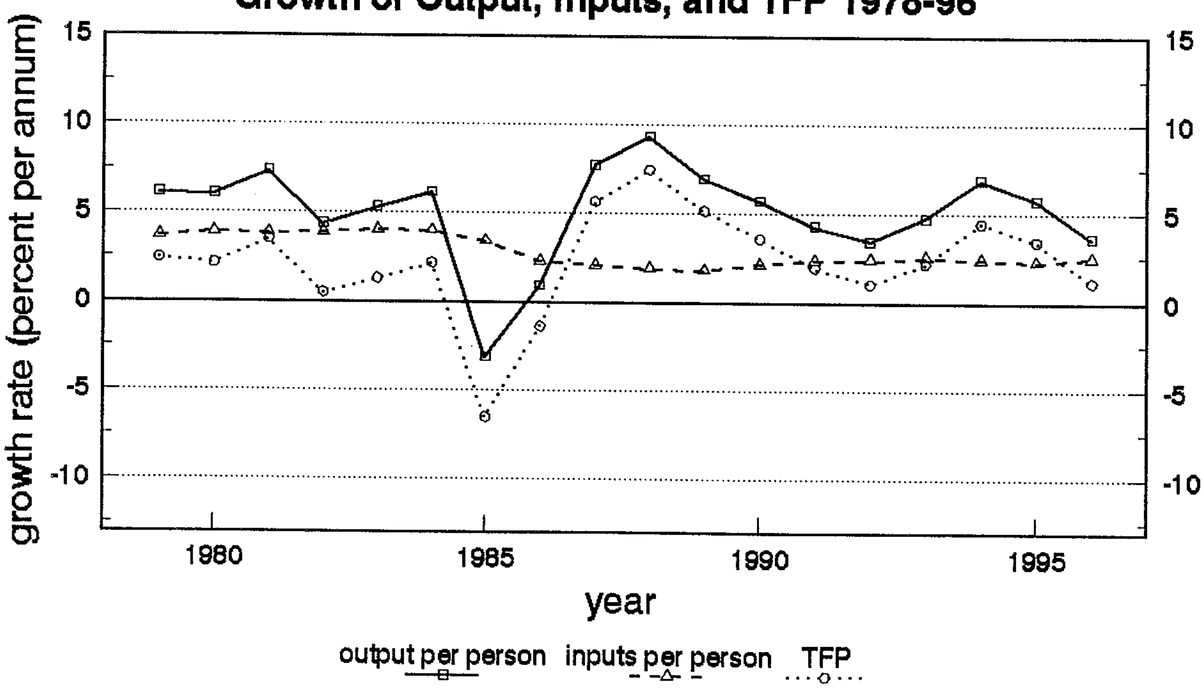


Figure 11 (a)
Thailand
Growth of Output, Inputs, and TFP 1978-96

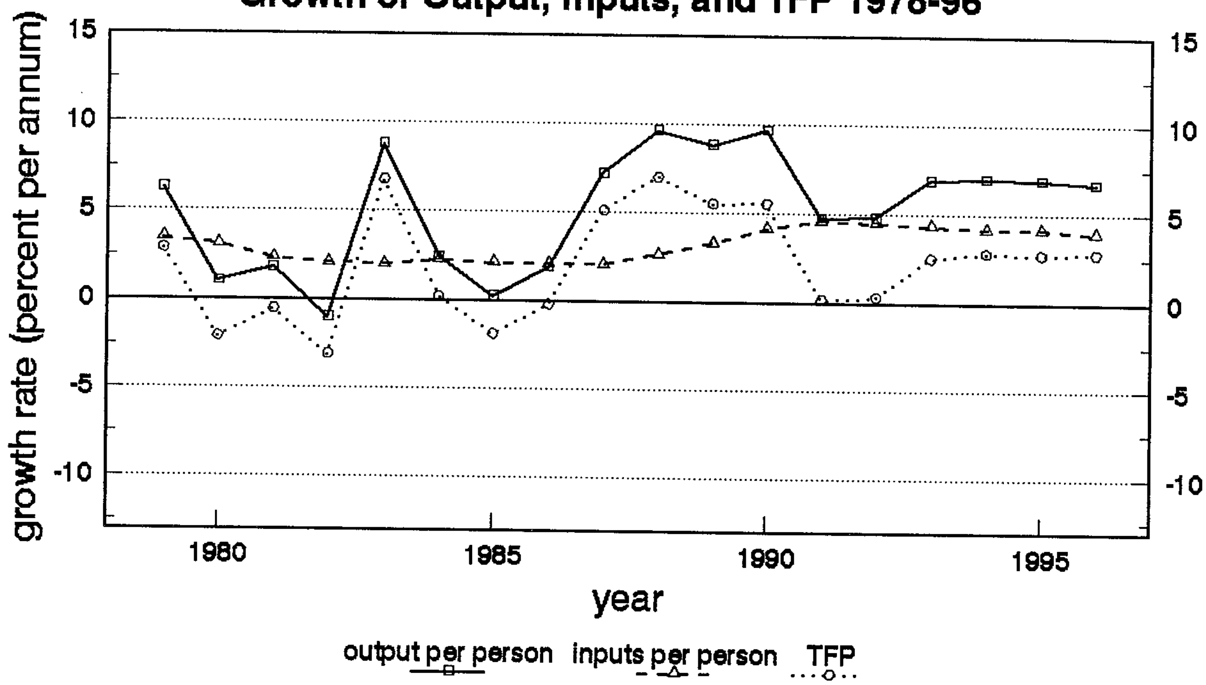


Figure 11 (b)
United States
Growth of Output, Inputs, and TFP 1978-96

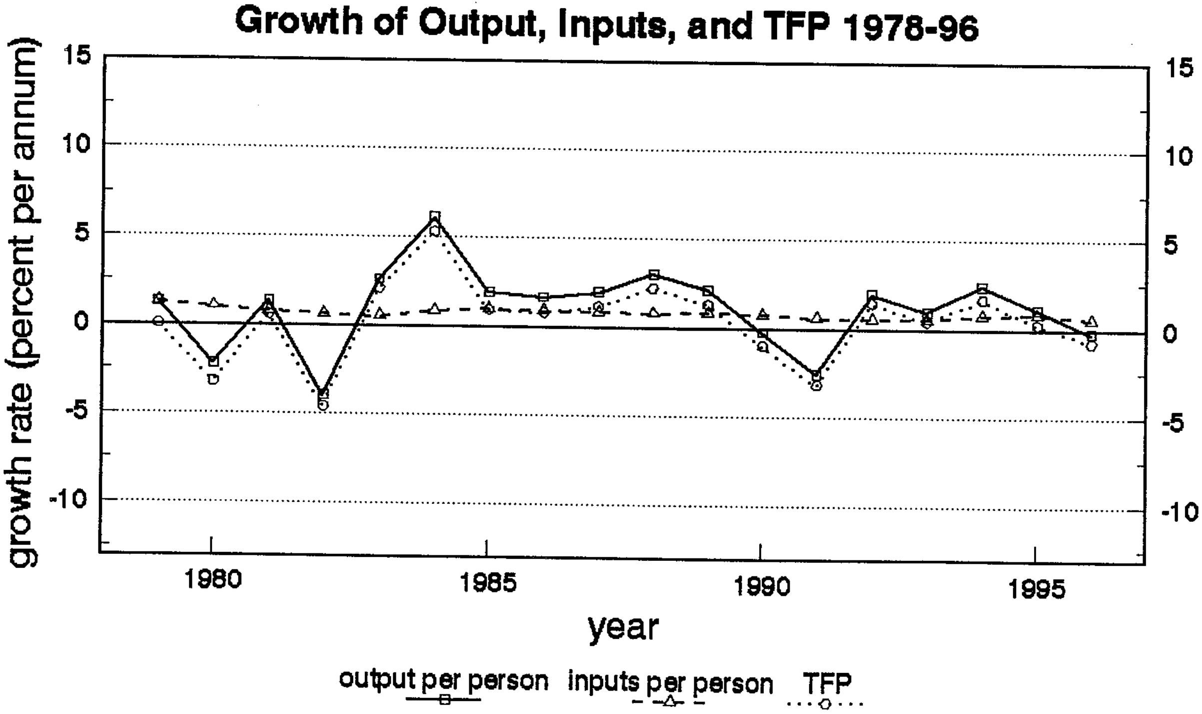


Figure 12 (a)
Five ASEAN Countries and U.S.
Growth of Output per Person 1978-96

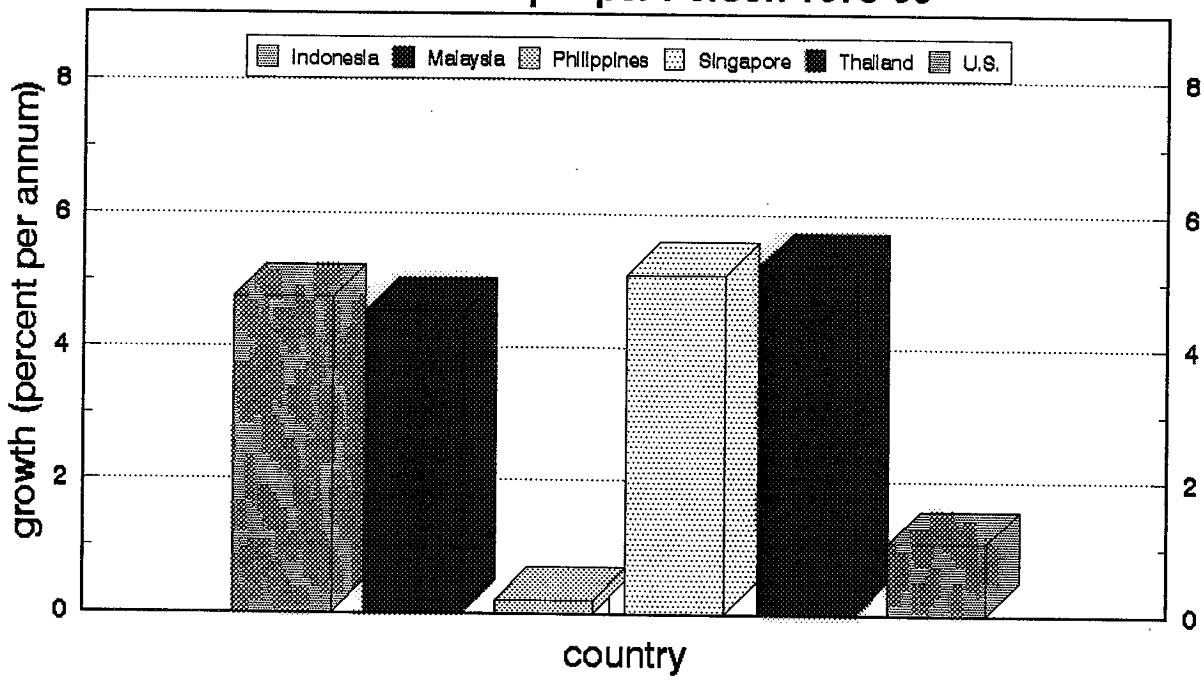


Figure 12 (b)
Five ASEAN Countries and U.S.
Growth of TFP 1978-96

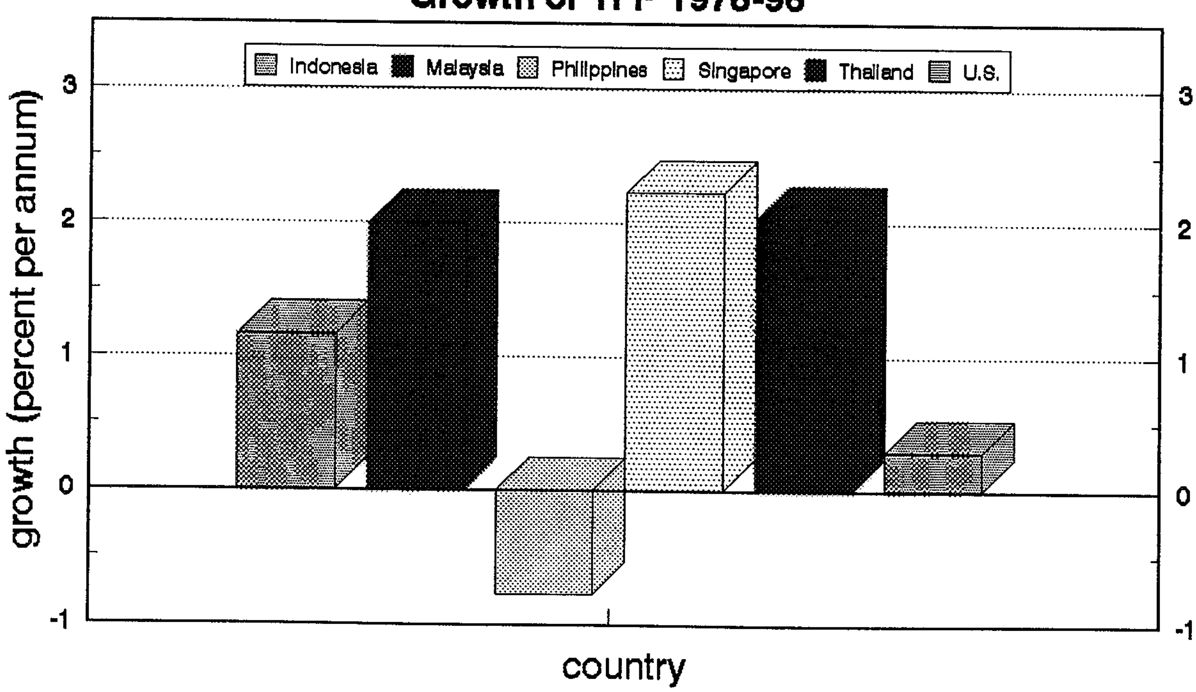


Figure 13 (a)
Five ASEAN Countries and U.S.
Growth of Output per Person 1991-96

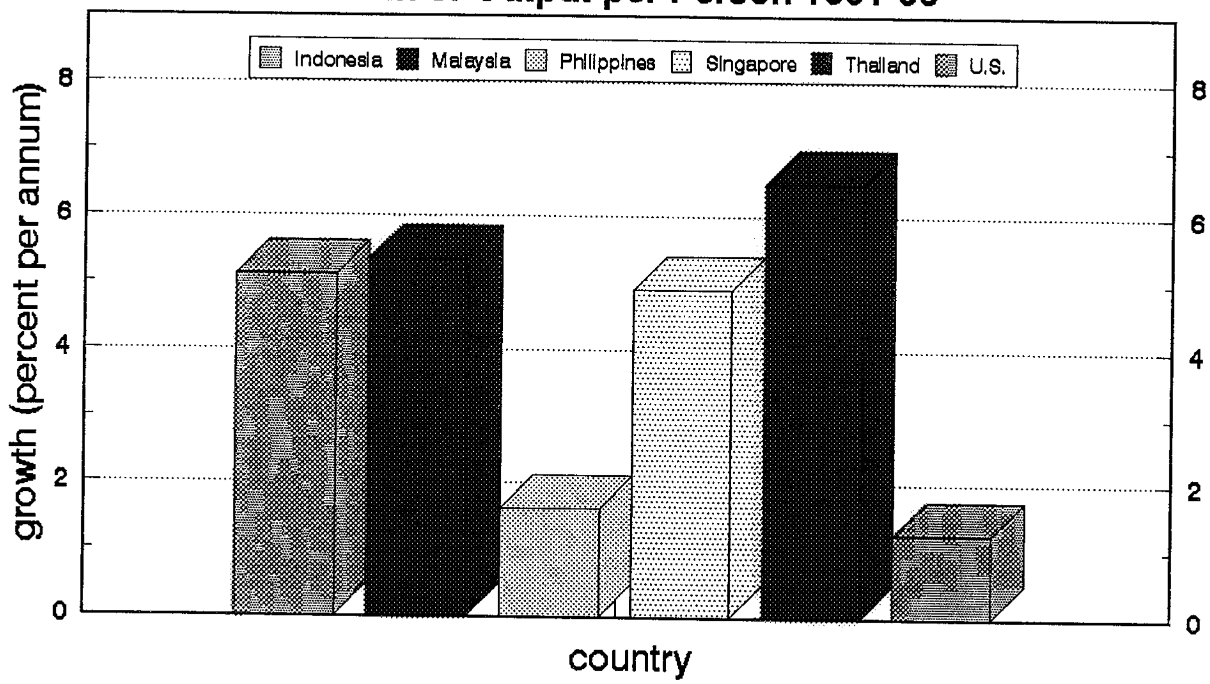
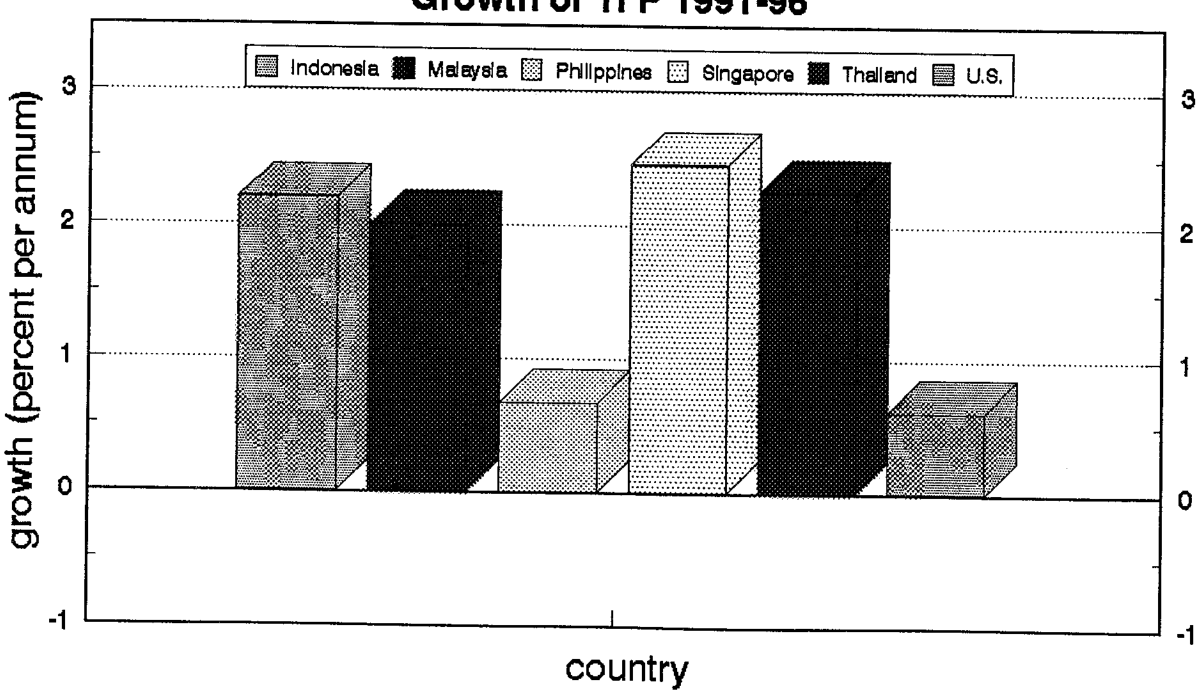


Figure 13 (b)
Five ASEAN Countries and U.S.
Growth of TFP 1991-96



in the present study: 0.337, compared with Young's 0.493. It is interesting to check what Young's estimate would have been if he had used the same capital share as here. The answer is a rate of TFP growth of 1.8 percent. Therefore, it appears that the difference in capital shares accounts for more than 70 percent of the difference between our estimate of TFP growth and Young's. The other factors that are responsible for the difference in the estimated growth of TFP include a different estimation period, the methods used for the measurement of capital stocks and labor supply, and the use of domestic and international prices.

Table 2. Growth Accounting

Growth in percent per annum
(and contribution as percentage of growth of output per person)

	Output per Person	Capital per Person	Effective Labor per Person	TFP
		Average, 1978–96		
Indonesia	4.74 (100)	8.97 (62)	0.93 (13)	1.16 (25)
Malaysia	4.54 (100)	6.86 (47)	0.58 (9)	2.00 (44)
Philippines	0.19 (100)	1.80	0.62	-0.78
Singapore	5.09 (100)	6.45 (42)	1.06 (14)	2.23 (44)
Thailand	5.24 (100)	7.32 (41)	1.51 (21)	2.03 (39)
United States	1.07 (100)	1.63 (44)	0.43 (28)	0.29 (27)
		Average, 1991–96		
Indonesia	5.11 (100)	6.98 (44)	0.96 (13)	2.20 (43)
Malaysia	5.35 (100)	8.25 (50)	0.97 (12)	2.00 (37)
Philippines	1.63 (100)	1.15 (21)	0.87 (38)	0.67 (41)
Singapore	4.91 (100)	5.60 (40)	0.77 (10)	2.46 (50)
Thailand	6.51 (100)	11.13 (50)	1.37 (15)	2.25 (35)
United States	1.26 (100)	1.19 (27)	0.43 (25)	0.61 (49)

VII. Outlook

Growth accounting exercises are valuable for understanding the sources of economic growth in the past. However, their usefulness for forecasting purposes is questionable. Whether the growth rate of total factor productivity estimated for the past continues in the future depends on many factors, not least on the economic policies being pursued. However, there are at least two questions that may be important in this context:

- What are the TFP levels of the six economies at the end of the sample period?
- Assuming that the economies will continue to experience the same rate of TFP growth as in recent years, what will be their growth rates of output per person in the long run?

A. Estimating TFP Levels

We assume a Cobb-Douglas production function and estimate the absolute levels of TFP as residuals. The estimated TFP levels for 1996 are presented in Figure 14, panel (b), and, for comparison, the output per person in levels is presented in panel (a) in the same figure. The results indicate that levels of TFP are closely related to levels of output per person, with two interesting exceptions.

The first exception is the much larger difference between Singapore and the United States in terms of TFP levels, compared with the difference between the two economies in terms of output per person: while Singapore in 1996 has an average income per person that was 83 percent of the level in the United States, its corresponding level of TFP was only 44 percent.

The second exception relates to the relative position of Indonesia and the Philippines. In terms of the level of output per person, the Philippines lags behind Indonesia in 1996 (by 30 percent), but in terms of the level of TFP it is ahead (by 11 percent). Indonesia compensates for its lower TFP level with a higher level of effective labor per person and, especially, a higher capital stock per person (66 percent higher than in the Philippines).

B. Estimating Long-Run Growth Rates

Assuming that recent TFP growth rates continue, it is possible in principle to estimate long-run growth rates.[23] To calculate long-run growth rates, it is assumed that the rate of capital accumulation is endogenously determined as in the standard neoclassical growth model, that effective labor per person and factor shares stay constant, and that TFP continues to grow at the same rate as during the five-year period that ended in 1996. The long-run

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[23]Such an estimation is, of course, very sensitive to underlying assumptions and is not intended to be used as a serious forecasting tool.

Figure 14 (a)
Five ASEAN Countries and U.S.
Output per Person 1996

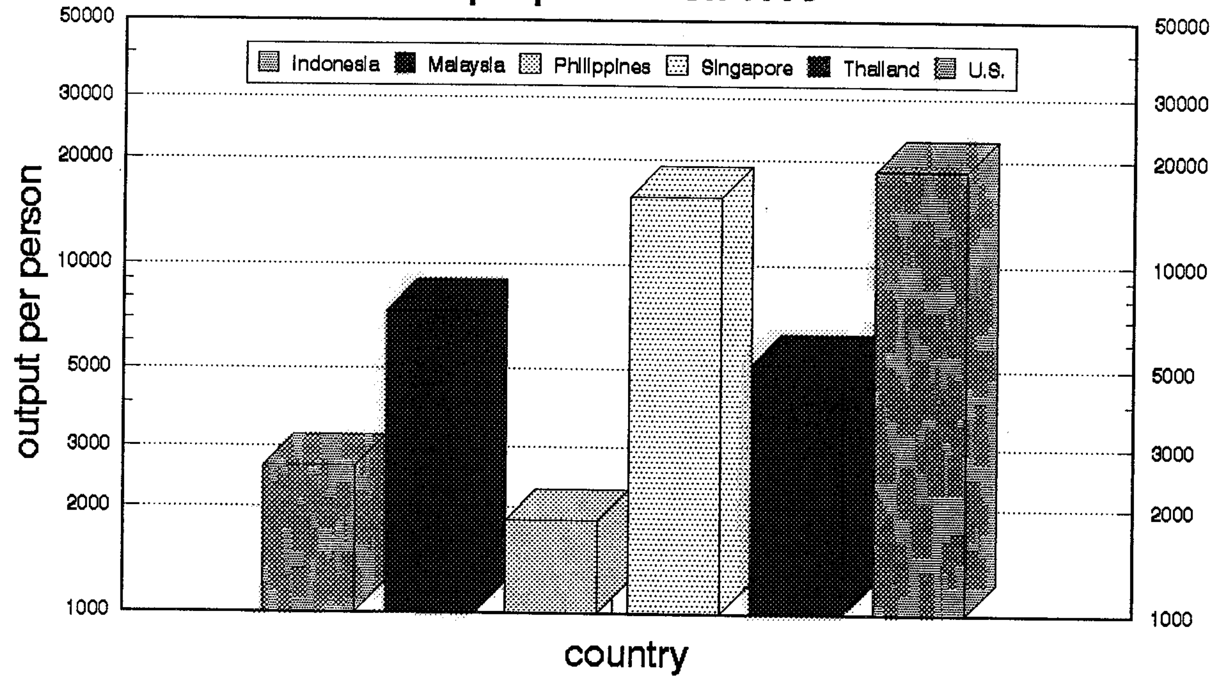
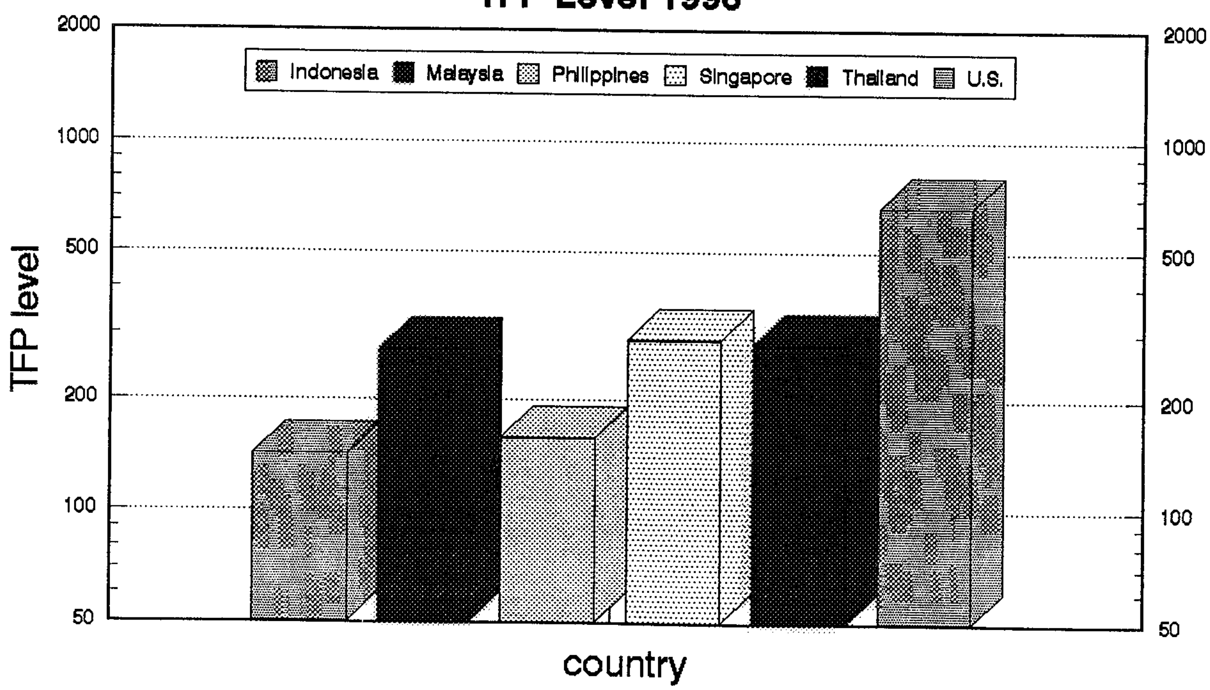


Figure 14 (b)
Five ASEAN Countries and U.S.
TFP Level 1996



growth rate of output per person in this case, according to the steady-state solution of the neoclassical growth model, is equal to the TFP growth rate divided by the share of labor in the production function (1-α) (see, for example, Sarel, 1994). The estimated long-run growth rates of output per person are presented in Figure 15, panel (b), and, for comparison, the growth rates during 1991–96 are presented in panel (a) in the same figure.

The results indicate interesting growth rate dynamics, both across time and across countries. The growth rates are expected to decline in all six economies in the sample, but in some the expected decline is much stronger than in others. The implied steady-state growth rate of Thailand, for example, is almost 3.3 percentage points lower than during 1991–96, when it was the fastest-growing economy in the sample. Relatively large declines are expected also in Malaysia (2.4 percentage points) and Indonesia (1.9 percentage points).

The growth rates in the ASEAN economies are expected to decline over time because past growth of output was partly driven by rates of capital accumulation that were faster than rates of output growth.[24] In the future, however, this tendency will diminish, as the output/capital ratio in these economies approaches a steady-state level. This effect is described in Figure 15.[25]

VIII. Conclusions and Beyond

The growth accounting study that was conducted in this paper covered five ASEAN economies and the United States during 1978–96. An attempt was made to ensure consistency of the data across countries, by eschewing, as far as possible, the use of national data sources. This approach is particularly important in the case of data on factor shares, but it also has significant effects on the estimated capital stocks and labor inputs.

The results show an impressive growth rate of TFP during 1978–96 for Singapore (2.2 percent), Thailand (2.0 percent), and Malaysia (2.0 percent); a slower rate for Indonesia (1.2 percent); and a negative performance for the Philippines (-0.8 percent). The estimated rate of TFP growth for the United States during this period was 0.3 percent. The proportion of the growth rate of output per person that can be attributed to TFP growth is not systematically different from that in the United States. These results confirm the conclusions

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[24]This was particularly important in Thailand.

[25]A second reason why growth rates in ASEAN economies are expected to decline in the future (and one that is not captured in Figure 15) is that these economies are gradually closing the technological gap with the more advanced economies. As this gap gets smaller over time, it is difficult to expect the high rates of TFP growth experienced by the ASEAN economies in the past to continue indefinitely in the future. When an economy changes from a technological follower to a technological leader, it probably cannot sustain rates of TFP growth that are much higher than those in the rest of the world.

Figure 15 (a)
Five ASEAN Countries and U.S.
Growth of Output per Person 1991-96

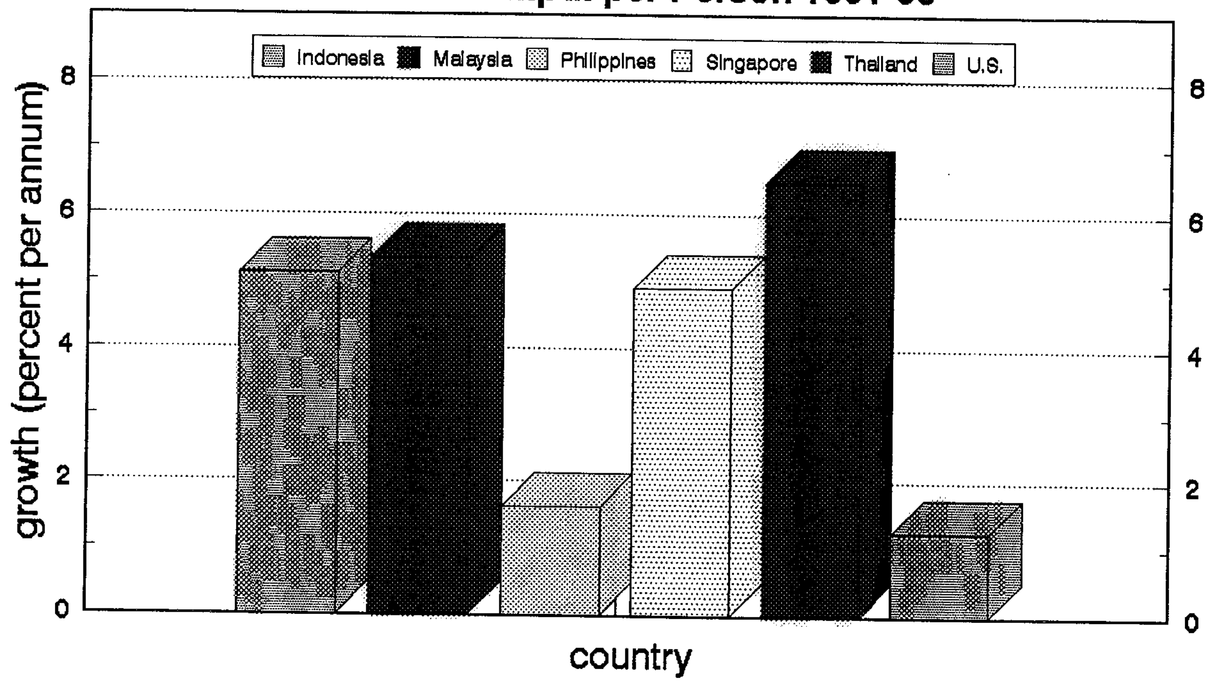
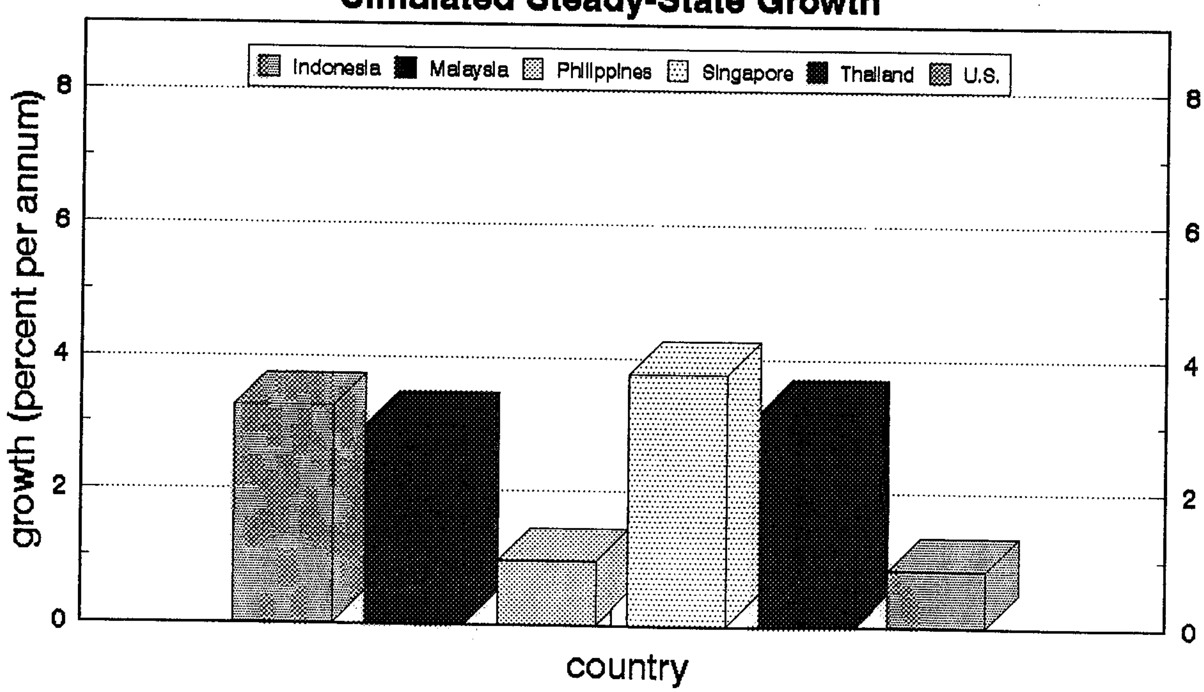


Figure 15 (b)
Five ASEAN Countries and U.S.
Simulated Steady-State Growth



of many previous studies, but are in sharp contrast to the conclusions reached in the studies of Alwyn Young, especially regarding the TFP growth rate in Singapore.

One of the main determinants of the results here is the difference between the estimated technological factor shares and the income shares that have been previously derived from the national accounts data. This difference can explain why previous studies found lower rates of TFP growth for fast-growing Asian economies, and especially for Singapore. Perhaps more important, this difference points to an interesting possibility. Assuming that the income shares have been correctly measured in previous studies, that of capital is much higher in the fast-growing ASEAN economies than its estimated technological share in the production function. The significant difference between technological shares and income shares may partly explain the impressive investment rates in this region that fueled the growth rates commonly described as the Asian "miracle." As far as these differences reflect taxes, incentives, or other government policies, they would imply that governments, by influencing the relative income shares of the factors of production, can affect the investment rate and the growth rate of the economy.

A Growth Accounting Framework

In presenting a framework for growth accounting, this appendix introduces the Cobb-Douglas production function, derives the growth accounting equation, explains how to calculate the rate of total factor productivity growth, and discusses the long-run economic implications of the growth accounting framework.[26]

The Cobb-Douglas production function is defined as:

$$Y_t = A_t\, K_t^{\alpha}\, L_t^{1-\alpha}, \tag{1}$$

where Y is the amount of output, A is a technological constant, K is the amount of capital used as input, L is the amount of labor used as input, t is a time subscript, and α is a parameter whose value is between 0 and 1.

This production function, with a value of α of about one-third, is often used to approximate the production possibilities of the economy. The reason is that it has many properties that we tend to observe in the national economies, such as constant returns to scale and constant factor income shares (with a capital share of α and a labor share of $1-\alpha$).

Dividing equation (1) by the population size, we get

$$y_t = A_t\, k_t^{\alpha}\, l_t^{1-\alpha}, \tag{2}$$

where y is the output per person, k is the capital per person, and l represents effective labor supply per person.

Equation (2) is a static equation. It represents the amount of output, as a function of inputs, in any specific period t. But from it, we can derive a dynamic version that describes how output per person increases over time:

$$\frac{\Delta y}{y} = \frac{\Delta A}{A} + \alpha\, \frac{\Delta k}{k} + (1-\alpha)\, \frac{\Delta l}{l}. \tag{3}$$

[26]The presentation here is identical to that in Sarel (1995b).

Equation (3) decomposes the growth rate of output per person into three elements: the first element describes the growth rate of total factor productivity (*TFP*);[27] the second element describes the contribution of the growth rate of the capital stock per person; and the third element describes the contribution of the growth rate of effective labor supply per person.

The decomposition done in equation (3) has a very important empirical application: we have a good idea about the magnitude of the parameter α (about one-third); it is easy to measure the growth rate of output per person (the left-hand side of equation (3)); it is possible, in principle, to measure the growth rates of capital per person and of effective labor supply per person (the last two terms in equation (3)); therefore, we can estimate the growth rate of TFP and we can also calculate what proportion of the growth of output per person is accounted for by this technological progress.

The growth decomposition in equation (3) also leads to an interpretation that plays a fundamental role in explaining long-run growth. It points out that a significant and sustained rate of technological progress is the only possible way, in the long run, for an economy to achieve a sustained rate of growth of output per person. The intuition for this result is that the effective labor supply per person can increase for a while, but obviously cannot increase without bounds in the long run; and higher growth in capital than in labor will lead to diminishing returns to capital in which output growth will fall over time even if capital growth is maintained. Therefore, in order to sustain a positive rate of per capita growth, an economy must continuously improve its technology. This kind of growth, which can continue forever, is called intensive growth. In contrast to intensive growth, extensive growth can work only for a limited period.

[27]This term is also known as the rate of Hicks-neutral technological progress or the Solow residual.

Estimation of Output, Capital, and Labor Growth

This appendix estimates the growth rates of per capita output, capital, and labor in five ASEAN countries and the United States, during 1978–96. The main concern is to treat the six countries in the sample uniformly, especially the capital and labor data, for which no standard measurement method exists. Therefore, we refrain from using national sources for estimates of these variables and rely instead on more country-neutral data from international sources, as described below. The main exception is the adjustment of Singapore's data to take into account the increasing presence of foreign workers in the economy.

A. Output and Population

We use the Penn World Tables data on output per person during 1978–92.[28] The major advantage of this database is that it measures output per person in 1985 dollars adjusted for purchasing power parity, meaning that this variable is, in principle, not affected by domestic prices of goods and services, relative to both domestic and foreign goods. Unfortunately, this database does not (so far) cover the period after 1992. Therefore, for 1993–96, we extrapolate the series using national accounts data and IMF staff estimates of population and GDP growth rates.

Because the foreign workers in Singapore constitute a significant, and increasing, fraction of the labor force, the official data on Singapore's population are adjusted to include the presence of foreign workers. The correct denominator in calculations of GDP per person should include, in addition to the official figure, the foreign residents working in the country, because they not only contribute to the production of GDP, but also share in the distribution of income. The net annual effect of the flow of foreign workers on Singapore's population is assumed to be 0.2 percent during 1978–92, and 0.6 percent during 1992–96. As a result, Singapore's de facto population (which is used in the study) is 2.8 percent higher than the official figure in 1992, and 5.3 percent higher in 1996.

B. Capital

We construct the capital stock series using historical data on investment flows. The Penn World Tables database contains data on investment flows during 1960–92, measured in 1985 dollars adjusted for purchasing power parity. We extrapolate the investment series forward to 1996, using official national accounts and IMF staff estimates of the growth rates of investment at constant prices. We also extend the series backward, using a logarithmic extrapolation up to the year 1901. We assume that the capital stocks were zero at the end of the year 1900, and that the rate of capital depreciation is 5 percent a year. We calculate the end-of-year capital stocks during 1901–96, assuming that the annual investment flows

[28]We use the latest available version of this database, PWT 5.6a. This is a version of PWT 5.0—described by Summers and Heston (1991)—that was updated by the National Bureau of Economic Research in 1995.

occurred in the middle of the year and that the effective rate of depreciation during the second half of the year was half of the annual depreciation rate (i.e., 2.5 percent). Finally, we calculate the average capital stock per person for each year as a geometric average of the capital stock at the end of the previous year and at the end of the current year, divided by the population size.

Using the Penn World Tables database to obtain data on investment flows has two distinct advantages. First, we can compute series of capital stocks and derive growth rates that are comparable across countries. This is essential for calculating and comparing rates of total factor productivity growth. Second, with the capital stocks and output series measured in a common currency and in common prices, we can estimate the output-capital ratio (as well as the marginal product of capital) and provide meaningful comparisons across countries.

In principle, we could start the sample period as early as 1960 (the earliest year for which we have data on investment flows), or even before (we could use the extrapolation estimates). However, estimating capital stocks from historical data on investment flows involves an estimation error that is necessarily larger in earlier periods. The choice of the starting year for the sample, 1978, is somewhat arbitrary. It does, however, neatly divide the observation period 1960–96 into two equal parts, so the sample period is limited to no more than half of the period for which data on investment flows are available. Starting the sample in 1978 also has the advantage of including the period of the second oil shock (1979–80) together with the subsequent decline in oil prices (especially 1986). Leaving the 1979–80 period out of the sample would introduce an asymmetric effect when comparing oil exporters (such as Indonesia) with oil importers (such as Thailand and the United States).

A few of the previous studies also attempted to include land, either as a component of the capital stock or as a separate factor of production. In this study, however, we ignore the existence of land. The main reason is our lack of knowledge regarding the way in which land enters the production function, as well as a lack of data on land rents and their share in national income. If land truly does enter the production function, ignoring its existence will tend to understate the amount of capital at the beginning of the estimation period, overestimate the rate of growth of capital, and underestimate the rate of TFP growth. The size of this estimation error is a negative function of the initial development level of the economy and a positive function of the rate of growth of capital. Therefore, TFP growth rates would be relatively more underestimated for fast-growing developing economies (such as the ASEAN economies) than for slow-growing industrial economies (such as the United States). A similar effect occurs in case land is a separate factor of production in a generalized Cobb-Douglas production function (see, for example, van Elkan, 1995). In this case, by ignoring the existence of land, we overstate the share of capital in the production function and underestimate the rate of TFP growth. Again, the size of this estimation error is a positive function of the rate of growth of capital.

C. Labor

Our objective is to estimate the average labor supply per person. One simple approach would be to use the official statistics on participation rates and working hours. However, this approach has obvious flaws. It ignores large cross-country differences in definitions of workers and in the quality of labor data collection. It also ignores age-related productivity differences across labor market participants. Furthermore, it implicitly assumes that young children, retired senior citizens, and other persons who do not participate in the formal labor market have a zero effect on the total productivity level in the economy. This assumption is obviously not correct. For example, the presence of young children may decrease the productivity of their parents. On the other hand, the presence of grandparents has an ambiguous effect on the productivity of the parents.

What is needed is a function that relates productivity to age as well as information on the age structure of the population for each country and every year in the sample. This would make it possible to construct a panel database that estimates the "effective labor supply per person" (i.e., that is adjusted for demographic differences), both across countries and over time. Fortunately, such a database exists: it is the Effective Labor Supply database, which was constructed in a previous study (Sarel, 1995a) using economic data from the Penn World Tables database and demographic data estimated and forecast by the United Nations (1990). That study covered 119 countries for 1950–2025 and contained estimates at five-year intervals. For the purpose of this study, we perform a logarithmic interpolation of the five-year intervals to obtain annual estimates during 1978–96 for the six countries in the sample.

Some previous studies (including Young's) have attempted to differentiate between different types of workers (based on their education levels) and to use a measure of quality-adjusted labor as the relevant factor of production. We feel, however, that doing so would tend to underestimate the true rate of TFP growth by attributing a large part of the increase in output to a better (more educated) labor force. The reason is that the treatment of education as a pure investment good exaggerates the causality between investment in education and economic growth. For example, education has an important consumption motive: having additional resources, people tend to spend more on education, just as they spend more on other consumption goods, simply because having a better education increases their utility. As another example, education has a strong signaling motive: smart people go to college in order to signal that they are smarter than other people and to gain better access to the labor market, not necessarily because going to college makes them smarter.

An additional reason not to adjust labor for education levels is related to the more general question of how one should regard TFP growth and technological progress. Defining TFP growth as a measure of an economy's capacity to generate more output using a fixed quantity of inputs, we implicitly include in TFP the absolute level of knowledge, proficiency, skill, efficiency, and other similar concepts. Measuring TFP growth, we gain valuable information on the rate of improvement of these factors. However, using education levels to define quality-adjusted labor, and counting this adjusted variable as a factor of production, we change our definition of TFP growth from an absolute standard to a conditional standard:

now, measuring TFP growth would only give us information on the rate of improvement of these factors conditional on the level of education. This conditional concept would mean something completely different from the absolute concept and would be significantly less useful.[29]

The presence of many foreign workers in Singapore is assumed to have a negligible net effect on the effective labor supply per person because there are two different effects: on the one hand, the age distribution of the foreign workers is more efficient (in terms of net effect on production) than in the population of domestic residents, which includes relatively unproductive young children and elderly persons; on the other hand, the average productivity of foreign workers is low relative to domestic workers in the same age group. For simplicity, the two effects are assumed to be roughly equal, and the net effect is therefore negligible.

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[29] An alternative way of regarding TFP growth would be as a measure of our ignorance (because it represents the residual in growth accounting exercises). In this case, it would make more sense to perform quality adjustments.

The Traditional Methods For Estimating Factor Shares

In this appendix, we evaluate the two methods that are commonly used to estimate the technological factor shares: the regression and the national accounts approaches.

A. The Regression Approach

This method estimates the factor shares by regressing the growth rate of output on the growth rate of each input and a constant. The estimate for each factor share is the estimated coefficient of the relevant input, and the constant in the regression can be viewed as an estimate of the growth rate of TFP. The regression approach has three main disadvantages.

First, it assumes that the growth rate of each input is exogenous, while the growth rate of output is endogenous. However, empirical evidence, as well as standard economic growth theory, points to other possibilities. Suppose, for example, that an economy enjoys, as a result of rapid TFP growth, a faster rate of output growth (either relative to another economy or relative to its own past experience). Then, it would also invest more and have a higher rate of capital growth.[30] Therefore, the regression approach will overestimate the capital coefficient. Furthermore, if labor supply also reacts to changes in the rate of TFP growth, the labor coefficient will also be biased.[31]

Second, the factor shares are usually estimated to be similar across countries (a cross-country regression) or over time (in a time-series regression). However, there are no special reasons to assume that these shares are constant.[32]

Third, the estimation of the factor shares is not done independently, but needs to rely on the growth rates of the factors of production. These rates are also not directly measured and are sometimes subject to significant errors.

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[30]In the steady state of the neoclassical growth model, both output per person and capital per person grow at the same rate, which is proportional to the growth rate of TFP, the exogenous variable in the model. An increase in TFP growth will cause the economy to shift to a new steady state, with a higher growth rate of output and capital. See, for example, Sarel (1994).

[31]This can be caused by endogenous fertility choice or endogenous labor participation. With a faster rate of technological progress, families may decide to have fewer children but to invest more resources in raising and educating each child.

[32]Some modifications to the regression specification can be made to estimate time trends or country effects, but these modifications necessarily reduce the number of degrees of freedom in the regression, which is usually quite low in the first place.

B. The National Accounts Approach

This method uses data derived from the national accounts statistics to estimate factor shares by measuring the share of income that is distributed to each factor of production (the "income shares"). This method suffers from at least four disadvantages.

First, using income shares to estimate the technological factor shares, this approach assumes, sometimes implicitly, that capital and labor markets are perfectly competitive and that the income of each factor of production is equal to the value of its marginal product. This ignores the possibility of market imperfections. For example, a strong labor union (or minimum wage legislation) may force wages above the level warranted by the marginal product of labor; a monopsonist firm (e.g., an enterprise that is the main provider of jobs in a remote town) may force wages in the opposite direction; and a monopolist firm, by increasing the price of its product, may increase the marginal product of both labor and capital above their respective rental prices.[33]

Second, this method ignores the effects of government policies and regulations, including tax policy. For example, the government may have a general strategy to encourage economic development through incentives in the tax system, and it may offer tax breaks or subsidies to capital-intensive industries. There is much anecdotal evidence to suggest that governments do indeed use tax policy for this purpose.[34] The incentives given to capital-intensive industries would be internalized by the firms, and the return to capital would exceed its technological marginal product. In this case, estimating the technological factor shares by measuring income shares would overestimate the share of capital and underestimate the share of labor.

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[33]Rachel van Elkan (1995, p. 8) discusses this problem in the context of foreign direct investment in Singapore and suggests an interesting partial solution: "The assumption that income shares reflect output elasticities is likely to be violated for capital goods, especially in the case of foreign direct investment, where monopoly suppliers of capital goods may earn a return in excess of the marginal product of capital. Accordingly, in what follows, income accruing to capital is reduced by the amount of the monopoly rent, assumed to be equivalent to 1 percent of the current value of the capital stock (see MAS [Monetary Authority of Singapore] (1993))." The MAS study was later published by Wong and Gan (1994).

[34]Pai (1991), for example, describes the tax policy in Taiwan Province of China, from his perspective as the Chairman of the Board of the Export-Import Bank. After describing the various tax measures that the government adopted over the past 40 years, Pai concludes: "It is very clear that the tax incentives described above were aimed at promoting investment in productive enterprises, stimulating export sales, and encouraging saving" (p. 49). As another example, Bahl, Kim, and Park (1986) write: "Korean tax policy was much oriented to supporting rapid economic growth" (p. 46).

Third, the national accounts approach ignores the problems related to the classification of workers who are not employees. The national accounts contain, at most, information on compensation to employees. They do not contain information on compensation to other types of workers, such as employers and the self-employed, and unpaid family workers.[35] If the distribution of workers according to type of worker is known, then the compensation of the other types of workers can in principle be imputed, using some general assumptions (e.g., that employers and own-account workers receive the same compensation as employees, and twice the compensation of unpaid family workers). However, the distribution of workers is not readily available for every country and each year. Statistics that are (more or less) uniform across countries are based on labor force surveys, which are typically conducted every ten years. Annual data are scarce; if available, they are based on questionable interpolations and extrapolations of these surveys. Furthermore, different types of workers are not usually distributed uniformly among the different sectors of the economy. For example, unpaid family workers are more likely to be over-represented in the agricultural sector, where employees probably receive lower compensation than in other sectors. This uneven distribution would create a serious problem in comparing countries with large differences in the share of the agricultural sector (e.g., Philippines and Singapore).

The fourth problem is more subtle. It is associated with the classification of workers, but is also related to the government's tax policies. The formal classification of workers is not an exogenous variable, but is itself affected by country-specific considerations, such as the tax and social security systems.[36] Because the compensation of employees differs from the compensation of other types of workers, the endogeneity of the formal classification of workers may introduce a significant bias in the estimation process. Furthermore, even if workers are correctly classified according to their type, tax policies can affect the total compensation of labor (and of capital) by creating incentives to under- or overreport the wage bill.

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[35]These other types of workers are a crucial component of the labor force in developing countries. For example, the International Labor Office (1992) reports that the total number of workers in Thailand in 1988 was 30 million (excluding the unemployed). Of these, 9 million were "employers and own-account workers," 13 million were "unpaid family workers," and only 8 million were "employees."

[36]For example, in a country that does not have extensive social security benefits but requires employers to pay social security contributions, the agricultural sector will mainly consist of unpaid family workers and will have relatively few employees; in a country that offers tax advantages to small firms, the commerce sector will mainly consist of small firms with the owner reporting as self-employed; and, in a country with very progressive tax rates on personal income, the commerce sector will consist of many small enterprises, where the extended family members of the enterprise owner are registered as formal employees and are (formally) receiving a generous salary.

The Estimation of Technological Factor Shares for Major Activities

This appendix details the estimation of the technological factor shares embodied in each major economic activity. We construct a sample of observations with complete data on national accounts and the composition of the labor force and use it to estimate the "typical" factor share for each major economic activity.

1. The data sources are *National Accounts Statistics* (Table 4.3—Cost Components of Value Added); *Year Book of Labour Statistics* (Table 2A—Economic Active Population by Industry, by Status in Employment, and by Sex); and Penn World Tables (PWT 5.6a).[37]

2. We include only countries with complete data in each of the three sources around the same years, close to the year 1980 or the year 1990.[38] The sample is described in Table 3.

3. The national accounts of some countries contain, in addition to the nine major types of economic activities (ISIC one-digit division), two additional activities, defined as "producers of government services" and "other producers." In these cases, we combine the two additional activities with the ninth ISIC activity, "community, social, and personal services."[39] We define the combined activity "government and other services."

4. The national accounts of some countries contain separate data on "capital consumption" (depreciation of existing capital) and on "net operating surplus." The two items are integrated into one combined item, which is defined as "gross surplus."[40]

5. The "imputed bank service charge" is divided between the different types of activity, using as weights their share in the total gross surplus.

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[37] The first database was published by the United Nations (1982, 1992), the second was published by the International Labor Office (1982, 1992), and the third is a 1995 NBER update of Summers and Heston (1991).

[38] Sixteen countries have complete information for one of the two periods and 10 have information for both. The sample therefore contains 36 observations. Although most countries in the sample have a relatively high income, some low-income countries are also included.

[39] This methodology follows United Nations (1992, pp. ix-x).

[40] Some countries do not provide separate data on "capital consumption," and this item is already included in "gross surplus."

Table 3. Countries in the Sample

Country	Year	Country	Year	Country	Year
Algeria	1977	Germany, W.	1990	Norway	1991
Australia	1977	Hong Kong	1990	Peru	1982
Australia	1990	Ireland	1979	Peru	1990
Cameroon	1976	Japan	1980	Spain	1990
Chile	1980	Japan	1990	Sweden	1981
Colombia	1991	Korea	1981	Sweden	1991
Denmark	1981	Korea	1991	Trinidad & Tobago	1990
Denmark	1990	Luxembourg	1991	United Kingdom	1990
Ecuador	1990	Netherlands	1979	United States	1981
Finland	1980	Netherlands	1991	United States	1990
Finland	1991	New Zealand	1990	Venezuela	1981
France	1989	Nigeria	1986	Venezuela	1990

6. The gross surplus is assumed to be the sum of the following three components: "compensation of employers and own-account workers," "compensation of unpaid family workers," and "compensation for the use of capital inputs."

7. We regard the first two components of gross surplus as an integral part of the compensation of labor (in addition to compensation of employees). The essence of the problem is to estimate these two components to obtain the estimate of the third component as a residual. For this, we need to use the information contained in the labor database.

8. In the labor database, the data for most countries classify the total number of workers along two dimensions: their status (employers and own-account workers, employees, unpaid family workers, and not classified by status (mainly the unemployed)), and their occupation (the nine one-digit ISIC classification, and "activities not adequately defined"). We ignore the

workers who are not classified by status, but divide the workers in activities not adequately defined among the nine ISIC activities.[41]

9. The compensation of workers classified as employers and own-account workers is considered to be equal to that of workers classified as employees, and the compensation of workers classified as unpaid family workers is considered to be equal to half that of workers classified as employees.[42]

10. Using the information on the total number of each group of workers (in each economic activity) and the information on their relative compensation shares, we now impute the first two components of gross surplus (compensation of employers and own-account workers and compensation of unpaid family workers). We subtract the sum of these two components from the gross surplus to obtain our estimate of "compensation for the use of capital inputs." We repeat this procedure for each major economic activity and for each observation in our sample.

11. We now estimate the typical compensation for the use of capital inputs (for each major economic activity) as the simple average of the sample. These averages (and the corresponding standard errors) are described in the third column of Table 4.

12. We wish to allow the typical income shares to be affected by the level of development of each economy.[43] We estimate the level of development of each economy, using as a proxy the average capital stock per person (measured in 1985 dollars adjusted for purchasing power parity) for each country (and period) in the sample. We calculate the capital stock using data on investment flows (from the Penn World Tables database), according to the method described in Appendix II.

13. For each major economic activity, we run a regression of the compensation for the use of capital inputs on a constant and on the log of real stock of capital per person. The estimated coefficients of these regressions (and the corresponding standard errors) are described in the last column of Table 4.

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[41]The rationale for doing so is that we have information about the status of these workers, which we can use to compute the weights that divide them among the different activities. For example, unpaid family workers are more likely to work in agriculture than in manufacturing.

[42]This is, admittedly, largely an ad hoc assumption. In the future, if more micro data about relative real compensation of the three groups becomes available, this issue can easily be readdressed.

[43]For example, the labor force is usually better educated in developed economies. Technologies that use better educated workers may differ from technologies that use less educated workers.

Table 4. The Kinds of Activity and Their Estimated Capital Shares

Kind of Activity	Average Capital Share	Capital Share as a Function of Income per Person
Agriculture	0.275 (0.232)	-0.808 + 0.0285 log(k) (0.363) (0.0363)
Quarrying	0.601 (0.278)	0.563 - 0.00378 log(k) (0.439) (0.0439)
Manufacturing	0.308 (0.174)	0.408 - 0.00999 log(k) (0.273) (0.0274)
Utilities	0.538 (0.232)	-0.346 + 0.0890 log(k) (0.333) (0.0334)
Construction	0.189 (0.174)	0.788 - 0.0603 log(k) (0.254) (0.0254)
Commerce	0.232 (0.196)	0.617 - 0.0388 log(k) (0.303) (0.0303)
Transport and communication	0.320 (0.112)	0.457 - 0.0138 log(k) (0.176) (0.0176)
Financial and business services	0.604 (0.141)	1.06 - 0.0462 log(k) (0.208) (0.0209)
Government and other services	0.0812 (0.0908)	-0.164 + 0.0246 log(k) (0.137) (0.0137)
Whole economy	0.315 (0.127)	0.412 - 0.00975 log(k) (0.200) (0.0200)

14. The estimated coefficients of the capital stocks are, in general, insignificant. At the 5 percent confidence level, they are marginally significant only for three sectors: utilities (positive), construction (negative), and financial and business services (negative). At the 1 percent level, they are insignificant for every sector.

15. For each economic activity we now have estimates of capital shares (α). The estimated labor share ($1-\alpha$) can easily be derived.

16. The last row in Table 4 presents the results of estimating the capital share after aggregating across activities (for each country, according to the relative share of each major

economic activity in GDP).[44] This information is not directly required by the estimation procedure, but is useful in comparing the estimate of α in our sample, 0.315, to the conventional estimates.

[44]These results describe the estimated capital share within the sample. Other economies' capital shares will vary according to their production structure and level of development.

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