Total Factor Productivity Growth in Japan, South Korea, and Taiwan*

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revised July 1996

Abstract

We present total factor productivity growth (TFPG) calculations for Japan, South Korea and Taiwan, using a consistent methodology and data sets. We reassess the productivity growth experience of Korea and Taiwan, as compared to Japan and to previous work on Latin American countries. We conclude that Korea and Taiwan's experience is not simply explained by factor accumulation, as has recently been suggested by Krugman (1994), nor was TFPG in these countries similar to Latin America.

*This research was supported by grants from the University of California Pacific Rim Research Program and the University of California, Santa Cruz Academic Senate. We have benefitted from the comments and suggestions of K.C. Fung, Kenneth Kletzer, J. David Richardson, and Pan Yotopoulos, and seminar audiences at the Asia Foundation, the World Bank, and the Delhi School of Economics. The authors alone are responsible for the views expressed here, and any remaining shortcomings.
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1. INTRODUCTION

Over the past three decades, developing countries have diverged significantly in terms of productivity growth and output growth. Japan has evolved from a developing country to an economic superpower. South Korea and Taiwan have lifted their economies from relative poverty to the ranks of the world's upper-middle income countries[1]. Although often referred to as a single group, the East Asian economies are considerably diverse[2]. The region includes the richest as well as some of the poorest countries in the developing world. With the region's success, two crucial questions are usually asked: what are the reasons for the remarkable performance; and what economic policies have contributed to this success?

High rates of investment in human and physical capital are often identified as

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1 Eight of the nine major economies of developing East Asia (China, Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand) were among the 12 most rapidly growing economies of the world during the 1965-1990 period." (Petri, 1993, p.1).

2 Although the economies of the four "tigers": Hong Kong, Singapore, South Korea and Taiwan, share many common characteristics, there are also significant differences. "The Korean and Taiwanese governments were committed to export-led growth, while Hong Kong was a prototype free-market economy. Korea grew with interlinked big corporations, while Taiwan's growth was more centered on small and medium-sized firms." (Ito and Krueger, 1995, p.1.)

major contributors to East Asian growth[3]. This source of growth has been particularly emphasized by Kim and Lau (1994), Young (1995) and Krugman (1995). However, this leaves the question of why such investments in human and physical capital have contributed to East Asian growth, but not elsewhere to others, such as in the Soviet economy. While we cannot answer these questions in this paper, we focus on an important aspect of the debate: the size and role of total factor productivity growth in some of the high-performing East Asian economies. We performed detailed growth accounting calculations for Japan, Korea, and Taiwan, choosing these countries to supplement Young's (1992) analysis of Hong Kong and Singapore. While Young (1995) has recently provided similar calculations for Korea and Taiwan[4] (as well as updating his earlier estimates for Hong Kong and Singapore), our contribution in terms of empirics is to provide closely comparable estimates for Japan, using comparable data, methodology, and periods, as well as an independent assessment of Korea and Taiwan's experience. This allows us to discuss more closely the interpretation of the results. A reassessment of Young's conclusions seems called for since his results have been made the basis for some extreme conclusions by Krugman (1994).

There are a significant number of other empirical studies in this area. Chen (1977) provided early calculations of TFPG. Kim and Park (1985) examined Korea in detail. The broad World Bank (1993) study also included TFPG calculations. Dougherty (1992) included

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[3] "These economies have consistently invested a larger share of output than other developing countries -- nearly 50 percent higher in 1990. As for human capital, in 1990 their primary enrollment rate was 25 percent higher and their infant mortality rate 50 percent lower than the average for all developing countries."(Thomas and Wang, 1993, p.1).

[4] Our study was done independently of and concurrently with Young's work. It should be noted that Young also provides sectoral analyses for all four countries in his latest work.

Japan in his study. However, only Young (1995) provides estimates with a comparable period and methodology, for two of our three countries[5]: thus we believe our results are a useful contribution.

Kim and Lau (1994) take an alternative approach to examining the role of the accumulation of capital (physical and human) in East Asian growth. By applying the concept of a meta-production function for Hong Kong, Singapore, South Korea and Taiwan, they find that capital accumulation alone can explain growth in these countries. This contrasts with their results for OECD countries, using the same approach, where there remains a residual attributable to technical change. Krugman (1994), relying on the Kim and Lau study, argues that the rapid growth in East Asian economies is only the result of massive capital investment, high saving rates, increases in educational levels, and other "astonishingly" mobilized resources. Here we re-examine this extreme conclusion[6].

While the Kim-Lau methodology has some advantages, including not imposing constant returns to scale[7], it also involved lumping together the four "tigers". Young's (1992, 1995) results, using the growth accounting approach, suggest that this may not be warranted.

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[5] This is not a comprehensive list. Some of the other studies are reviewed in Young (1995).

[6] A working paper version of our results was used by Husain (1995), in his response to Krugman. The same issue of *Foreign Affairs* contains other comments as well.

[7] We impose constant returns to scale: this is consistent with almost all other studies of TFPG, including Young, though not with some of the models of endogenous growth discussed in section 3. Seung Rok Park and Jene Kwon, in a then unpublished study, cited in Wade (1994), found no TFPG in Korea when increasing returns to scale were allowed for. However, Wright (1996), Essay 2, estimates TFPG higher than ours once increasing returns and imperfect competition are allowed for.

His results for Singapore support the view that physical capital accumulation has been the dominant factor in that country's per capita output growth. However, the results for Hong Kong, Korea and Taiwan are quite different, with there being a substantial TFPG residual.

Our own results also indicate that the percentage contribution of TFPG to output growth in the three countries we study has not been negligible. Of these three economies -- Japan, Korea, and Taiwan -- Japan had the highest proportionate contribution of TFPG to growth over the same period of 1965-1990. Thus, in this sense, there is partial support for the view that the Newly Industrializing Economies (NIEs) have relied more heavily on factor accumulation. The results suggest that the percentage contribution of TFPG to overall growth in South Korea and Taiwan is similar to the earlier estimates by Young for Hong Kong. Thus, the extreme position that TFPG played no role does not find support. The results are quite consistent with Young (1995).

The rest of the paper is organized as follows: In section 2, the economies and recent experiences of the three countries studied are briefly discussed. In section 3, we consider recent theories of growth and their relationship to the current study. Section 4 describes the methodology for estimating TFPG, which closely follows that of Young (1992)[8]. Section 5 presents the basic estimation results. Section 6 provides a discussion of these estimates, including a comparison with other work on TFPG in Latin America. Section 7 provides concluding remarks.

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[8] The proximate methodological source for Young is Jorgenson, Gollop and Fraumeni (1987). Of course many aspects of the methodology go back considerably further.

2. THE COUNTRIES

Japan, South Korea, and Taiwan differ substantially in many ways. Japan, for example, is much more economically advanced than Korea and Taiwan. It is the wealthiest country in Asia, having experienced over a century of industrialization, whereas the other two Asian countries have had less than fifty years of industrial growth. However, Japan is included in this study because it is often viewed as a role model for the more recently industrialized East Asian countries. Furthermore, it provides a specific comparison for TFPG experience. It has been suggested that these three countries have had to overcome similar problems; namely being relatively densely populated while limited in natural resources. The other members of the NIEs, Hong Kong and Singapore, were excluded partly because they face different problems, being small city-states and having no agricultural sectors.

Japan, Korea, and Taiwan have had high investment ratios, relatively small public sectors, fairly competitive labor markets, expanding exports, and substantial government intervention in the economy. They also have had large and efficient investments in their human capital and well developed capacities to absorb new technology. In addition, the three countries are similar in several noneconomic characteristics: ethnic and linguistic homogeneity, compact geography, low population's growth rates, and the Confucian tradition. One similarity that has possibly been of major significance has been the relatively low degree

of inequality of income and wealth.[9] These characteristics in turn have influenced their labor productivity, saving behavior, and other aspects of the economy.

However, Japan, Korea, and Taiwan have striking dissimilarities as well. There are differences in the size of each country's market, scale economies (for example, in the automobile industry, where Japan is a strong international competitor, Korea is a newcomer, and Taiwan is not even a beginner), economic structure (ie., the contribution of agriculture to GDP differs considerably: for Japan it was 4 percent in 1982, while in 1983, Korea and Taiwan had shares of 16 percent and 7 percent, respectively), and dependency on trade (it being more important in Korea and Taiwan than in Japan). All of these characteristics described above make the three countries a useful empirical case study.[10]

Finally, although South Korea and Taiwan have common structural characteristics and export-led industrial sectors, the role of their governments has differed[11]. The Korean government has been cooperative in relations with the private sector, whereas the Taiwanese government, while supportive, has been less interventionist. Rodrik (1994), however, suggests

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9 See Rodrik (1994) in particular on this point.

[10] Of course such comparisons are common, and not novel in any way. One example of comparison, from which we have drawn, is Kuznets (1988). The recent World Bank (1993) reports provide more detailed discussions of the similarities and differences of the East Asian economies.

[11] Several studies have documented an active role for government, beyond correcting market failures. (See Kuznets, 1988, Park, 1990, Wade, 1990 and Rodrik, 1994).

that the end result was similar in both cases: a significant increase in the return to private capital.

According to Park (1990), there are some lessons that can be drawn from this diverse experience. First, there is no ideal model for the governments of both Korea and Taiwan to follow. The efficiency of export-led development strategy does not seem to relate to policy activism. The initial conditions and structural characteristics have been more important than strategy itself, and the differences in the role of government between the two countries are due to technology differences. For instance, Korean policymakers have always sought to adopt increasing-returns, or large scale technologies for efficiency purposes, whereas Taiwanese's policymakers have not. Second, the governments in both countries assumed particular roles in the development process, and sometimes failed to adjust their roles to the changing environment. Third, for Korea and Taiwan, it is reasonable to believe that their governments, through intervention, have contributed somewhat to the rapid growth and industrialization. Without this direct government intervention, it is hard to believe that the private sector itself could have launched and maintained the investment- and export-led development strategy. Thus, the efficiency of government intervention in South Korea and Taiwan has been quite successful in facilitating economic stability and rapid growth.[12]

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[12] The idea is drawn from Park (1990). Also, according to Leipziger and Thomas (World Bank, 1993, p.6) “Contrary to the currently fashionable views worldwide, one of the key ingredients in East Asia's success was active government. But it was not more government which had a positive effect -- it was better government.” Rodrik (1994) argues that the government was able to successfully subsidize and coordinate investment decisions, helped by equality of income and wealth that reduced rent-seeking.

3. RECENT THEORIES OF GROWTH

In the last decade, there have been substantial advances in theories of endogenous growth. This "new" growth theory allows for investment in education, changes in the labor force, and technological change to be determined within the economy, rather than set by unexplained external forces. These theories emphasize the role of economic policy in affecting the long-run growth. For instance, any economic policy which changes the economy's tendency to invest in education, training or technology, will enhance growth. Such policies would involve changes in taxes and subsidies for research and development (R&D)[13]. Thus, the regulation of imported technology and foreign goods can potentially create long-run growth implications (See, e.g., Grossman and Helpman, 1992; Romer, 1990).

Most empirical studies based on the new growth theories use large cross-sections of countries, for example, the United States (see e.g., Barro, 1991). However, Young (1992) emphasizes the value of examining individual country experiences:

> Case study analysis provide both the author and the reader with the opportunity to develop a rich understanding of the conditions, processed, and outcomes that

[13] The role of R&D and total factor productivity growth in Japan, South Korea, and Taiwan are examined in Trieu (1995) and in Trieu and Singh (1996).

> have governed the growth experience of actual economies. As such, they provide a means of testing the implications of existing theories and developing one's thinking on the growth process.(p. 13)

Young (1992) is able to relate the results from his case study of Hong Kong and Singapore to his theory of endogenous growth based on “learning by doing”. He suggests that Hong Kong's experience along with his estimates of TFPG are consistent with moving down learning curves in relatively “low tech” manufacturing, while Singapore's results are in keeping with its policy of actively pursuing the development of capabilities in new sectors before realizing all the learning gains in old ones.

While our results for the three countries are similar to Young's results for Hong Kong, they do not suggest that his model is necessarily the only explanation[14]. In fact, as discussed in the previous section, Korea and Taiwan have been contrasted in terms of structure and industrial strategy, with Korea having a more interventionist government in terms of industrial targeting, and with larger firms being a more important part of the economy. Thus, one might think that the results on TFPG's contribution for Korea would be closer to those for Singapore, and those for Taiwan closer to Hong Kong. However, this turns out not to be the case.

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[14] In fact, Young (1994) in his recent paper stresses neoclassical factor accumulation more than does his earlier work.

Allowing for changes in factors such as education of the labor force makes a dramatic difference in the percentage contribution of labor or to the TFPG estimates for Taiwan, but to a much lesser extent for Korea. This can be interpreted as being consistent with recent growth models that stress human capital accumulation as a factor in growth. However, these models do not necessarily include a "learning-by-doing" story with respect to how human capital affects growth. To some extent the role of human capital and of technological change are intertwined, as is the accumulation of physical capital. Human capital refers to the knowledge and skills accumulated by people. Such knowledge can be measured directly by competence such as literacy or other test scores. However, it is usually measured indirectly by years of schooling. Data on years of technical training represent a mixture of direct and indirect measurement. Technological change refers to new ways of doing things -- coming up with a new products or improving old ones. Since improvement in technology often goes hand in hand with improvement in the skill and knowledge of workers, it is difficult to separate the two. Similarly, improvements in technology may be embodied in new capital equipment. The weakness of the growth accounting approach is that it does not allow for these interactions and complementarities. Thus, one must be cautious about what can be inferred about different theories of growth from TFPG calculations alone[15].

[15] Ito and Krueger (1995), in their introduction to a substantial volume on growth theories and East Asian experience conclude: "the papers...do not provide a clear-cut conclusion as to the relevance of endogenous growth theory in explaining the East Asian experience." (p. 5)

4. TOTAL FACTOR PRODUCTIVITY: CONCEPT AND MEASUREMENT

Total factor productivity (TFP) shows the relationship between a composite input and the output, calculated as a ratio of output to input. Productivity increases when the growth in output is greater than the growth in input, or when the rate of growth of output minus the rate of growth of the composite input is positive. Economic growth can be obtained either by increasing inputs or by improving productivity factor. Productivity growth occurs when a higher output can be attained with a given amount of input, or a certain level of output can be attained with smaller amounts of factor input. This productivity growth is obviously preferable to growth due to increases in factor inputs, since the latter might be subject to diminishing marginal returns. For countries with limited natural resources, such as Japan, Korea, and Taiwan, an improvement in efficiency is distinctly more significant than for countries abundant in natural resources, and thus improvement in efficiency is especially important for their economies' growth. In the remainder of this section, we describe in detail our methodology for estimating TFP growth.

4.1 The Model

Following Young (1992) and Jorgenson, Gollop, and Fraumeni (1987), we use a general form for the aggregate production function for the economy. The translogarithmic value added production function can be written in logarithmic form as:

$$\ln Q = \alpha_0 + \alpha_K lnK + \alpha_L lnL + \alpha_t t + \frac{1}{2}\beta_{KK}(lnK)^2 + \beta_{KL}(lnK)(lnL) + \beta_{Kt} lnK.t + \frac{1}{2}\beta_{L.L}(lnL)^2 + \beta_{Lt} lnL.t + \frac{1}{2}\beta_{tt} t^2 \quad (1)$$

where Q is output, K and L are capital and labor input, respectively.

With the assumption of constant-returns-to-scale, one requires that the parameters satisfy the following conditions:

$$\alpha_K + \alpha_L = 1$$
$$\beta_{KK} + \beta_{KL} = \beta_{L.L} + \beta_{KL} = \beta_{Kt} + \beta_{Lt} = 0 \quad (2)$$

In the case of differentiated inputs, one can assume that aggregate capital and labor inputs are constant-returns-to-scale translog indices of sub-inputs with the same restrictions on the parameters:

$$lnK = \alpha_1^K lnK_1 + \alpha_2^K lnK_2 + \ldots + \alpha_n^K lnK_n + \frac{1}{2}\beta_{11}^K (lnK_1)^2 + \beta_{12}^K (lnK_1)(lnK_2) + \ldots + \frac{1}{2}\beta_{nn}^K (lnK_n)^2 \quad (3)$$

$$lnL = \alpha_1^L lnL_1 + \alpha_2^L lnL_2 + \ldots + \alpha_m^L lnL_m + \frac{1}{2}\beta_{11}^L (lnL_1)^2 + \beta_{12}^L (lnL_1)(lnL_2) + \ldots + \frac{1}{2}\beta_{mm}^L (lnL_m)^2$$

Differencing the logarithms of these translog production functions, we obtain a measure of the contributions to growth across two discrete points in time:

$$\ln\left[\frac{Q(T)}{Q(T-1)}\right]=\bar{\Theta}_K \ln\left[\frac{K(T)}{K(T-1)}\right]+\bar{\Theta}_L \ln\left[\frac{L(T)}{L(T-1)}\right]+TFP_{T-1,T} \quad (4)$$

$$\textit{where:}\quad \ln\left(\frac{K(T)}{K(T-1)}\right) = \Sigma_j \bar{\theta}_{kj} \ln\left[\frac{k_j(T)}{k_j(T-1)}\right)$$

$$\ln\left(\frac{L(T)}{L(T-1)}\right) = \Sigma_j \bar{\theta}_{lj} \ln\left(\frac{l_j(T)}{l_j(T-1)}\right)$$

$$\bar{\Theta}_i = \frac{1}{2}(\Theta_i(T)+\Theta_i(T-1))$$

$$\bar{\theta}_i = \frac{1}{2}(\theta_i(T)+\theta_i(T-1))$$

and where: Θ_i is the share of each aggregate factor in total factor payments.

θ_i is the share of each sub-factor in payments to its aggregate factor.

$TFP_{T-1,T}$ is the translog index of TFPG.

4.2 Measuring Factor Inputs

Once again, following Young (1992) and Jorgenson, Gollop, and Fraumeni (1987), we focus on two aggregate inputs, capital and labor, differentiated into sub-input categories. For each of the countries, capital input is divided into five categories: residential buildings, nonresidential buildings, construction, transport equipment, and machinery and equipment. Differentiated labor input is based on sex, age, and education.

For measuring the stock of each capital input (in real terms), we apply geometric rates of capital depreciation[16]. We assume that the capital stock is zero at one early year, then more as its accumulated investment flows. For example, the benchmark for capital stock in 1963 for the aggregate estimation in the case of Taiwan is estimated by accumulating 10 previous years (1953-1962) of government data on gross fixed capital formation, and by using a depreciation rate of 10 percent.

We performed both aggregate and differentiated estimations. The point of doing both estimates is to provide a way of measuring how much factors such as education changes matter to the economy. In the case of differentiated labor and wages in Korea and Taiwan, labor force and wages classified by age, sex, and education were not available. An approximation of the maximum likelihood estimate of each cell is derived by applying the iterative proportional fitting technique suggested by Bishop, Fienberg, and Holland (1975), to available labor force and wages data. For Japan, however, complete data for the labor force and wages, classified by age, sex, and education, are available.

4.3 Measuring Factor Shares

The aggregate share of labor is derived by multiplying aggregate compensation of employees as a percentage of GDP by the ratio of working population to paid employees.

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[16] These were based on Hulten-Wykoff estimates of geometric rates of capital depreciation as used in Young (1992). We use depreciation rates of 1.3% for residential buildings, 2.9% for nonresidential buildings, 18.2% for transport equipment, 13.8% for machinery, and 0% for construction.

The aggregate share of capital under perfect competition and constant-return-sto-scale is obtained by subtracting the aggregate share of labor from 1.

For differentiated capital, with perfect foresight, and geometric depreciation, the rental price of capital good K can be expressed in the following:

$$P_{ki}(T) = P_{Ii}(T-1)r(T) + \delta P_{Ii}(T) - [P_{Ii}(T) - P_{Ii}(T-1)] \quad (5)$$

where P_{Ii} denotes the investment price of capital good i, r(T) is the nominal rate of return between period T-1 and T. Assume that all assets earn the same rate of return. Thus, we derive r(T) by equating total payments to capital, to my estimate of the aggregate share of capital. We then obtain the estimation of the rental price of each capital good, i, and by extension derive the share of payments to capital, following the methodology used by Jorgenson, Gollop, and Fraumeni (1987).

5. ESTIMATION RESULTS

The results of the growth accounting calculations used in estimating TFPG are presented in Tables 1 to 3. Results are presented for five-year averages, and for the whole period. For brevity, annual figures are not presented, but are available in Trieu (1995).

5.1 Estimation Results for Japan

Tables 1A and 1B present the results for Japan. Table 1A uses the aggregate measures of capital and labor. The results suggest that TFPG has been consistently high in Japan over the last 25 years, contributing over 50 percent to overall output growth. For the period 1965-1970, Japan had a high growth rate of output (average ranging from over 9 to 12 percent per year); the remaining growth rates of output across annual average range from 2.6 percent to over 7.5 percent. The contribution of TFPG increases in the earlier years, then gradually decreases. With the exceptions of the years 1973 and 1974, the yearly numbers (not shown) on TFPG were reasonable. This is clearly due to the recession: the five-year averages smooth out such effects. The five year averages indicate that the contribution of TFPG was particularly high in 1965-70, despite the rapid growth of capital also in this period.

Allowing for differentiated capital and labor reduces the estimated contribution of annual TFPG by five percentage points (Table 1B), with the increase showing up in the contribution of labor. The contribution of labor increases from approximately 17 percent to 22 percent. We conjecture that this is the result of allowing for differences in education over the period rather than age composition or gender balance in the work-force. This might therefore be interpreted as a human capital effect. It should be noted that this effect operates primarily in the years after 1970, with TFPG after the quality correction being much lower for

these later years. This fits with a view that Japan moved up the "quality ladder" as analyzed by Grossman (1990)[17].

We also performed a sensitivity check with respect to the estimated share of labor. When this was reduced uniformly by 10 percentage points for the aggregate estimation of TFPG in Japan there was a 12 percent point decrease in the estimated contribution of TFPG to output growth, and a small decrease in the estimated share of labor. This suggests that the contributions of capital and TFPG may be relatively hard to disentangle. These results are not shown, but (along with other checks) are available in Trieu (1995).

5.2 Estimation Results for Korea

The results for Korea are presented in Tables 2A and 2B. Table 2A gives five-year averages, using the undifferentiated measures of capital and labor. The calculations indicate that TFPG was much higher in the 80's than in 70's, and the contribution of TFPG over the last 25 years was close to 29 percent of the overall output growth. The annual estimates (not shown) were reasonable, with some negative TFPG contributions in the 1960's and 1970's being smoothed out in the five-year averages.

Table 2B shows the results with differentiated measures of capital and labor. Allowing for differentiated capital and labor reduces slightly the estimated contribution of

[17] Our estimates of TFPG are slightly higher than those obtained by Dougherty (1992). He estimates TFPG for the period 1960-1989 at 2 % per annum, while annual GDP growth in Japan was 6.8 % over this time. In addition to the different time periods, there are some differences in data and methodology that should account for our slightly different numbers.

annual TFPG by 2 percentage points, with the corresponding increase showing up mostly in the contribution of capital. Thus, allowing for the heterogeneity of labor and capital made little difference to the TFPG estimates for Korea. This is also true for the five-year averages, with TFPG still estimated as much stronger in the 1980's than in the previous period.

The sensitivity check of the undifferentiated estimation of TFPG for Korea, again with a 10 percentage point reduction in the share of labor, resulted in a 13 percent decrease in percentage contribution of TFPG to output growth. The effect on labor's estimated contribution was relatively small. Thus, as in Japan's case, the relative contributions of TFPG and capital are sensitive to the share calculations.

5.3 Estimation Results for Taiwan

Tables 3A and 3B present the results for Taiwan. Table 3A displays five- year averages, using the aggregate measures of capital and labor. The outcomes suggest that TFPG has been consistently high in Taiwan over the last 28 years, contributing over 45 percent to overall output growth. The annual calculations identified only the periods 1973-74 and 1981-82 for which the yearly numbers on TFPG were negative. The five-year average smooth out such effects, but still indicate substantial fluctuations in TFPG over the time period, with the 1960's and 1980's showing much higher TFPG.

Allowing for differentiated capital and labor (Table 3B) reduces the estimated contribution of TFPG by about 18 percentage points, with the increase showing up in the contributions of labor, which then increases from 27 percent to 40 percent, and of capital,

which then increases from around 26 percent to 30 percent). As with Japan, we conjecture that this is the result of allowing for differences in education over the period rather than age composition or gender balance in the labor force. Therefore, this can again be interpreted as a human capital effect in overall output growth. The fluctuation in TFPG over the five-year periods is not much affected by allowing for heterogeneity in labor and capital.

The sensitivity checks of the aggregate estimation of TFPG for Taiwan, reducing the labor share by 10 percentage points, resulted in a 3.5 percent and 10 percent decrease in percentage contribution of labor and TFPG to output growth, respectively. Thus they were quite similar to the results for Japan and Korea.

6. DISCUSSION

The results of our TFPG calculations, allowing for the heterogeneity of capital and labor, are summarized in Table 4. Several points stand out. First, the estimates of TFPG are quite close for the three countries, despite their different levels of development. In particular, using a consistent methodology for the three countries, we have established that South Korea and Taiwan were able to match more developed Japan in terms of TFPG. In his broad analysis of growth and transformation for the period 1950-73, Chenery (1986) found that Japan's experience of output, input and productivity growth fitted better with a small group of developing countries, including Korea and Taiwan. For the considerably later period considered here, Japan was more like the other industrial economies in terms of its growth

rate, and relative contribution of TFPG. What is significant is that Korea and Taiwan matched it in terms of productivity growth over this approximate 25 year span. Our results clearly contradict the italicized part of the following statement: "Japan, *unlike the East Asian "tigers"*, seems to have grown both through high rates of input growth and through high rates of efficiency growth" (Krugman, 1994, p. 73, emphasis added).

The second point is that Korea and Taiwan's higher growth rates for this period, again using Japan as a benchmark, can be attributed to higher input growth, in both capital and labor. This accords well with Young's (1995) study, and also with the World Bank's (1993) interpretation of East Asian experience. Thus, on this ground, one might be inclined to agree with Young's conclusion that "Neoclassical growth theory...[based on input accumulation] can explain most of the difference between the performance of the NICs and that of other postwar economies" (Young, 1995, p. 675). However, we believe there is more to be said on this, and we return to this point below, in the context of comparisons with other countries.

A third point to be noted from Table 4 is that relatively more growth in Korea is explained by capital accumulation, as compared to Taiwan. Again, this fits well with what we know about Taiwan and Korea's policies and industrial structures[18], with Korea having larger firms and deliberately focusing on capital-intensive heavy industries.

Our basic results, just summarized, provide the foundation for our discussion of what seems to be the fundamental questions: what, if anything makes the experience of East Asian

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[18] See, for example, Amsden (1989) on Korea, and Wade (1990) on Taiwan, as well as Park (1990) and World Bank (1993).

economies such as Korea and Taiwan special, and what are the prospects for their continued rapid growth? We can dismiss statements such as "[In] rapidly growing East Asian economies...there is startlingly little evidence of improvements in efficiency" (Krugman, 1994, p. 71). The real issue is whether the estimated improvements in efficiency for Korea and Taiwan are of note. Young (1995), in his abstract, states:

> Once one accounts for the dramatic rise in factor inputs, one arrives at estimated total factor productivity growth rates that are closely approximated by the historical performance of many of the OECD and Latin American economies. While the growth of output and manufacturing exports in the newly industrializing countries of East Asia is virtually unprecedented, the growth of total factor productivity in these economies is not.

However, in a broad-based study, Chenery (1986) found that typical low- and middle-income countries had TFPG contributions of the order of 10 to 20 per cent, while for the high-income countries the TFPG contribution was 30 to 50 percent. Thus, the fact that Taiwan and Korea were able to come close to Japan in this respect seems to be noteworthy, even if, as Young (1995) points out, and our results confirm, TFPG in Korea and Taiwan is not that different from the case of Japan.

Another issue worth examining is the comparison with Latin America. Young's numbers for Latin America are taken from the study by Elias (1992). The economy-wide

TFPG numbers he quotes for Brazil, Chile and Mexico, 1.6, 0.8 and 1.2 % respectively (Young, 1995, Table XIV, p. 673) are all lower than his calculations for Korea and Taiwan, which are 1.7 and 2.1 % respectively. One of the main reasons our estimates are somewhat higher than Young's is that he has excluded agriculture from his economy-wide TFPG estimates. This is as one would expect: our numbers are picking up the effect of reallocation of labor from less productive agriculture to more productive manufacturing. Whether it is useful to do so is a separate point (we think that it is, at least for recording experience, if not for predicting future trends). Here the point is that Elias's calculations make no such adjustment. Thus his numbers are better compared with ours. Furthermore, an examination of Table 2 in Elias (1992, pp. 50-52) reveals that much of the data used by Young to reduce his TFPG estimates (as summarized in Table XV of Young, 1995) was not available to Elias, especially for the later years of his sample period. Thus Elias's numbers are perhaps more comparable to our aggregate estimates of TFPG, which are still higher, or Young's "naive" estimates. Seen in this light, the experience of Korea and Taiwan is nowhere "closely approximated" by the performance of Latin American economies. We think this is a

significant point in the debate[19], since it helps restore to some extent the specialness of Korea and Taiwan's experience.

7. CONCLUSION

The growth accounting calculation results, estimating TFPG for the Japan, South Korea, and Taiwan may be summarized as follows. All three countries show similar TFPG rates, with Japan's TFPG representing a higher fraction of output growth than in the case of Korea and Taiwan. The five-year averages accord well with what one knows about the three countries' policies and experience of growth over time, as do the estimated contributions of capital and labor. There is some evidence for the importance of human capital in the three countries' growth. And the accumulation of physical capital clearly was important. Our results are not out of line with other studies that have used similar methodology.

Our interpretation of the results is that they confirm that Korea and Taiwan are different from Singapore (studied by Young, 1992, 1995) in terms of their productivity growth. Thus lumping the four NIE "tigers" together, as in Kim and Lau (1994) may hide

[19] Two other aspects of the Latin American data are worth noting. Though not central to our argument, they highlight the further differences between the countries examined by Elias versus Korea, Japan and Taiwan. First, TFPG in the Latin American sample is high only in the first decade for which there is data (1950's for Brazil, 1940's for the other countries), and falls off dramatically thereafter (Elias, 1992, Table 2, pp. 50-52). Second, the estimated share of capital income in GDP is much higher in the Latin American economies than in East Asia (Elias, 1992, Table E9, pp. 208-209). The second point is clearly related to Rodrik's (1994) observations on lower inequality in Korea and Taiwan.

information. We have emphasized that the TFPG experience of Korea and Taiwan (and Hong Kong, though it is not in our study), while not miraculous, is exceptional. It is not higher than Japan, but the fact that it is comparable, for countries at lower levels of income, is noteworthy with respect to earlier broad patterns noted by Chenery (1986). Furthermore, Korea and Taiwan's TFPG record is not approximated by any of the Latin American countries. Thus, our conclusion is that the simple factor accumulation story cannot explain all of the growth experience of countries such as Korea and Taiwan. Identifying the relative roles of government policies, trade[20] and so on is beyond our scope. But it seems safe to conclude that technological progress, as broadly measured by TFPG has been an important component of growth in Korea and Taiwan.

[20] The comment of Gibney (1995) on Krugman is of interest here: "Part of the increased productivity in these export-driven economies can be attributed to imports of foreign knowledge and technology -- a significant by-product of the HPAEs' intense 'exports first' emphasis. The product of export-driven economies must compete with other nations' products to succeed. This means learning intensively from one's competitors and others. By contrast, the Soviet economy was a classic case of import substitution at all cost -- a short-sighted policy followed, disastrously, by various Third World countries outside East Asia in the postwar period." Again, one should not Rodrik's (1994) study here: he finds that the two economies' investment boom shaped their outward orientation.

Table 1A Estimates of Total Factor Productivity Growth in Japan (Aggregate Capital and Labor)

Year	Growth of			Average Capital Share	Percentage Contribution of		
	Output	Capital	Labor		Capital	Labor	TFPG
65-70	0.5324	0.7311	0.0737	0.2047	0.2811	0.1101	0.6088
70-75	0.2163	0.5061	0.0325	0.1688	0.3951	0.1247	0.4802
75-80	0.2244	0.2783	0.0596	0.1722	0.2136	0.2199	0.5665
80-85	0.1834	0.1890	0.0539	0.2413	0.2488	0.2231	0.5281
85-90	0.2195	0.2623	0.0682	0.2799	0.3345	0.2238	0.4417
85-91	0.2592	0.3209	0.0870	0.2832	0.3507	0.2406	0.4087
65-91	1.4156	2.0256	0.3067	0.2169	0.3103	0.1697	0.5200

Table 1B Estimates of Total Factor Productivity Growth in Japan (Differentiated Capital and Labor)

Year	Growth of			Average Capital Share	Percentage Contribution of		
	Output	Capital	Labor		Capital	Labor	TFPG
65-70	0.5324	0.7222	0.0971	0.2047	0.2776	0.1449	0.5775
70-75	0.2163	0.4754	0.0740	0.1688	0.3711	0.2844	0.3445
75-80	0.2244	0.2487	0.1149	0.1722	0.1909	0.4238	0.3853
80-85	0.1834	0.2214	0.0806	0.2413	0.2914	0.3333	0.3753
85-90	0.2195	0.2872	0.0883	0.2799	0.3663	0.2897	0.3440
85-91	0.2592	0.3534	0.1091	0.2832	0.3861	0.3018	0.3121
65-91	1.4156	2.0169	0.3995	0.2169	0.3090	0.2209	0.4701

Notes:
- Output and factor growth rates are natural log differences.
- Output and capital variables are at 1985 constant prices.

Table 2A Estimates of Total Factor Productivity Growth in South Korea (Aggregate Capital and Labor)

Year	Growth of			Average Capital Share	Percentage Contribution of		
	Output	Capital	Labor		Capital	Labor	TFPG
65-70	0.5274	1.0840	0.1409	0.3803	0.7817	0.1655	0.0528
70-75	0.4162	0.6866	0.1906	0.3368	0.5555	0.3037	0.1408
75-80	0.3612	0.7990	0.1581	0.2278	0.5039	0.3380	0.1581
80-85	0.4038	0.4577	0.0759	0.2238	0.2537	0.1458	0.6005
85-90	0.4865	0.5662	0.1703	0.2704	0.3147	0.2554	0.4299
65-90	2.1951	3.5934	0.7357	0.2884	0.4721	0.2385	0.2894

Table 2B Estimates of Total Factor Productivity Growth in South Korea (Differentiated Capital and Labor)

Year	Growth of			Average Capital Share	Percentage Contribution of		
	Output	Capital	Labor		Capital	Labor	TFPG
65-70	0.5274	1.0284	0.1479	0.3803	0.7416	0.1738	0.0846
70-75	0.4162	0.7243	0.1840	0.3368	0.5860	0.2933	0.1207
75-80	0.3612	0.8601	0.1558	0.2278	0.5424	0.3331	0.1245
80-85	0.4038	0.4619	0.0906	0.2238	0.2560	0.1742	0.5698
85-90	0.4865	0.5969	0.1823	0.2704	0.3318	0.2734	0.3948
65-90	2.1951	3.7012	0.7434	0.2884	0.4862	0.2410	0.2728

Notes: - Output and factor growth rates are natural log differences.
- Output and capital variables are at 1985 constant prices.

Table 3A Estimates of Total Factor Productivity Growth in Taiwan (Aggregate Capital and Labor)

Year	Growth of			Average Capital Share	Percentage Contribution of		
	Output	Capital	Labor		Capital	Labor	TFPG
63-68	0.4956	0.7736	0.1359	0.0886	0.1383	0.2499	0.6118
68-73	0.5604	0.7903	0.2273	0.1579	0.2226	0.3416	0.4358
73-78	0.4140	0.6442	0.1603	0.2307	0.3590	0.2979	0.3431
78-83	0.3248	0.4962	0.1374	0.2710	0.4140	0.3084	0.2776
83-88	0.4464	0.3098	0.1266	0.2516	0.1747	0.2123	0.6130
88-90	0.1205	0.1801	0.0211	0.2445	0.3655	0.1324	0.5021
88-91	0.1908	0.2686	0.0383	0.2350	0.3308	0.1535	0.5157
68-90	1.8661	2.4207	0.6728	0.2275	0.2951	0.2785	0.4264
63-91	2.4320	3.2828	0.8259	0.2014	0.2718	0.2712	0.4570

Table 3B Estimates of Total Factor Productivity Growth in Taiwan (Differentiated Capital and Labor)

Year	Growth of			Average Capital Share	Percentage Contribution of		
	Output	Capital	Labor		Capital	Labor	TFPG
68-73	0.5604	0.8890	0.2251	0.1579	0.2504	0.2914	0.4582
73-78	0.4140	0.6375	0.3360	0.2307	0.3553	0.5458	0.0989
78-83	0.3248	0.5287	0.2145	0.2710	0.4410	0.4313	0.1277
83-88	0.4464	0.3297	0.1626	0.2516	0.1859	0.2424	0.5717
88-90	0.1205	0.1923	0.0494	0.2445	0.3902	0.3101	0.2997
68-90	1.8661	2.5897	0.9418	0.2275	0.3157	0.3783	0.3060

Notes: - Output and factor growth rates are natural log differences.
- Output and capital variables are at 1986 constant prices.

Table 4 Decomposition of Growth Rates in Japan, Korea, Taiwan

Country/ Period	Average Growth of Output Attributable to			Average Output Growth
	Capital	Labor	TFP	
Japan 1965-91	1.68	1.20	2.56	5.44
Korea 1965-90	4.27	2.12	2.39	8.78
Taiwan 1968-90	2.68	3.21	2.59	8.48

Appendix: Data Sources

Japan

Gross Domestic Product : Annual Report on National Accounts, Economic Planning Agency, Government of Japan, various issues. Economic Statistics Annual, Research and Statistics Department, Bank of Japan, 1992.

Gross Domestic Fixed Capital Formation : Economic Statistics Annual, Research and Statistics Department, various issues.

Labor Force (in 10,000 persons) : Economic Statistics Annual, various issues.

Aggregate Compensation of Employees : Annual Report on National Accounts Economic Planning Agency, Government of Japan, 1982 & 1992. Economic Statistics Annual, Research and Statistics Department, various issues.

Consumer Price Index : Economic Statistics Annual, 1971, 1981, and 1992.

Paid Employees and Working Population (in 10,000 persons) : Yearbook of Labour Statistics, Division of Labour Statistics and Research, Ministry of Labour, Japan, various issues.

Wages: Yearbook of Labour Statistics, Ministry of Labour, Japan, various issues.

Differentiated Capital Components: Economic Statistics Annual, Statistics Department, Bank of Japan, 1971, 1972, 1976, and 1992. Annual Report on National Accounts, Economic Planning Agency, Government of Japan, 1992.

Differentiated Labor Components: Yearbook of Labour Statistics, Policy Planning and Research Department, Ministry of Labour, Japan, various issues. Annual Report on the Labour Force Survey, Bureau of Statistics, Office of the Prime Minister, Japan. various issues.

Korea

Gross Domestic Product : National Income Statistics Yearbook, The Bank of Korea, 1972. National Accounts, The Bank of Korea, 1990. Korea Statistical Yearbook, National Bureau of Statistics, Economic Planning Board, ROK, 1992.

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Taiwan

Gross Domestic Product : National Income in Taiwan Area of the Republic of China, DGBAS, Republic of China, 1991, pp. 72-75.

Gross Domestic Fixed Capital Formation (GDFCF): National Income in Taiwan Area of the Republic of China, 1991, Table 15, pp. 130-137, for 1951-1990; for 1991, Taiwan Statistical Data Book, 1992.

Labor Force : for 1951-1968, Taiwan Statistical Data Book, 1992, p.13; for 1968-1991, Statistical Yearbook of the Republic of China, 1992, p.52.

Aggregate Compensation of Employees: derived from data in the National Income in Taiwan Area of the Republic of China, 1991, Accounts 1 & 2, pp. 30-41.

Paid Employees: Yearbook of Manpower Survey Statistics, Taiwan Area, Republic of China, 1990, and Statistical Yearbook of the Republic of China, 1975 and 1992.

Working Population: 1963-64: Taiwan Statistical Data Book, Council for Economic Planning and Development, Republic of China, 1991. for 1968-91: Statistical Yearbook of the Republic of China, 1992.

Differentiated Capital Stock: National Income in Taiwan Area of the Republic of China, 1991, Table 14, pp. 116-129 for current prices, and Table 15, pp. 130-137 for constant prices.

Income Data: derived from an approximation of the maximum likelihood estimate of 154 cells using the iterative proportional fitting technique suggested by Bishop, Fienberg, and Holland (1975) with data from: 1. Report on the Survey of Personal Income Distribution in Taiwan Area, Republic of China, DGBA, Statistics, Executive Yuan, ROC, various issues. 2. Statistical Yearbook of the Republic of China, 1991.

Consumer Price Index: Statistical Yearbook of the Republic of China, 1992, p. 296.

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