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TOTAL FACTOR PRODUCTIVITY GROWTH IN EAST ASIA: A CRITICAL SURVEY

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Foreword

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Abstract

This paper surveys the empirical literature on total factor productivity (TFP) and the sources of growth in the East Asian countries. It raises the question whether the literature has helped us understand better the factors that have propelled growth in the region. The paper discusses the main theoretical aspects in the estimation of TFP growth, as well as the empirical results, and provides a survey of estimates of TFP growth for nine East and Southeast Asian countries. It is concluded that: (i) the main merit of the literature is that it has helped focus the attention of scholars on the growth process of East Asia, and has made countries in the region aware of the importance of productivity; (ii) the theoretical problems underlying the notion of TFP are so significant that the whole concept should be discarded; (iii) the TFP growth estimates are contentious: they vary significantly, even for the same country and time period, depending on assumptions and data sources; and (iv) research on growth in East Asia based on the estimation of TFP growth is an activity subject to decreasing returns. If we are to advance in our understanding of how East Asia grew during the last 30 years we need new avenues of research.

I. Introduction

The revival of interest in growth theory during the 1980s with the development of the new neoclassical endogenous growth models (Lucas 1988, 1993; Romer 1986, 1990) has opened new avenues of research and initiated several debates. Growth theory has been in a lethargic state since the late 1960s. Certainly work in the area continued after Solow's (1956) development of the neoclassical model, but most of this work were refinements of his model. One had to wait until the mid-1980s to observe path-breaking work in the form of the new neoclassical endogenous growth models. Although many of the policy implications of these models are not new, they are different and innovative in several respects. The endogenous growth models explicitly introduce imperfect competition, increasing returns, and admit, by preventing the marginal product of capital from falling, the possibility of differences in country growth rates, and lack of convergence of per capita incomes. At the same time, economists realized that there was a group of countries in East and Southeast Asia which has been growing formidably for the last 30 years, giving rise to the so-called "East Asian Miracle" (World Bank 1993). The attempt to explain how these countries grew has produced one of the most interesting discussions in the field of growth in this decade, trying to match the empirical results with the models' rationale. During recent years, we have witnessed a mushrooming of empirical papers trying to explain East and Southeast Asia's miracle. Young (1992, 1994a, 1994b, 1995); World Bank (1993); Kim and Lau (1994); Pack and Page (1994a); Fishlow et al. (1994); *World Development* (1994); and Collins and Bosworth (1997) among others, have opened several intellectually stimulating debates discussing how this group of countries grew so phenomenally for such a long time. One strand of this literature has used cross-country regression analysis to explain differences in growth rates across nations. A second one has concentrated on the debate on the role of public policy. A third one has discussed the role of high investment rates and export orientation. Finally, another strand has concentrated on decomposing growth into factor accumulation and productivity gains, and has opened the discussion of whether growth in the region was driven by accumulation of factors or by productivity and learning.

This paper addresses the above last line of research and the debate it has sparked. The central question asked is whether the literature that this exchange has generated has helped us to gain a better understanding of the factors that have propelled growth in the region. Though not perfectly demarcated, and including scholars with heterogeneous views, several groups have emerged. Their views are not entirely opposing, and in some respects they share some common ground. However, they have substantial disagreements in key issues, so that for purposes of this discussion, one can say that there are three distinctive clusters with different views of the productivity debate. First are the fundamentalists (Young 1992, 1994a, 1994b; Kim and Lau 1994; Krugman 1994; Collins and Bosworth 1997), who claim that growth in the region was mainly input-driven. Second are the assimilationists (Dahlman and Westphal 1981; Dahlman et al. 1987; Hobday 1994a, 1994b, 1994c, 1995; Romer 1993a, 1993b; Pack 1993; Pack and Page 1994a, 1994b; Nelson and Pack 1996), who argue that the essential component of the recipe followed by the East Asian countries was the acquisition and mastery of foreign technology, and the capacity to put ideas into practice. Third is a group that offers a rather nihilistic view of the debate—Felipe and McCombie (1997) maintain that the whole debate about the sources of growth is misplaced due to a serious methodological problem inherent in the tools used in the analysis.

The polemic was ignited by the fundamentalists (Young 1992), who maintain that growth in the region was input-driven, mainly capital, and that productivity increases were negligible if not zero. Capital accumulation (i.e., investment effort) followed from the willingness to sacrifice current consumption. But, without any doubt, it was Krugman's (1994) paper that popularized and fanned the debate when, based on the results of Young (1992) and Kim and Lau (1994), he provided a controversial interpretation of the East Asian Miracle and compared the Asian NIEs to the Soviet Union. The so-called "Krugman's thesis", that there was no miracle behind East Asia's growth but simple capital accumulation, has important implications for the understanding of the East Asian miracle, namely, that these countries will not be able to sustain their economic growth, and may end up like the Soviet Union. This line of reasoning is neoclassical in nature. In this growth model, output level and growth are a function of a country's resource endowment and the productivity of factors of production, or total factor productivity (TFP). This has been the dominant paradigm in most explanations of East Asia's phenomenal growth (see *World Development* 1994 for a critique) and in the discussion about the sources of growth. Growth is explained from the supply side with the help of an aggregate production function that describes the production possibilities of a country. According to the standard neoclassical growth model (Solow 1956), input-driven growth is not sustainable because there are limits to input mobilization and because incremental growth in inputs is subject to the law of diminishing returns. In this model, capital per worker rises over time, generating a decline in the marginal product of capital, up to the point where the economy reaches the steady state. Countries' growth rates will level off at a growth rate equal to the sum of their labor and productivity growth rates, as capital per worker peaks at a level determined by saving behavior and the pace of productivity growth. Thus, this model implies that if there is no technical progress (and in the absence of exogenous increases such as population growth), and growth results exclusively from the accumulation of resources, then the process will stop as a result of diminishing returns to the factors. Hence the emphasis on productivity.

What is the fundamentalists' contention about the Asian Miracle? It was almost an article of faith that the fast rates of growth in per capita income of the high-performing Asian economies were partly due to the catch-up phenomenon, according to which the rapid growth in per capita income that these countries achieved could be attributed to the high rates of technological change made possible by the diffusion of technology from the more advanced countries. Likewise, an important result of the new literature on endogenous growth is to show how economic integration helps long-run growth (Rivera-Batiz and Romer 1991). The Asian miracle has given credence, through empirical analysis, that there is a positive relationship between outward orientation and growth. This conventional wisdom, however, was challenged by the empirical work of Young (1992, 1994a, 1994b, 1995) and Kim and Lau (1994), who claimed that technological progress, measured by TFP, was not spectacularly high. In the special case of Singapore, it was virtually zero. This finding cannot be understood even within the new growth theories framework, where a high rate of capital accumulation induces technical change.

The fundamentalists' conclusions, however, seem to be very counterintuitive, and question many of the traditional beliefs about growth in East and Southeast Asia. The assimilationists stress that what made the East Asian countries' performance special and different was how spectacularly well they mastered foreign technology; and Romer (1993a, 1993b) says that what distinguishes countries, and explains their different growth rates, is their capacity to generate and put ideas into practice. In order to understand this, the assimilationists claim, one has to go beyond the argument of accumulation embedded in a production function, and discuss how these countries developed new skills and learned how to use efficiently the technology they imported. Most technology is acquired through a long process of learning, since it is often tacit, not codified in a manual. They also tend to emphasize the benefits of government industrial policies aimed at planning the economy. Their analysis, however, is also neoclassical in its philosophy (see Nelson and Pack 1996).

The debate about the sources of growth in East Asia has been, so far, mostly a confrontation between fundamentalists and assimilationists. Both agree on the general framework to analyze growth, the neoclassical model, and both agree that TFP is a measure of productivity. The discord resides on where to put the emphasis in some of the transmission mechanisms in explaining growth (e.g., learning, exports), on the role of government, and, ultimately, on the interpretation of the TFP numbers. Felipe and McCombie (1997), on the other hand, argue that the problem with this debate resides in the inadequacy of the main tool used, i.e., the aggregate production function, to analyze the problem at hand. The analysis of the sources of growth in East Asia has been mostly at a highly aggregate level, and it is based either explicitly or implicitly, on the notion of aggregate production function. They question the use of the aggregate production function on the basis that the work developed during the 1950s and 1960s proved the theoretical fragility of such a concept (see Fisher 1993 for a summary). This presents serious consequences for the interpretation of TFP as a measure of productivity.

It is difficult to give an overall verdict about the state of the debate, though it seems that the fundamentalists' position is the standard view today with the other two groups trailing behind. The fundamentalists were the ones who raised the controversy; their work is very careful and detailed, and they use standard tools derived from neoclassical production theory. The assimilationists, in their disbelief of the fundamentalists' results, have tried in different ways to recalculate TFP in an attempt to show that it was positive; however, this line of work is doomed to be unsuccessful. Their argument that one has to understand how the East Asian countries mastered foreign technology in order to understand growth in the region seems to be more useful, although the lack of mathematical formalization makes it less attractive. Felipe and McCombie argue that the measure of productivity fundamentalists and assimilationists discuss is flawed and that the overall discussion leads nowhere. In any case, this debate is relevant for two reasons. First, scholars and policymakers are engaged in an intellectual discussion about how this geographically concentrated group of countries grew so phenomenally for 30 years. Second, the debate is important because other developing countries are searching for replicable lessons in the experience of East Asia.

With this background, the objective of the paper is twofold. First, like all surveys, its intent is to provide an overview of the literature, with a discussion of the relevant work in the area of TFP in East Asia. The paper reports estimates of TFP for Hong Kong, China; Indonesia; Japan; Republic of Korea; Malaysia; Philippines; Singapore; Taipei,China; and Thailand. Second, to discuss up to what point this literature has helped us gain a better understanding of the factors that have propelled growth in the region. The organization of the paper is as follows. Section II reviews the notion of total factor productivity, as well as the most widely used techniques to estimate it, namely, growth accounting and the econometric estimation of production functions. Section III summarizes the works of Young and Kim and Lau, as representative of the prevailing fundamentalist view. The works of Young and Kim and Lau are the most well-known papers on the subject, and the ones that initiated the debate. Section IV discusses the results of other papers. Section V provides a critical evaluation of this literature by summarizing a series of arguments that question both the current wisdom about the lack of productivity in the East Asian miracle and the methodologies used. This gives the paper a rather negative tone. It is done in an attempt to put brakes to a literature that continues growing empirically and which has crossed interdisciplinary boundaries, but which has paid little attention to theoretical considerations. Section VI summarizes Felipe and McCombie's (1997) position on the debate. Among the three groups, the latter is the only one which has not based its claims on empirical estimates of TFP. Section VII concludes the paper, while the Appendix provides further estimates of TFP growth.

II. Total Factor Productivity and Its Estimation

Growth in the neoclassical framework stems from two sources: factor accumulation and productivity (TFP) growth. The key point of the debate (at least between fundamentalists and assimilationists) is the importance of each of these two components. Most of the debate nevertheless has focused on TFP. The reason is that its modus operandi is less well known than that of factor accumulation, and its estimation places it at the center of the debate, since it is not a simple issue. It is thus important to begin by reviewing the notion of TFP and how it is computed.

A. Concept

Total factor productivity is a neoclassical concept. Besides the above general ideas about the neoclassical conceptualization of growth, the term "neoclassical" as used in this paper means two specific things. First, that TFP is an attempt to measure productivity taking into account all factors of production, thus, the underlying assumption that labor is not the only input (classical Ricardian labor theory of value). Second, that TFP is a notion linked to the aggregate production function, a neoclassical tool. Productivity, per se, is a technical concept which refers to a ratio of output to input, a measure of efficiency. When referring to a single input (i.e., partial productivity), typically labor (Q/L), the notion of productivity does not pose any problem. However, when more than one input is to be taken into account (e.g., labor and capital), the problem that arises is how to weight each factor in the quotient. Standard forms of the "total" productivity ratio are

$$A = \frac{Q}{\alpha L + \beta K} \qquad A = \frac{Q}{L^{\alpha} K^{\beta}} \tag{1}$$

where the first is an arithmetic index and the second a geometric. A denotes the productivity index; Q, L, and K are output, labor and capital, respectively; and α and β are the weights. What does A measure? It is an index of the efficiency with which all factors of production, in this case labor and capital, are used. How does neoclassical economics solve the weighing problem? By relating the productivity ratio to an aggregate production function from which the weights can be taken and interpreted. In its simplest form, the aggregate production function can be written as

$$Q_t = F[K_t, L_t, t] \tag{2}$$

Equation (2) expresses output as a function of the stock of capital, employment, and a shift factor (t), time, where the latter proxies the effects of productivity and technical progress. The subscript t also represents time. Assuming that the argument "t" is separable from K and L

$$Q_t = A_t F[K_t, L_t] \tag{3}$$

and then

$$A_t = \frac{Q_t}{F[K_t, L_t]} \tag{4}$$

This way, A_t is referred to as exogenous, disembodied, and Hicks-neutral technical progress, and is measured by how output changes as time elapses with the input bundle held constant. These concepts will be discussed below. Therefore, the notion of overall productivity can be reinterpreted as an index of all those factors other than labor and capital not explicitly accounted for but which contribute to the generation of output. What are these factors? Managerial capabilities and organizational competence, research and development, intersectoral transfer of resources, and diffusion of technology.

B. Estimation

The two methodologies used in most papers on productivity growth have been growth accounting and econometric estimation of production functions. We briefly review the two methods.

(i) *Growth Accounting*

For empirical purposes, expression (4) poses a conceptual problem. Although it represents output per unit of joint inputs, its interpretation is much less straightforward than that of the partial productivity index, and its meaning, i.e., level of technology, is not clear in direct comparison among different economic units (see the discussion about Kim and Lau's work [1994] in Section III). For this reason, it is usually expressed in growth rates, that is,

$$T[K, L, t] = \frac{d\,A_t}{d\,t} = \varphi_t = q_t - \frac{L_t}{Q_t}\frac{\partial Q_t}{\partial L_t}\, l_t - \frac{K_t}{Q_t}\frac{\partial Q_t}{\partial K_t}\, k_t \tag{5}$$

where q_t, l_t, k_t denote the growth rates of output, labor, and capital, respectively, and φ_t is the rate of total factor productivity growth. The expressions in front of the growth rates of the factors are the respective elasticities. How does neoclassical economics proceed empirically? By assuming perfect competition and profit maximization. Under such conditions, the price elasticity of demand is infinite, factor elasticities equal the factor shares in output, and thus (5) becomes

$$\varphi_t = q_t - a_t\, l_t - (1-a_t)\, k_t \tag{6}$$

where a_t and $(1-a_t)$ are the labor and capital shares, respectively (this is the so-called Divisia Index weighing system). Since the national accounts and other statistics provide estimates of all the right-hand side variables, one can easily obtain the rate of productivity growth as a residual category. Expression (6) is the so-called "Solow-residual", a procedure called growth accounting. The objective of this method is to determine how much economic growth is due to accumulation of inputs and how much can be attributed to technical progress; or, put in different terms, how much of growth can be explained by movements along a production function, and how much should be attributed to advances in technological and organizational competence, the shift in the production function (Nelson 1973). Thus, growth accounting implicitly assumes the existence of a well-behaved neoclassical production function which is used as an organizing device (not as an estimation framework in the econometric sense), in order to isolate the contribution of the various factors to growth of output, assuming a neoclassical world. What makes this controversial is that TFP is treated as a residual category. The development of this method dates back to the pioneering works of Abramovitz (1956), Solow (1957), and Kendrick (1961) who, working with either productivity indexes like (1) or production functions like (2), derived similar expressions. Standard growth accounting following Solow (1957) assumes the existence of an aggregate neoclassical production function, homogeneous of degree one, with constant returns to scale, diminishing returns to each input, and a positive elasticity of substitution. Solow (1957) used this framework to estimate the rate of productivity growth in the manufacturing sector of the American economy for the period 1909-1949. The importance of Solow's seminal paper is that it set the pace for the analysis of technological progress as a residual category when he found that productivity growth accounted for over 80 percent of overall growth in the U.S. manufacturing sector during the said period. Solow's astonishing result created the path for the study of productivity, and reoriented the discussions of growth policy from an emphasis on savings to a stress on all those factors believed to be in the residual, namely, education, R&D, etc. The possibility of quantifying technical progress through this relatively simple method was a temptation economists could not resist.

With discrete data, researchers use the so-called Tornqvist index. This views that expressions (5)-(6) are derived using differential calculus. In the discrete case it can be shown that (Chambers 1988)

$$\varphi_{t,t-1} = \ln \frac{Q_t}{Q_{t-1}} - \Theta_L \ln \frac{L_t}{L_{t-1}} - \Theta_K \ln \frac{K_t}{K_{t-1}} \tag{7a}$$

where

$$\Theta_L = \frac{\theta_L + \theta_{L-1}}{2} \qquad \Theta_K = \frac{\theta_K + \theta_{K-1}}{2} \tag{7b}$$

where the θ_is denote the share of each aggregate factor in total factor payments.

(ii) *Econometric Estimation of Production Functions*

The rationale for the growth accounting approach depends ultimately not only on the existence of the aggregate production function for the total economy like (2), but also on the validity of the (aggregate) marginal productivity theory of factor pricing. Therefore, the direct estimation of the aggregate production function is an alternative to the growth accounting approach. In this case, (3) takes a definite form with an assumption about A_t. Due to its simplicity, the most widely used form has been the Cobb-Douglas, although other forms are equally valid (Chen 1991, Kim and Lau 1994), and A_t has usually taken the form of an exponential time trend (although there are other possibilities). This way, technical change is viewed as a shift of the production function over time at a reasonably smooth rate over time. The coefficient of the trend measures the average rate of TFP growth. Thus, the standard form used has been

$$LnQ_t = c + \alpha LnL_t + \beta LnK_t + \varphi t + u_t \quad (8)$$

where φ measures the average growth rate of output holding inputs constant, and u_t is the disturbance term. According to Kennedy and Thirlwall (1972, 17), Tinbergen was the first one to use this framework. This equation has been directly estimated in most cases using OLS.

How different is this procedure from growth accounting? Both methods use the production function as a starting point. However, growth accounting is an estimator of technical change that lacks a stochastic term. Therefore, the model is not estimated statistically. As a result, the usual test statistics used in econometric work cannot be applied to growth accounting. For practical purposes, the latter imposes the assumption of profit maximization that allows us to equate the elasticities to the factor shares, so that there is no need to estimate the parameters α and β. On the other hand, in the econometric estimation, the parameters are, in general, unrestricted, and do not necessarily have to add up to 1. It is hoped, however, that the estimates of α and β will take on interpretable values, that is, coefficients that could be taken to be reasonable elasticities. Growth accounting makes it easy to calculate the change in total factor productivity growth from year to year, while the econometric estimation provides an average rate for a given period. On the other hand, there is a series of technical issues which affect regression analysis, like possible simultaneity (Marshak and Andrews 1944, Zellner et al. 1966), measurement error, and the choice of a specific functional form. Finally, since we do not have actual values of technical progress, neither procedure can be subjected to ex-post validation based on the model's predictive performance. The most one can do is to test the model's maintained hypotheses of linear homogeneity and perfect competition.

In the above framework (expression [8]), the production function expresses the maximum output obtainable from a given combination of inputs. However, empirical models which incorporate random errors taking both positive and negative values, i.e., estimates using OLS like in (8), can only obtain estimates of *average* production functions. The best practice or production frontier methodology, on the other hand, assumes that there exists an unobservable function (the production frontier or best-practice function), corresponding to the set of maximum attainable output levels for a given combination of inputs. In this context, the idea of maximum output refers to the production function underlying a given group of firms, which might be considered the best available practice or technological frontier. It does not refer necessarily to an engineering blueprint devised in a laboratory. The advantage of this approach is that it allows decomposing the change in TFP into *technological progress* and *technical efficiency change*; the former is associated with changes in the best-practice production frontier, and the latter with other productivity changes, such as learning by doing, improved managerial practice, and changes in the efficiency with which a known technology is applied. This distinction is fundamental for policy actions, especially in developing countries, where identifying TFP growth with technological progress can miss the fact that technical efficiency change seems to be the most relevant component of the total change in TFP (Nishimizu and Page 1982), and therefore, the introduction of new technologies without having realized the full potential of the existing ones might not be meaningful.

These, or small variations, have been the techniques applied to the study of the sources of growth in East Asia. Thus, this discussion is intrinsically a debate based on a particular way of understanding growth, namely, through a neoclassical aggregate production function, and through a corresponding set of behavioral assumptions, namely, profit maximization, competitive factor markets, and constant returns to scale. Although some voices have questioned the validity of the behavioral assumptions for the East Asian countries, in no way has the aggregate production function been challenged as a valid tool to explain growth. These issues are discussed in Sections V and VI.

III. Zero Total Factor Productivity Growth in East Asia

In this section we briefly summarize the works of Young (1992, 1994a, 1994b, 1995) and Kim and Lau (1994) as examples of the prevailing view that productivity growth in East Asia was zero during the last two to three decades, and that the main source of growth was capital accumulation. Table 1 summarizes their results. Their conclusions have become the standard departing point in the discussions of productivity in East Asia. For example, Lucas says that Young

> ...demonstrates that output growth in Singapore since the 1960s can be accounted for *entirely* by growth in conventionally measured capital and labor inputs, with nothing left over to be attributed to technological change (Lucas 1993, 257; italics original).

and Rodrik:

> Recent work by Jong-Il Kim and Lawrence J. Lau and Alwyn Young has shown that these were miracles of accumulation rather than of productivity: the sharp increases in physical and human capital as well as in labor-force participation account for virtually all of the rise in output, and consequently the East Asian tigers' performance with respect to total factor productivity (TFP) growth does not look outstanding. Of course, for accumulation to have taken place at such rates, the profitability of investment in the region must have been very high, which needs explanation (Rodrik 1996, 13).

In his controversial comparative study, Alwyn Young (1992) used growth accounting to estimate TFP growth for Singapore and Hong Kong, China. He concluded that, in the former, the average value of the residual had been zero, if not negative, for the last 30 years. Young computed the Solow residual for these two economies using the Tornqvist index with and without differentiating capital and labor inputs among several categories. In the first case, without differentiating inputs, he concluded that the average annual contribution of total factor productivity to output growth in Singapore between 1974 and 1989 was approximately -0.004 or -6 percent of output growth. Differentiating inputs his results were very similar: between 1970 and 1990, total factor productivity growth contributed to -8 percent of output to growth in Singapore. Capital accumulation explained 117 percent of the increase in output per worker in the Singaporean economy during this period. On the other hand, in the case of Hong Kong, China, growth in total factor productivity had contributed to a substantial 30-50 percent of output growth, with an overall contribution of 35 percent between 1971 and 1990. Young's second controversial finding for Singapore was the enormous decrease in the implied rate of return on capital, from 37 percent in the mid-1960s, to 13 percent in the late 1980s. This, according to Young, is one of the lowest returns in the world today. On the other hand, for Hong Kong, China the decrease was very small, from 28 percent in 1960, to 22 percent in the mid-1980s.

Young (1994a,1994b) conducted a larger analysis including 118 countries. In this case, Young estimated a cross-country regression for the period 1970-1985 of the growth of output per worker, using the Summers and Heston data set (purchasing power parity values), on a constant and the growth of capital per worker. The capital stock was constructed using the perpetual inventory method with the cumulating investment flows for 1960-1969 as benchmark, and a 6 percent depreciation rate. This regression yielded the following result

$$q_i - l_i = -0.21 + 0.45\,(k_i - l_i) + E_i$$

where E_i is the growth of TFP. The results confirm Young's previous work, namely, that TFP growth in Hong Kong, China was relatively high and, in Singapore, nonexistent. These results also allowed Young to conclude that TFP in other East and Southeast Asian countries had not been higher than in many other parts of the world (see Pack and Page 1994a, 1994b for a reply).

Young (1995) performed a growth accounting analysis for Hong Kong, China; Republic of Korea; Singapore; and Taipei,China (except for Hong Kong, China he also provided sectoral estimates of TFP growth), using the same methodology as in his 1992 paper. The conclusions for Singapore and Hong Kong, China were very similar to those in his previous work. For the former, and for the overall economy, the TFP growth rate for 1966-1990 was virtually zero, while for the manufacturing sector for 1970-1990, it was -1 percent, equivalent to -11 percent of overall growth. In the case of Hong Kong, China, the rate of TFP for the whole economy was 2.3 percent for 1966-1991, accounting for 31 percent of overall growth. For the Republic of Korea and Taipei,China, Young found positive rates of productivity growth for 1966-1990. For the Republic of Korea, the annual growth rate of TFP for the overall economy for the period 1966-90 was 1.7 percent, accounting for 16.5 percent of overall growth; and for the manufacturing sector, it was 3 percent, accounting for over a fifth of overall growth of the sector. For Taipei,China, the TFP growth rate for the same period was 2.6 percent, representing 28 percent of total growth. For the manufacturing sector, the annual rate of productivity growth was 1.7 percent, or 16 percent of the overall growth of the sector.

What did Young conclude out of his extensive exercises? He argued that the centralized Singaporean economy had compelled its citizens to save too much and had always pushed itself too fast into new technologies, emphasizing movement up the technological ladder, without fully realizing the benefits of learning by doing at each stage, thus incurring increasing costs of production. The tone of the paper implies that industrial policy in Singapore was a total failure, and that Singapore has been a victim of its own targeting policies. The implication is that the future of other developing countries trying to pursue and emulate similar policies is rather gloomy. On the other hand, Hong Kong, China with its laissez-faire and hands-off policies, has spent the right time at each stage. According to Young, the main source of growth in Singapore has been capital accumulation, and virtually nothing was due to productivity growth. Young concluded that Singapore, which started its development process much later than Hong Kong, China, traversed many of the same industries but in a much more compressed time frame. The conclusion of Young's work is the demystification of Singapore as an example of an economy with dynamic gains. The main source of growth has been of static neoclassical nature, plain factor accumulation.

Kim and Lau (1994) implemented a regression procedure called the meta-production function approach. A meta-production function is defined as the common underlying production function that can be used to represent the input-output relationship of a given industry in all countries. In practice, the approach amounts to estimating a regression pooling time series and cross-section data for several countries. In their study, Kim and Lau pooled data for the G-5 countries (Britain, France, Germany, Japan, and US) and the four NIEs (Hong Kong, China; Republic of Korea; Singapore; and Taipei,China) for data since the mid-1960s to 1990. Although the use of data drawn from more than one country to estimate a production function is a peculiarly hazardous undertaking, partly because relative prices differ from country to country, and partly because the collection of data is never on an exactly similar basis, this method, in the words of the authors, has two advantages. First, it allows to separate the effects of economies of scale and technical progress. And second, since intercountry data normally show more variability than data for a single country (causing multicollinearity), the parameters of the production function can be estimated with more precision. And with respect to growth accounting, this formulation has the primary advantage that it does not depend on the assumption of constant returns to scale, neutral technical progress, and profit maximization with competitive output and input markets, assumptions which underlie most growth accounting exercises. Instead, these assumptions are directly tested.

For empirical purposes, Kim and Lau (1994) fitted a translog production function where technical efficiency was proxied by a time trend. Likewise, their production function included augmentation factors that allowed to test whether technical progress is of the augmenting type. Algebraically,

$$1nQ_t^* = 1nQ_0 + a_K\ 1nK_{it}^* + a_L\ 1nL_{it}^* + \frac{B_{KK}}{2}\ (1nK_{it}^*)^2 + \frac{B_{LL}}{2}(1nL_{it}^*)^2 + \\ + B_{KL}\ (1nK_{it}^*)\ (1nL_{it}^*) \quad (9)$$

where

$$Q_{it}^* = A_{i0}\ (1+\lambda_{i0})^t\ Q_{it} \quad X_{ijt}^* = A_{ij}\ (1+\lambda_{ij})^t\ X_{ijt} \quad j=1,\ldots,m,\ \ i=1,\ldots,n \quad (10)$$

the A_{i0}s, A_{ij}s, λ_{i0}s, λ_{ij}s are constants; the A_{i0}s, A_{ij}s are referred to as augmentation level parameters; the λ_{i0}s, λ_{ij}s are referred to as augmentation rate parameters (discussed below); and m and n denote the number of inputs and countries, respectively. In addition to the production function, Kim and Lau also considered the equation for the share of labor costs in the value of output, $w_{it}\ L_{it}\ /\ p_{it}\ Y_{it}$, where w is the nominal wage rate and p is the nominal price of output in the i-th country at time t. Algebraically,

$$\frac{w_{it}\ L_{it}}{p_{it}\ Y_{it}} = a_{Li}^{**} + B_{KLi}\ 1nK_{it} + B_{LLi}\ InL_{it} + B_{Lti}\ t \qquad (11)$$

Assuming that the firm is a profit maximizer and that it operates as if it were in a perfectly competitive market, it will choose labor so that the marginal revenue product of each factor is equal to its price. This also implies that the elasticity of output with respect to labor is equal to the share of labor in total output. Under the hypothesis of profit maximization, the parameters of the production function are identical with those of the share equation. This provides a basis for testing the hypothesis of profit maximization with respect to labor by testing the equality of the estimated parameters in the production function and in the labor share equation. The two-equation system was estimated using nonlinear instrumental variables and in first differences.

The main findings of their study were: (i) the null hypothesis that productivity growth in the four NIEs was zero could not be rejected; however, technical progress was the mainspring of growth in the G-5 countries; (ii) the standard assumptions behind growth accounting, that is, constant returns to scale, neutral technical progress, and profit maximization, were rejected; and (iii) technological progress is capital-augmenting (the augmentation rates are zero for the NIEs).

TABLE 1
Young and Kim and Lau Estimates of TFP

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[c]
Indonesia	Young (1994a)	1970-85	1.2	...
Malaysia	Young (1994a)	1970-85	1.0	...
Thailand	Young (1994a)	1970-85	1.9	...
Hong Kong, China	Young (1992)[a]	1961-66	22.5	39.0
		1966-71	10.7	33.0
		1971-76	22.1	54.0
		1976-81	9.4	18.0
		1981-86	7.4	25.0
	Young (1994b)	1970-85	2.5	...
	Kim and Lau (1994)[b]	1966-90	0; 2.4; 2.0	0; 35.0; 27.0
	Young (1995)	1961-66	3.5	32.1
		1966-71	2.3	35.4
		1971-76	3.9	48.1
		1976-81	2.2	22.2
		1981-86	0.9	15.5
		1986-91	2.4	38.1
		1966-91	2.3	31.5

Continued next page

TABLE 1 *(cont'd.)*

Economy	**Author**	**Period**	**Annual Rate TFP (%)**	**% Output Growth[c]**
Republic of Korea	Young (1994b)	1970-85	1.1	...
	Kim and Lau (1994)[b]	1966-90	0; 1.2; -0.5	0; 14.0; -6.0
	Young (1995)	1960-66	0.5	6.5
		1966-70	1.3	9.0
		1970-75	1.9	20.0
		1975-80	0.2	2.2
		1980-85	2.4	28.2
		1985-90	2.6	24.3
		1966-90	1.7	16.5
Singapore	Young (1992)[a]	1966-70	11.7	23.0
		1970-75	-16.3	-36.0
		1975-80	2.0	5.0
		1980-85	-6.0	-20.0
	Kim and Lau (1994)[b]	1966-90	0; 1.9; 0.4	0; 23.0; 5.0
	Young (1994b)	1970-85	0.1	...
	Young (1995)	1966-70	4.6	35.4
		1970-80	-0.9	-10.2
		1980-90	-0.5	-7.2
		1966-90	0.2	2.3
Taipei,China	Young (1994b)	1970-85	1.5	...
	Kim and Lau (1994)[b]	1966-90	0; 1.2; 0	0; 15.0; 9.0
	Young (1995)	1966-70	3.4	30.6
		1970-80	1.5	14.6
		1980-90	3.3	42.3
		1966-90	2.6	27.6
Japan	Young (1994b)	1970-85	1.2	...
	Kim and Lau (1994)[b]	1966-9	2.9; 1.0	46.0; 15.0

[a]Young (1992) are not annual rates, but the growth rate for the whole period.

[b]The first estimate for Hong Kong, China; Republic of Korea; Singapore; and Taipei,China provided by Kim and Lau (1994) is based on the estimation of the production function under the following assumptions: single meta-production function for all nine economies, identical augmentation levels of capital and labor, zero technical progress for the NIEs, and purely capital-augmenting technical progress. The second estimate allows the rates of capital augmentation in the NIEs to be nonzero. The third estimate uses growth accounting. For Japan, the first estimate is from the production function (using same assumptions as in the second estimate for the NIEs), while the second is from growth accounting.

[c] ... means data not available.

For comparison purposes, Kim and Lau also provided estimates of TFP growth using growth accounting, but they did not furnish details about factor shares and growth rates of the inputs. Lastly, Kim and Lau calculated the level of technology of the nine countries in their analysis, taking the US as reference. This was done by estimating the output each country would produce if it were given the same input bundle as the US. They reached the conclusion that the technological level of the NIEs in 1990 was only 20 percent that of the US. Furthermore, this level has been declining since the 1950s, when it was 25 percent.

IV. Other Empirical Work on TFP in East Asia

After the impact of the work conducted by Young and by Kim and Lau, many other papers have appeared confirming or contradicting their results. In this section we briefly discuss the findings of other relevant empirical work on productivity in East Asia. The TFP estimates of these studies are summarized in Table 2. The results of other less well-known are summarized in the Appendix.

Ikemoto (1986) provided estimates of the TFP growth rate for 1970-1980 for several Asian economies using the Tornqvist index. He differentiated between the contributions of domestic and imported capital. His results indicate that productivity growth was positive in all economies considered. The contributions of TFP growth to overall growth in Taipei,China and Republic of Korea are very high. On the other hand, those of Hong Kong, China; Malaysia; Philippines; Singapore; and Thailand are much lower. Ikemoto indicates that in the cases of Hong Kong, China; Malaysia; and Singapore these economies already have a high level of technology, and thus it is more difficult to realize productivity gains. On the other hand, the Philippines and Thailand do not utilize enough the backlog of technological innovations. It is worth noting that in computing the input weights Ikemoto argued that in the cases of Singapore, Philippines, Indonesia, and India, wage data did not seem to be reliable or did not exist, and therefore assumed the labor share to be 50 percent for Singapore, 60 percent for the Philippines and Indonesia, and 70 percent for India (Ikemoto 1986, 375).

It is difficult to draw any conclusions from the work of the World Bank (1993). The reason is that, unfortunately, it provided five measures of TFP growth for the East Asian countries (see Figure 1.10, Figure 1.11, Table A1.2 [two estimates], Table A1.3), using different methods and assumptions. Each consecutive estimate is smaller than the previous one. This leaves the reader rather perplexed, since this is not a matter of choosing the most convenient figure. Only one can be true. In the words of Cappelen and Fagerberg (1995, 183):

> The purpose of all this appears to be to support the view that the lion’s share of East Asian growth can be explained by conventional sources, i.e., that there is no miracle to explain.

I doubt it is possible to draw sensible conclusions out of all these numbers. Furthermore, Kwon (1994) criticized the work of the World Bank (1993) from a technical point of view. His estimates for the Korean manufacturing sectors (introducing increasing returns to scale and using a generalized Leontief cost function) are very different from those of the World Bank (1993). Kwon criticized the World Bank’s estimates because they were based on a

> particular specification of the neoclassical production function. But it is worth noting that the assumptions underlying neoclassical production theory—namely constant returns to scale, perfect competition, and long-run equilibrium with variability of all factor inputs, including capital stock—are typically unsuitable for the estimation of rapidly growing dynamic economies (Kwon 1994, 636).

Fischer (1993) estimated three sets of TFP growth rates using growth accounting, each with a different weight, using the Summers and Heston data. First, the so-called Bhalla residuals, derived from a panel regression, with weights 0.398 for capital, 0.44 for labor, and 0.012 for education (the equation also included regional dummies); second, the Solow residuals, with weights 0.4 for capital and 0.6 for labor; and third, the Mankiw-Romer-Weil residuals (derived from the estimation of a production function) with equal weights of 0.333 for capital, labor, and education. Since all three sets were highly correlated, Fischer decided to work with the Solow residuals. Fischer estimated a TFP growth rate of 1.69 percent for Taipei,China for 1961-1988 (the highest in East Asia); while for Singapore, the estimate was of -2.82 percent (the lowest in Southeast Asia). On the other hand, Myanmar appeared to have the highest TFP rate in South Asia, 1.47 percent. Fischer concluded that

> ...the estimates raise obvious questions about the underlying Summers and Heston data, or perhaps the input data. When similar calculations were made using the World Bank income data, the productivity residuals looked more plausible [...] However, since the Summers-Heston income data are widely used, I chose to work with those, leaving the investigation of the apparent anomalies [...] for later research (Fischer 1993, 495).

Marti (1996) disputed Young's results. She fitted the same regression as Young (1994b) using a more updated version of the Summers and Heston data base, including data for 1970-1990 (five more years than Young) and for 104 countries (Young used 118). The results of Young and Marti are radically different. The latter estimated, for example, that Singapore's annual rate of TFP for 1970-1990 was 1.45 percent, while Young's estimate was 0.1 percent for 1970-1985. Moreover, Marti also estimated the regression for the period 1970-1985, the same as Young. The results indicate that Singapore's TFP rate was 1.49 percent (similarly and for reference, while Young estimated a TFP growth rate for Uganda of 2.1 percent, Marti gave -0.57 percent).

Finally, Collins and Bosworth (1997) probably have the most comprehensive study carried out recently. The authors used growth accounting for a large set of countries. The results of their analysis tend to indicate that while positive, TFP growth in East Asia was not particularly high when compared to that of other regions (although the interpretation of a low or a high residual is subjective). Like the other fundamentalists, Collins and Bosworth reach the conclusion that factor accumulation was more important. Collins and Bosworth's aggregate production function included capital and the product of labor and education, hypothesizing that the benefits of education are labor-augmenting. Algebraically,

$$Q_t = A_t K_t^{\alpha} (H_t L_t)^{1-\alpha} \qquad (12)$$

The authors use fixed weights both across time and across countries with α=0.35 and 1-α= 0.65. Collins and Bosworth offered the following explanation:

> We believe, from the existing literature, that a plausible range for the capital share is 0.3 to 0.4; and there is also considerable evidence that the capital elasticity is higher in developing economies than in industrial economies. However, to minimize concern about methodological differences in our comparison of growth in East Asia with that in other regions, we use a uniform capital share of 0.35 for the entire sample (Collins and Bosworth 1997, 155).

This review of the most relevant studies in the field leads to the conclusion that this work has become a war of figures. From the crudest calculations to the most detailed studies, the purpose of this literature is to come up with a number that justifies the author's arguments about growth in East Asia. In many cases these are straight exercises in data mining embedded in fancy arguments and justifications from which very little can be learned. The variation in the estimates of TFP growth is rather large, and the figures are very sensitive to the specific assumptions of each study. Often, one is led to contradictory results. This should be a warning sign in drawing conclusions out of this literature. If anything, this indicates a general fragility about the empirical studies on the nature and sources of growth in East Asia.

TABLE 2
Other Estimates of TFP

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[b]
Indonesia	Ikemoto (1986)	1970-80	2.4	31.5
		1970-75	3.1	39.0
		1975-80	1.8	24.3
	World Bank (1993)[a]			
	Figure 1.10	1960-89	1.6	...
	Figure 1.11	1960-89	1.6	...
	Table A1.2	1960-90	1.2; -0.8	...
	Table A1.3	1960-89	-1.2 (technical efficiency)	...
	Marti (1996)	1970-85	0.8	...
		1970-90	-0.5	-9.6
	Collins and Bosworth (1997)	1960-94	0.8	23.5
		1960-73	1.1	44.0
		1973-94	0.7	17.5
		1973-84	0.5	11.6
		1984-94	0.9	24.3
Malaysia	Ikemoto (1986)	1970-80	1.7	21.7
		1970-75	1.4	20.0
		1975-80	1.8	21.5

Continued next page

TABLE 2 *(cont'd.)*

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[b]
Malaysia *(cont'd.)*	World Bank (1993)[a]			
	Figure 1.10	1960-89	1.6	...
	Figure 1.11	1960-89	1.5	...
	Table A1.2	1960-90	1.1; -1.3	...
	Table A1.3	1960-89	-1.8 (technical efficiency)	...
	Marti (1996)	1970-85	0.5	...
		1970-90	0.4	12.9
	Collins and Bosworth (1997)	1960-94	0.9	23.7
		1960-73	1.0	25.0
		1973-94	0.9	24.3
		1973-84	0.4	11.1
		1984-94	1.4	36.8
Philippines	Ikemoto (1986)	1970-80	1.3	20.6
		1970-75	1.4	24.0
		1975-80	1.1	17.4
	Marti (1996)	1970-85	-1.1	...
		1970-90	-0.4	-37.8
	Collins and Bosworth (1997)	1960-94	-0.4	-30.8
		1960-73	0.7	28.0
		1973-94	-1.1	-220.0
		1973-84	-1.3	-108.3
		1984-94	-0.9	300.0
Thailand	Ikemoto (1986)	1970-80	1.4	19.7
		1970-75	1.3	19.8
		1975-80	1.7	23.0
	World Bank (1993)[a]			
	Figure 1.10	1960-89	3.0	...
	Figure 1.11	1960-89	2.4	...
	Table A1.2	1960-90	2.5; 0.5	...
	Table A1.3	1960-89	0.1 (technical efficiency)	...
	Marti (1996)	1970-85	1.3	...
		1970-90	1.6	42.5
	Collins and Bosworth (1997)	1960-94	1.8	36.0
		1960-73	1.4	29.2
		1973-94	2.1	40.4

Continued next page

TABLE 2 *(cont'd.)*

Economy	Author	Period	Annual Rate TFP (%)		% Output Growth[b]
Thailand *(cont'd.)*		1973-84	1.1		30.6
		1984-94	3.3		47.8
Hong Kong, China	Ikemoto (1986)	1970-80	2.0		21.3
		1970-75	0.6		8.8
		1975-80	3.6		29.0
	World Bank (1993)[a]				
	Figure 1.10	1960-89	4.2		...
	Figure 1.11	1960-89	3.8		...
	Table A1.2	1960-90	3.6; 2.4		...
	Table A1.3	1960-89	1.9	(technical efficiency)	...
	Marti (1996)	1970-85	2.4		...
		1970-90	2.4		48.1
Republic of Korea	Ikemoto (1986)	1970-80	3.5		41.2
		1970-75	4.6		48.7
		1975-80	2.0		26.6
	World Bank (1993)[a]				
	Figure 1.10	1960-89	3.5		...
	Figure 1.11	1960-89	3.2		...
	Table A1.2	1960-90	3.1; 0.2		...
	Table A1.3	1960-89	-0.2	(technical efficiency)	...
	Marti (1996)	1970-85	1.6		...
		1970-90	1.4		...
	Collins and Bosworth (1997)	1960-94	1.5		26.3
		1960-73	1.4		25.0
		1973-94	1.6		27.6
		1973-84	1.1		20.8
		1984-94	2.1		33.9
Singapore	Ikemoto (1986)	1970-80	1.8		19.7
		1970-75	2.0		20.7
		1975-80	1.6		18.6
	Fischer (1993)	1961-88	-2.8		...
	World Bank (1993)[a]				
	Figure 1.10	1960-89	1.7		...
	Figure 1.11	1960-89	1.6		...
	Table A1.2	1960-90	1.2; -3.0		...
	Table A1.3	1960-89	-3.4	(technical efficiency)	...

Continued next page

TABLE 2 *(cont'd.)*

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[b]
Singapore *(cont'd.)*	Marti (1996)	1970-85	1.5	...
		1970-90	1.4	27.9
	Collins and Bosworth (1997)	1960-94	1.5	27.8
		1960-73	0.9	15.2
		1973-94	2.0	39.2
		1973-84	1.0	23.2
		1984-94	3.1	51.7
Taipei,China	Ikemoto (1986)	1970-80	4.8	50.0
		1970-75	4.3	48.1
		1975-80	5.2	51.1
	Fischer (1993)	1961-88	1.7	...
	World Bank (1993)[a]			
	Figure 1.10	1960-89	4.2	...
	Figure 1.11	1960-89	3.9	...
	Table A1.2	1960-90	3.8; 1.3	...
	Table A1.3	1960-89	0.8 (technical efficiency)	...
	Marti (1996)	1970-85	2.2	...
		1970-90	2.1	35.7
	Collins and Bosworth (1997)	1960-94	2.0	34.5
		1960-73	2.2	32.4
		1973-94	1.8	34.6
		1973-84	0.9	18.4
		1984-94	2.8	50.0
Japan	Ikemoto (1986)	1970-80	1.4	29.5
		1970-75	0.7	15.2
		1975-80	2.6	50.1
	World Bank (1993)[a]			
	Figure 1.10	1960-89	3.7	...
	Figure 1.11	1960-89	3.7	...
	Table A1.2	1960-90	3.5; 1.4	...
	Table A1.3	1960-89	0.9 (technical efficiency)	...
	Marti (1996)	1970-85	1.2	...
		1970-90	0.9	25.8

[a]World Bank (1993), Figures 1.10 and 1.11: Approximate figures, read from the graph. Table A1.2: The first figure comes from a regression pooling data for developed and developing countries. The second estimate is derived from a regression including only developed countries. It appears that the World Bank estimated the parameters of the production function (it did not impose them), then carried out a growth accounting exercise.

[b] ... means data not available.

V. A Reconsideration of the Work on Productivity Growth in East Asia

In this section we provide an evaluation of the above literature by pointing out different issues, some of them empirical, others theoretical, relating to the computation and the meaning of the measures of productivity. Some of them are generally accepted problems, while others, at the very least, deserve some explanation. In each case we emphasize the implications for understanding East Asia's growth. For classification purposes, we have divided these issues into four groups: conceptual issues, measurement problems, policy implications, and assimilationist arguments. The argument about the aggregate production function is discussed in Section VI.

A. Problems Relating to the Concept of Technical Progress

(i) As noted above, technological progress as viewed in most studies is exogenous, disembodied, and Hicks-neutral. Exogenous technical progress implies that technology is superimposed on the system, in the sense that A_t is assumed to grow over time for no stated reason, and determined outside the economic system considered. Disembodied technological change is a type of exogenous technical progress in which technical change does not require new inputs, and the production function maintains the same form as time elapses. Finally, according to the effect on relative input utilization, it is Hicks-neutral. This implies that at points on the expansion path, the rate of technical substitution is independent of time, and that for a given ratio of factor prices, technological progress does not influence the proportions in which capital and labor are combined. In other words, a neutral invention is one which, with given factor proportions, raises the marginal product of labor in the same proportion as the marginal product of capital. Conceptualized this way, technology is viewed as "manna from heaven", and is completely dissociated from the process of investment and capital accumulation. Technology is considered to be a public good, that is, firms just choose from a shelf of techniques readily available to the public domain; the acquisition of knowledge is assumed to be costless; and time is de-emphasized by assuming instantaneous acquisition of technology. The disembodied assumption implies that all vintages of capital equally share in technical progress, and disregards the possibility that capital may vary in productivity because it is not of the same vintage. Finally, there is no reward to whoever generated the technology: since income is divided between capital and labor, the cost of generating technology is not accounted for.

The hypothesis of embodiment states that new technical knowledge is present only in new capital goods, and thus more recent additions to the capital stock must be weighted more heavily than earlier additions. Embodied technical innovation implies new methods and new inputs, specially capital, entering the production process (and in some cases this leads to a new output) which can only be represented through a new production function. Analytically, embodied technical change requires differentiating the production function itself as well as the input bundle. Algebraically,

$$Q_t = F_t [K_t, L_t, t] \quad (13)$$

where $F_\tau [K_\tau, L_\tau, \tau]$ and $F_T [K_T, L_T, T]$, $t = 1,...\tau,...T$ need not be the same functional form, and the input bundles at times τ and T may also be different (see Hulten 1992 for a model of growth accounting with embodied technical change). This is not to say that models where technology is embodied are to be seen as diametrically different to models where technology is disembodied, and that the embodiment hypothesis is not without critics (Scott 1989). The aspect to stress is that most of the literature on the sources of growth in East Asia has disregarded this, or any other, possibility. Kim and Lau (1994) are the exception (see expression [10] above), since they hypothesized and tested that technological change was factor-augmenting, that is, technical change improves input efficiency. This is represented as

$$Q_t = F[\lambda_K K_t, \lambda_L L_t, t] \tag{14}$$

where λ_K and λ_L are the augmentation coefficients of capital and labor, respectively. The idea behind this formulation is that input quality varies with time, so that one unit of labor, for example, in year t does not yield the same effective labor units as in year t+1. This formulation, however, still maintains a stable relationship between output, inputs, and time, and therefore is not the same as embodied technical change.

The question at hand is important in a double sense. First, we have to ask whether one can conceive of any type of technical progress as exogenous, disembodied, and Hicks-neutral. Intuitively, most technological progress (if not all) *must be* embodied in new inputs; that is, the act of purchasing a new piece of machinery represents technical progress in itself in that it involves a different method of production. It is not clear that purchasing the machinery represents exclusively capital accumulation, that how well one uses it represents technical progress, and that both can be easily split. We must not forget that one important strand of work questioned the possibility of estimating the so-called technical progress as an independent factor. In particular, Kaldor (1957) argued that it was pointless and artificial to try to distinguish either between investment and technical change, or between shifts in the production function and movements along it. This cannot be done because in the real world we do not observe the production function, but only actual combinations of factors and output. Capital is the instrument for the introduction of technical change in the production process. Thus, Kaldor continued, saying that the annual growth of (exogenous, disembodied, and Hicks-neutral) technology was x percent for a given period is meaningless. Solow (1960) and Arrow (1962) likewise argued that most technical progress, except for very small improvements (e.g., better arrangement of the shop floor due to learning by experience through the passage of time), had to be embodied in capital goods. These arguments do not deny that factors such as political stability, or the role of institutions, factors not embodied in capital, do not affect growth. The question is whether these factors are part of the residual. In recent empirical work, Wolff (1991, 1996) could not reject the embodiment hypothesis.

The discussion is also important from a methodological point of view. The above paragraphs are not intended to convey the message that the notion of neutral, disembodied, and Hicks-neutral technical progress is wrong. As a theoretical conceptualization of technical progress, and for pedagogical purposes it is perfectly valid. The question is, however, whether one can take the residual notion of technical progress as the initial and only working hypothesis in an empirical study. What do we conclude if, as Young did, the residual accounts for virtually nothing of overall growth? Or, if one prefers, take the opposite case, where the residual accounts for a very large share of overall growth (Chen 1977). The reason for using this formulation of productivity must be its sheer simplicity. The models of embodiment (Solow 1960; Nelson 1964; Wolff 1991, 1996) are much more complicated to implement empirically, since they require estimates of a measure of the change in the gap between the average level of technology and the best-practice technology, as well as of the growth of the average quality of capital. If in fact most technical progress is embodied in capital goods, then the finding of a zero residual may not be such a surprising finding, and authors should concentrate on explaining the meaning of high residuals.

B. Problems of Measurement

(ii) An important problem with growth accounting is that the measurement of TFP depends critically on assumptions about production functions, choice of output measure (value added versus gross output), use of capital stock versus flows of capital services, quality of inputs, cyclical smoothing, time period studied, errors of measurement in the variables, and so on. Different assumptions yield radically different results (Fishlow et al. 1994, 61). Krugman, in fact, pointed out this issue in his comment on Young's (1992) work. This makes all studies intrinsically different and not amenable to direct comparison, and explains the variety of results in the studies for East Asia.

(iii) The appropriateness of the growth accounting method hinges on how well the assumption of perfectly competitive markets approximates the real economy at the aggregate level. If such an approximation is not close, then one cannot use factor prices to approximate marginal products of inputs and consequently, weighing growth rates of various contributing factors by their factor shares in national income to account for total growth becomes problematic. If markets are not competitive, the output elasticities will not equal their respective factor shares. Factor markets can be distorted in developing countries due to many reasons, such as regulations concerning job security, existence of social security schemes, minimum wage legislation, and wage and employment policies in the public sector (Balassa 1988). This may be the case of the rapidly industrializing economies of East and Southeast Asia where most likely there are market imperfections causing a divergence between the price per unit of each employed factor and its marginal value product. In fact, Chen (1991) rejected this hypothesis for Singapore and Kim and Lau (1994) for the G-5 and the four NIEs. Likewise, Williamson (1969), in an empirical analysis of the sources of growth in the Philippines, assumed that the opportunity cost of unskilled labor in the Philippines was roughly one half of the going wage, thus reducing the labor share from 0.7 to 0.55, on the grounds that wages exceeded the marginal productivity of labor. To see the implications of this argument, assume that the demand for output is given by

$$X = B_1 \; p^{-\eta} \tag{15}$$

where B_1 is a constant, p is the output price, and $-\eta$ is the price elasticity of demand for output ($\eta > 0$). The labor and capital supply functions are given by

$$L = B_2 \; w^{\psi} \qquad K = B_3 \; r^{\varphi} \tag{16}$$

where ψ and φ are the relevant supply elasticities (ψ, $\varphi > 0$). B_2 and B_3 are constants. The first order condition of profit maximization leads to the following results

$$\alpha = \frac{(1+\frac{1}{\psi})}{(1-\frac{1}{\eta})} a \qquad (17a)$$

and

$$\beta = \frac{(1+\frac{1}{\varphi})}{(1-\frac{1}{\eta})} (1-a) \qquad (17b)$$

where α and β are the output elasticities of labor and capital, respectively, and "a" is the labor share. Notice that the standard growth accounting weights, i.e, factor shares, are a special case of expressions (17a)-(17b), where η, ψ, and φ are infinite (competitive markets). These results indicate that the use of labor's share will understate the corresponding output elasticity provided $(1 + 1/\psi) > (1 - 1/\eta)$. Also notice that under these conditions, α plus β do not add up to one. A similar result holds for capital's share. Thus, under these circumstances, the use of factor shares under conditions of imperfect competition leads to underestimating the role of resource mobilization and overestimating that of technical progress.

(iv) An issue of particular relevance is the so-called "attribution problem" (Nadiri 1970, Nelson 1981, Shaw 1992). The neoclassical growth model assumes smooth substitution among inputs along an isoquant. According to expression (6), a 1 percent increase in output could be achieved by either a 1 percent increase in productivity growth, or a $(1/a_t)$ percent increase in employment, or a $(1/(1-a_t))$ percent increase in the capital stock. As a matter of arithmetic this is true; but if the inputs exhibit complementarity and are interdependent, this conceptualization of the production process poses problems. Under these circumstances, it is not clear what the meaning of separating the contributions of inputs such as human and physical capital is (e.g., think of a computer programmer and a computer). If factors are complements, growth is super-additive in the sense that overall growth from the growth in inputs is greater than the mere sum of the individual growth rates of each input. In the words of Nelson:

> Consider the sources of a well made cake. It is possible to list a number of inputs—flour, sugar, milk, etc. It is even possible to analyze the effects upon the cake of having a little bit more or less of one ingredient, holding the other ingredients constant. But it makes no sense to try to divide up the credit for a good cake to various inputs (Nelson 1981, 1054).

If inputs in the production process are complements, the isoquant would be closer to the fixed-coefficients type, and thus performing growth accounting would be a disputable exercise. There are three possible sources of interdependence (Fagerberg 1994, 1153-4): (i) technological progress may be embodied in new capital goods; (ii) technological progress may be biased, hence, the contributions from technological progress and factor growth will be interdependent and empirically indistinguishable; and (iii) if there is learning by doing, the contributions from capital accumulation and technological progress to growth are interdependent.

C. Conclusions and Policy Inferences

(v) What is the theoretical link and empirical evidence between a zero residual in Singapore and the possibility that the city-state may have pushed itself into technologies too far ahead of itself to benefit from learning by doing? Or, what is the link with the deleterious results of industrial policies, as Young claimed? There is no empirical evidence. Likewise, do the conclusions of this type of exercises have policy implications? Growth accounting exercises are just that, accounting exercises. There is no presumption of a causal behavioral relationship from factor input growth or from the residual to output growth. Exogenous increases in technology could cause both output and capital to grow. The problem is that most studies confound this decomposition of overall growth with its explanation. This stems from the indisputable association between the residual and the idea of technical progress, when it is not clear that it exists (Griliches 1988, Scott 1989). This has been the case in the recent analysis of growth in East Asia, and it has important implications for policy analysis, since by definition we cannot explain what we do not know (the residual). It is surprising, in this sense, that much of the East Asian controversy concentrates on the role of policies that are supposed to operate by promoting growth in TFP. However, in the words of Sudit and Finger:

> Public exhortations for deliberate efforts to "improve" the rate of growth in aggregate productivity suffer from an underlying contradiction in logic. We simply cannot hope to affect consciously something that is defined to measure our lack of knowledge (Sudit and Finger 1981, 7).

Nevertheless, authors insist on interpreting the TFP calculations and on deriving policy implications (Krugman 1994; Mowery and Oxley 1995, 69; Collins and Bosworth 1997, 138). In some cases, authors even run regressions with the TFP growth rate as the dependent variable (World Bank 1993, Fischer 1993, Collins and Bosworth 1997, Thomas and Wang 1997).

D. The Assimilationist Arguments

(vi) The assimilationists have pointed out that the analysis based on the calculations of residuals or the estimation of production functions, although useful in some sense, misses the core of what has been the growth process of East Asia during the last 30 years, and in particular the role of the assimilation of technology from the developed countries. They argue that in order to understand many of the subtleties of the process, one requires a different type of analysis, a different framework more microeconomic in nature and where technical progress is explicitly studied. Likewise, the learning process cannot be framed in the ideas proposed by the new neoclassical endogenous growth models, such as learning by doing or R&D, where technology accumulation is a passive and costless activity, just another variable not clearly measured in an aggregate production function (Hobday 1995). Technological progress is a dynamic process difficult to measure due to the fundamental uncertainty that characterizes it. For example, on Young's reasoning about Singapore's inadequate timing of learning by doing and fast movement up the development ladder, Huff argues

> This fails to understand the quickly-exhausted nature of the learning curve, and so the limited gains available in the particular international division of labor on which Singapore's spectacular manufacturing growth depended. Singapore has in fact benefitted from higher value-added activities (even in some parts of the electronics sector), and Singaporeans were increasingly employed as technicians and in supervisory positions. But for electronics, the bulk of technological progress and learning gains were found in developed countries where research and development and process and product design concentrated (Huff 1995, 742).

Hobday summarized his case studies on the Asian NIEs as follows:

> Rather than leapfrogging from one vintage of technology to another [...] TNCs and local East Asian firms engaged in a painstaking and cumulative process of technological learning: a hard slog rather than a leapfrog. The route to software and advanced information technology was through a long difficult learning process, driven by the manufacture of electronics goods for export (Hobday 1995, 200).

and Goh concluded

> The dynamic effects of economic restructuring and scaling the technology ladder appear neglected in the analysis [...] A proper assessment of the dynamics of the industrial revolution in the East Asian economies needs to take account of their structural transformation and their sustained investment in human capital (Goh 1996, 11).

(vii) In recent work, some of the assimilationists (Nelson and Pack 1996) have begun questioning growth accounting and the estimation of production functions on technical grounds. They base their argument on the Diamond et al. (1972, 1978) forgotten "Impossibility Theorem". Diamond et al. proved that there are circumstances where it is not possible to disentangle factor-augmenting technological change from the shape of the production function (and in particular from its elasticity of substitution). Nelson (1973) used a similar argument to point out that there is an identification problem in determining the form of the production function and that this poses difficulties for calculating a unique value of TFP growth. According to Nelson, the data are not able to discriminate between a number of different functional forms, with the result that we cannot be sure that any particular estimate of the rate of technical change is correct. The problem stems from the fact that growth accounting exercises cannot distinguish between two different explanations of the growth decomposition equally consistent with the time series data: one arising from a production function with unitary elasticity and Hicks-neutral technical change, and another arising from a production function with an elasticity less than one and labor-saving technological change. In the second interpretation, the lower elasticity of substitution means that less of output growth can be attributed to growing capital intensity, hence more must be attributed to improved technology. This is a case of two different underlying production functions that satisfy identical data sets. Hence there is an identification problem.

VI. The Aggregate Production Function

As indicated in previous sections, the debate about the sources of growth in East Asia is, implicitly, a debate within the neoclassical framework, and assumes the existence of an aggregate production function. Felipe and McCombie's (1997) arguments are nihilistic: they distrust this whole debate on the grounds that there is plenty of theoretical literature that questions the notion of aggregate production function and, by implication, the idea of TFP. First, although the Cambridge controversies of the 1950s and 1960s died without a definite answer, it seems that there was agreement on the issue that the notion of aggregate production function was very dubious (Robinson 1954, Solow 1957, Harcout 1972). Second, without being a direct participant in the Cambridge controversies, Fisher (1969, 1971, 1993) proved that the existence of aggregate production functions depends on very stringent conditions, seldom fulfilled by real world economies. In particular, capital aggregation requires capital augmentation of technical differences among firms; all firms must hire the same mix of labor types (i.e., absence of specialization in employment); and all firms must produce the same basket of outputs (i.e., absence of specialization in production). Certainly real economies do not fulfill these conditions. Using simulation analysis, Fisher (1971) showed that if Cobb-Douglas micro economies were aggregated violating the aggregation theorems, the aggregate Cobb-Douglas production function would produce a good fit, and elasticities would be close to the factor shares, provided that the latter were sufficiently constant. This led Fisher to conclude that

> ...the view that the constancy of labor's share is due to the presence of an aggregate Cobb-Douglas production function is mistaken. Causation runs the other way and the apparent success of this aggregate production function is due to the relative constancy of labor's share (Fisher 1971, 306).

Despite the aggregation arguments, aggregate production functions, when fitted econometrically, tend to give good fits and approximately constant returns to scale. This has been the instrumentalist argument for continuing to use them. Following independent work, Shaikh (1974, 1980) and Simon (1979) proved that the national income accounting identity (i.e., output equals the wage bill plus the surplus) can be rewritten, under different assumptions about the factor shares path, as a mathematical expression that is equivalent to a production function. From here, the residual that traditionally is referred to as the growth of technical progress equals a weighted average of the growth rates of the factor prices. Consider a general specification of the production function like expression (2), $Q_t = F(L_t, K_t, t)$ where t is the shift factor proxying the rate of technical progress. Expression (6) above gives us the rate of TFP as the difference between the growth of output and the weighted growth of the factor inputs. The weights are the factor shares by invoking the marginal productivity conditions. Now consider the national income accounting identity $Q_t = w_t L_t + r_t K_t$. This relationship is an identity that holds every period and for every market condition. It says that output (value added) equals the wage bill plus profits; each term is expressed as the product of the factor price (w_t, r_t) times the quantity (L_t, K_t). Differentiating this expression totally with respect to time and expressing it in growth rates yields

$$q_t = \varphi_t + a_t l_t + (1-a_t) k_t \qquad (18)$$

where

$$\varphi_t = a_t\varphi_{wt} + (1-a_t)\varphi_{rt} \quad (19a)$$

$$a_t = \frac{w_t L_t}{Q_t} \qquad 1-a_t = \frac{r_t K_t}{Q_t} \quad (19b)$$

$$\varphi_{wt} = \frac{\dot{w}_t}{w_t} \qquad \varphi_{rt} = \frac{\dot{r}_t}{r_t} \quad (19c)$$

The variables q, l, and k denote the growth rates of output, labor and capital, and φ_{wt} and φ_{rt} are the growth rates of wages and of the profit rate. Finally, a_t and $(1-a_t)$ represent the labor and capital shares in total output. Comparing expressions (6) and (18) one can see that they are equivalent. Thus, in order to derive the growth accounting equation, one does not need to resort to a production function, and assume profit maximization and the existence of competitive markets. Equation (6) must always hold. It can be easily seen that if φ_t and the factor shares were constant, then integrating (18) would yield the Cobb-Douglas production function, expression (8). But notice that the expression is an identity, equivalent with the national income accounting identity. Under different assumptions for φ_t and the factor shares, other functional forms can be derived (Felipe 1997a, Felipe and McCombie 1997). Expression (19a), the weighted average of the growth rates the wage and the profit rates, cannot be interpreted as the growth rate of TFP, since in order to do it, one would have to accept the existence of an aggregate production function ex-ante. This is what Jorgenson and Griliches (1967) did, and referred to (19a) and (6) as dual measures of TFP. Therefore, there is an identification problem which does not allow to differentiate between the accounting identity and the production function, and thus the latter cannot be considered to be a refutable proposition. Under this view, the econometric estimation of production functions is a dubious exercise. Any production function can be shown to be a particular way of rewriting the national income accounting identity under different assumptions about the factor shares path. By implication, the marginal productivity conditions derived from profit maximization are also identities and they cannot be used to test for profit maximization the way Kim and Lau (1994) did. These arguments are different from those embedded in the Diamond et al. Impossibility Theorem, since the latter does not question the notion of aggregate production function.

VII. Conclusions

In this paper we have surveyed the current state of the literature on productivity growth in the East Asian region. This literature has a clear empirical tone, where the notion of productivity used is the Solow residual, estimated via growth accounting or through the econometric estimation of production functions. The major question that this paper has posed is whether we have learned anything about growth in the East Asian region by carrying out these exercises. The answer is rather negative. We have discussed five arguments that justify this conclusion. First, the notion of technological progress most papers refer to is exogenous, disembodied, and Hicks-neutral. Although theoretically correct, this view of technical progress cannot be taken as the departing point in the analysis of productivity growth. An important part of technical progress is embodied in the factors of production. Second, there are serious objections as to the intrinsic meaning of decomposing overall growth (the attribution problem) and the validity of this exercise if factors exhibit complementarity. Likewise, if imperfect competition prevails, factor shares and elasticities will diverge. Third, the results of growth accounting exercises or estimation of production functions do not allow us to make an overall evaluation of the industrial policy and government intervention in any country, e.g., Singapore vis-a-vis the laissez faire policies of Hong Kong, China, much less to conclude that the latter have proven to be superior. Performing a growth accounting exercise with the aim of decomposing overall growth or fitting a production function is not the same as explaining the ultimate causes of growth. Therefore, most explanations about the growth of the countries under study, advanced ex-post, are unwarranted, and thus, fallacious. In other words, there is an unfilled gap between calculating zero productivity growth and attributing it to the failure of industrial policy. Fourth, the assimilationists have indicated that in order to understand how East Asia grew, one has to understand how technology from the developed countries was assimilated. Fifth, the results of most of the literature can also be questioned on methodological grounds. The state of the art in measuring technological change by the use of aggregate production functions (for sectors or countries) is not satisfactory, since the underlying theory is weak. The conditions for aggregation in real economies are so stringent that it hardly makes sense to think of such a concept. Finally, there is a wide variety of significantly different estimates of productivity growth, calculated using different models and under different assumptions. This is of little use. It is surprising that most researchers investigating the Asian Miracle compute the measures of productivity without warning about the problems of the method used. All in all, we conclude that the rate of TFP is not a *sufficient statistic* to draw conclusions and to make any policy statement about growth in East Asia, much less to predict its future.

The reader should not infer from the previous lines that the work on productivity growth in East Asia has been completely futile. These conclusions do not intend to convey the message that today we do not know more about the nature of growth in the region than five years ago, and that the intense debate about the sources of growth has not had a positive side. The main merit of this literature is that it has focused the attention of scholars on the growth process of East Asia. And, concurrently, it has made countries in the region aware of the importance of productivity. Singapore, for example, has set a target of achieving a TFP growth rate of 2 percent a year (Asian Productivity Organization 1997). Independently of the problems inherent in the notion of TFP, certainly the intention of increasing "productivity" must be seen as a positive factor. What we want to stress is that, perhaps, we have abused and misused the notion of total factor productivity growth, and talked about productivity in a very loose and imprecise sense. Probably too much has been inferred about the policies of the East Asian countries from the simple techniques used in neoclassical economics (as defined in Section II) to estimate the contribution of productivity to overall growth. And without any doubt, at this point, the *Solowresidualization* of the East Asian economies is an activity that one would like to discourage, since it is subject to significant decreasing returns. The arguments put forward by the assimilationists about the importance of understanding how East Asian countries mastered foreign technology are essentially correct. But the analysis of growth, and in particular of productivity, in East Asia, has to move beyond the use of aggregate production functions and look into other paradigms. The aggregate production function is a concept with little theoretical justification.

We need to keep studying the experience of these countries. However, if we are to advance in our quest for understanding how East Asia grew during the last 30 years we need new avenues of research in the following directions:

(i) Working on a theory outside the neoclassical framework that can explain how the East Asian countries grew. At the macro level, there are paradigms other than the neoclassical which explain growth and do not use an aggregate production function (McCombie and Thirlwall 1994, Felipe 1997b).

(ii) Understanding technology and the microeconomic foundations of the process of technology transfer in the region. Neither the original neoclassical model nor the recent advances in the form of the new neoclassical endogenous growth models make a true effort toward understanding what technology is (see Pack 1994 for a criticism of the endogenous growth models, and Khan 1998 for a proposal of modeling technology as a complex system).

(iii) Providing a better understanding of the interaction between human and physical capital.

(iv) Pursuing the recent works of Hobday (1995) and Nelson and Pack (1996), which, in looking into the micro data are proposals in the right direction that should bear important fruits. The end result of this work would be not the ability to measure something called the rate of productivity growth, but rather a correct and more complete understanding of the forces that drove East Asia's growth during the last 30 years.

Appendix

Other Estimates of Total Factor Productivity Growth for the East and Southeast Asian Economies (Total Economy)

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[b]
Indonesia	Elias (1990)	1950-87	1.2	22.8
	Kawai (1994)	1970-80	3.1	...
		1980-90	-0.1	...
	Lindauer and Roemer (1994)	1965-90	2.7	...
	Bosworth et al. (1995)	1960-70	0.8	44.0
		1970-80	1.1	22.0
		1980-86	-1.1	-42.0
		1986-92	0.8	20.0
Malaysia	Elias (1990)	1950-87	0.9	16.1
	Salleh and Meyanathan (1993)	1971-75	3.0	...
		1976-80	2.6	...
		1981-85	-0.4	...
		1986-89	1.8	...
	Kawai (1994)	1970-80	2.5	...
		1980-90	0.7	...
	Lindauer and Roemer (1994)	1965-90	1.1	...
	Bosworth et al. (1995)	1960-70	0.6	16.0
		1970-80	0.8	20.0
		1980-86	-1.9	-126.0
		1986-92	2.8	52.0
Philippines	Williamson (1969)	1947-65	2.1	37.0
	Nadiri (1972)	1947-65	2.5	43.5
	Elias (1990)	1950-87	1.6	33.9
	Kawai (1994)	1970-80	0.8	...
		1980-90	-2.2	...
	Lindauer and Roemer (1994)	1965-90	0	...

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APPENDIX, Other Estimates of TFP Growth *(cont'd.)*

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[b]
Philippines *(cont'd.)*	Bosworth et al. (1995)	1960-70	0.2	8.0
		1970-80	0.8	24.0
		1980-86	-4.6	139.0
		1986-92	0	0
Singapore	Chen (1977)	1957-66	3.7	69.0
		1966-70	5.1	43.8
		1957-70	3.6	55.2
	Tsao (1986)	1966-72	0.6	4.8
		1972-80	-0.9	-11.2
	Elias (1990)	1950-87	1.8	22.5
	Kawai (1994)	1970-80	0.7	...
		1980-90	1.6	...
	Lindauer and Roemer (1994)	1965-90	3.6	...
	Bosworth et al. (1995)	1960-70	0.1	1.0
		1970-80	0.4	9.0
		1980-86	-0.8	-22.0
		1986-92	4.0	54.0
Thailand	Elias (1990)	1950-87	1.43	22.0
	Kawai (1994)	1970-80	1.2	...
		1980-90	2.6	...
	Lindauer and Roemer (1994)	1965-90	3.3	...
	Bosworth et al. (1995)	1960-70	1.2	23.0
		1970-80	0.9	23.0
		1980-86	0.3	9.0
		1986-92	4.0	48.0
Hong Kong, China	Chen (1977)	1955-60	2.5	29.1
		1960-66	4.3	40.4
		1966-70	4.3	62.3
		1955-70	4.3	46.5
	Elias (1990)	1950-87	3.2	36.8
	Lindauer and Roemer (1994)	1970-89	3.6	...

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APPENDIX, Other Estimates of TFP Growth *(cont'd.)*

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[b]
Republic of Korea	Chen (1977)	1955-60	2.0	47.4
		1960-66	4.1	59.3
		1966-70	5.1	50.1
		1955-70	4.9	56.4
	Elias (1990)	1950-87	2.8	36.4
	Kawai (1994)	1970-80	0.7	...
		1980-90	2.8	...
	Lindauer and Roemer (1994)	1965-90	4.9	...
	Bosworth et al. (1995)	1960-70	0.6	11.0
		1970-80	0.8	13.0
		1980-86	2.5	40.0
		1986-92	1.9	28.0
Taipei,China	Chen (1977)	1955-60	3.1	59.5
		1960-66	6.0	65.1
		1966-70	1.8	22.6
		1955-70	4.3	53.6
	Kawai (1994)	1970-80	5.1	...
		1980-90	3.9	...
	Lindauer and Roemer (1994)	1965-90	4.9	...
	Bosworth et al. (1995)	1960-70	1.4	21.0
		1970-80	1.1	18.0
		1980-86	1.8	40.0
		1986-92	2.5	42.0
Japan	Chen (1977)	1955-60	3.1	59.5
		1960-66	6.0	65.1
		1966-70	1.8	22.6
		1955-70	4.3	53.6
	Elias (1990)	1950-87	3.6	52.1
	Inoue (1995)	1961-65	1.5	...
		1966-70	4.1	...
		1971-75	-0.2	...
		1976-80	1.5	...
		1981-85	1.2	...
		1986-90	1.9	...
		1991-93	-0.7	...

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APPENDIX, Other Estimates of TFP Growth *(cont'd.)*

Economy	Author	Period	Annual Rate TFP (%)	% Output Growth[b]
Japan *(cont'd.)*	Maddison (1995)[a]	1890-13	-0.3	...
		1913-50	0.4	...
		1950-73	5.1	...
		1973-92	1.0	...
		1890-92	1.4	...
	Bosworth et al. (1995)	1960-70	5.0	56.0
		1970-80	0.5	14.0
		1980-86	1.1	42.0
		1986-92	1.0	38.0
	Wolff (1996)	1950-60	4.9	...
		1960-73	4.0	...
		1973-79	0.1	...
		1979-89	1.2	...

[a]Maddison (1995): first estimate refers to the period 1890-1913; last estimate refers to 1890-1992.
[b] ... means data not available.

References for Sectoral Estimates of Total Factor Productivity Growth for the East and Southeast Asian Economies

Economy	Authors
Indonesia	Osada (1994)
Malaysia	Okamoto (1994)
Philippines	Kajiwara (1994)
Singapore	Chen (1977), Tsao (1985), Wong and Gan (1994), Young (1995)
Thailand	Urata and Yokota (1994)
Hong Kong, China	Chen (1977)
Republic of Korea	Chen (1977), Kwon (1994), Young (1995)
Taipei,China	Chen (1977), Okuda (1994), Young (1995)
Japan	Bernard and Jones (1996a, 1996b); Chen (1977); Inoue (1995)

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