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THE TYRANNY OF NUMBERS: CONFRONTING THE STATISTICAL REALITIES OF THE EAST ASIAN GROWTH EXPERIENCE

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ABSTRACT

This paper documents the fundamental role played by factor accumulation in explaining the extraordinary postwar growth of Hong Kong, Singapore, South Korea and Taiwan. Participation rates, educational levels and (with the exception of Hong Kong) investment rates have risen rapidly in all four economies. In addition, there have been large intersectoral reallocations of labour, with (again, excepting Hong Kong) non-agricultural and manufacturing employment growing one and a half to two times as fast as the aggregate working population. Thus, while the growth of output per capita in these economies has averaged 6% to 7% per annum over the past two and a half decades, the growth of output per effective worker in the non-agricultural sector of these economies has been only 3% to 4% per annum. If one then allows for the doubling, tripling and even quadrupling of the investment to GDP ratio in these economies, one arrives at total factor productivity growth rates, both for the non-agricultural economy and for manufacturing in particular, which are well within the bounds of those experienced by the OECD and Latin American economies over equally long periods of time. While the growth of output and manufacturing exports in the newly industrializing economies of East Asia is virtually unprecedented, the growth of total factor productivity in these economies is not.

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I. Introduction

This is a fairly boring and tedious paper, and is intentionally so. This paper provides no new interpretations of the East Asian experience to interest the historian, derives no new theoretical implications of the forces behind the East Asian growth process to motivate the theorist, and draws no new policy implications from the subtleties of East Asian government intervention to excite the policy activist. Instead, this paper concentrates its energies on providing a careful analysis of the historical patterns of output growth, factor accumulation and productivity growth in the Newly Industrializing Countries of East Asia, i.e. Hong Kong, Singapore, South Korea and Taiwan.

Tables 1-1 and 1-2 and figure 1 below present some basic information on growth in the NICs, drawn from national accounts and census sources.[1] As seen in table 1-1, the extraordinarily rapid and sustained growth of output per capita in all four economies, averaging some 6% to 7% per annum for two and a half decades, is truly remarkable. It is this record of growth, along with its apparent association with the rapid growth of manufactured exports, that has led most economists to believe that productivity growth in these economies must be extraordinarily high, particularly in their manufacturing sectors. This view, however, ignores an equally remarkable record of factor accumulation.

As table 1-1 shows, one important area of factor accumulation has been labour input. The rapid post-war decline in birth rates (changing dependency ratios) and rising rates of female labour force participation have led to a substantial rise in the aggregate participation rate in each

[1] The appendix provides a full description of sources. All growth rates reported in this paper are logarithmic, rather than geometric, growth rates. The labour force estimates for Korea and Taiwan exclude their large (predominantly conscript) armies, whose measured output (in the form of wages) is comparatively small. Section VI below examines the sensitivity of the results reported in this paper to the inclusion/exclusion of military personnel.

of the NICs.[2] In moving to measures of output per worker, rising participation rates remove an average of 1% per annum from the per capita growth rate of Hong Kong, 1.2% and 1.3% per annum from Korea and Taiwan, respectively, and a stunning 2.6% per annum (for 24 years!) from the growth rate of Singapore. Intersectoral transfers of labour have also been extremely important. Thus, removing agriculture from the analysis lowers the growth rate of output per worker in Taiwan and South Korea by .6% and .7% per annum, respectively, reflecting the rapid decline in the share of agricultural employment in total employment in both economies.[3] Although the growth of manufacturing output has been unusually rapid in these economies, so has the growth of manufacturing employment. Once one accounts for the transfer of labour into manufacturing one finds, surprisingly, that, as regards labour productivity growth, manufacturing in both Singapore and Taiwan actually underperformed the aggregate economy.

Capital input has also grown rapidly in the NICs. As shown in figure 1, although the investment to GDP ratio has remained roughly constant in Hong Kong, in the other NICs it has risen substantially over time. In Singapore, the constant price investment to GDP ratio, at 11% in 1960 had reached 38% by 1980 and an extraordinary 47% by 1984, after which it declined substantially, only to begin another rise in the late 1980s. In South Korea, investment rates, which were around 5% (in constant prices) in the early 1950s, exploded up to 20% in the mid-60s, reached 30% in the early 1980s, and were approaching 40% by 1991. Finally, in Taiwan, the constant price investment to GDP ratio, at around 10% in the early 1950s, grew steadily to a high of 27% in 1975, after which it fluctuated around a value of 20%.

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[2] Changes in age specific male participation rates are minimal in all four economies, while, with the exception of Hong Kong (where they fell), reported hours of work have remained roughly constant. This suggests that the increase in participation is genuine, and not some statistical artifact.

[3] This intersectoral transfer was strongest in Taiwan during the 1970s, when the difference in the growth of output per worker was 2.2% (5.7% vs. 3.5%), and in Korea during the 1980s, when the difference in growth rates was 1.6% (6.7% vs. 5.1%).

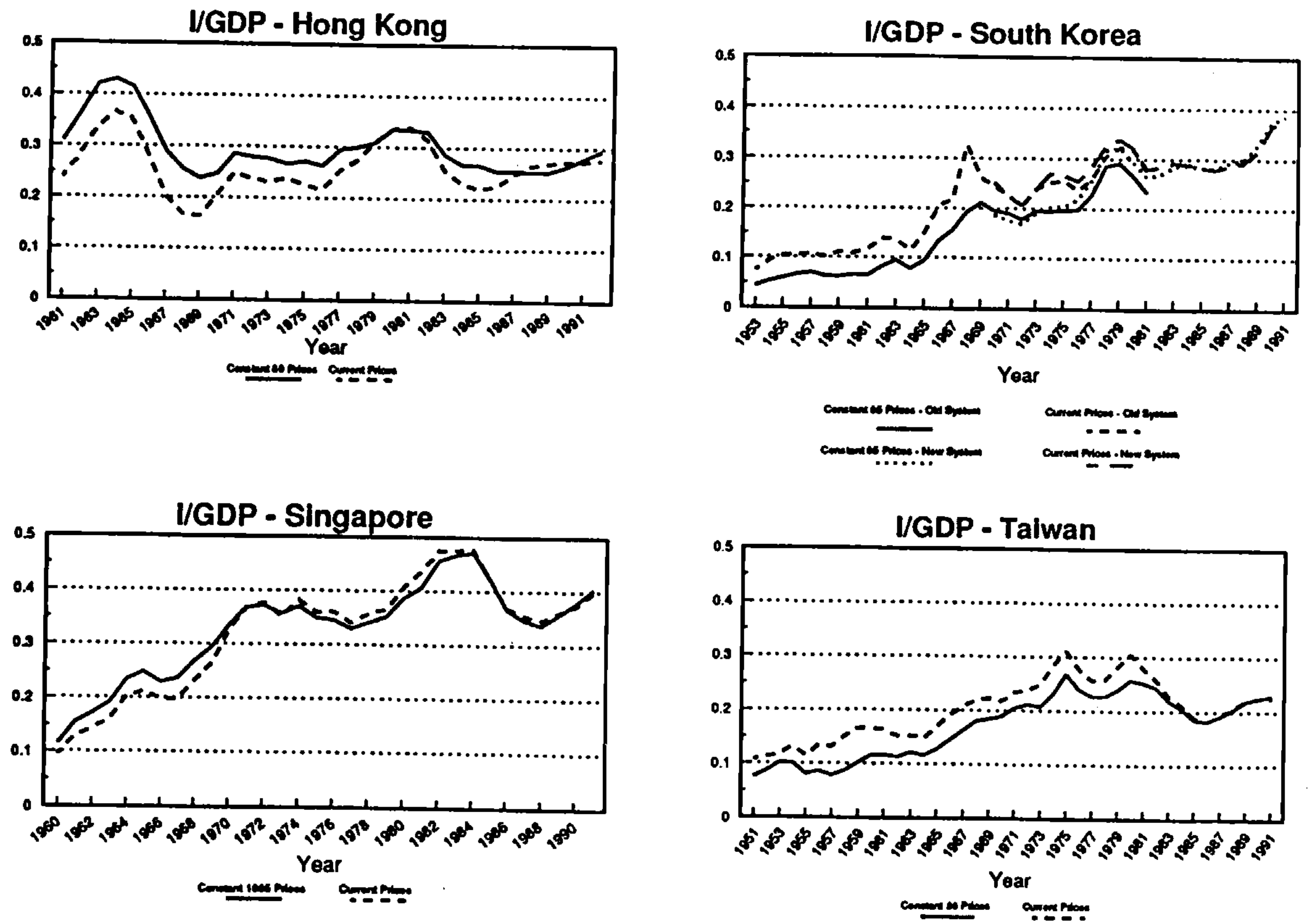
Table 1-1: Growth Rates (%)						
	Hong Kong (1966-1991)			Singapore (1966-1990)		
	N	D	N-D	N	D	N-D
GDP per Capita:	7.3	1.6	**5.7**	8.5	1.9	**6.6**
GDP per Worker:	7.3	2.6	**4.7**	8.5	4.5	**4.0**
Excluding Agriculture	NA	2.8	NA	8.6	4.6	**4.0**
Manufacturing	NA	1.3	NA	10.1	6.2	**3.9**
Δ Participation Rate:	.38 → .49			.27 → .51		
	South Korea (1966-1990)			Taiwan (1966-1990)		
	N	D	N-D	N	D	N-D
GDP per Capita:	8.5	1.8	**6.9**	8.6	1.8	**6.8**
GDP per Worker:	8.5	2.8	**5.7**	8.6	3.1	**5.5**
Excluding Agriculture	10.4	5.4	**5.0**	9.4	4.6	**4.9**
Manufacturing	14.1	6.3	**7.8**	10.8	5.9	**4.9**
Δ Participation Rate:	.27 → .36			.28 → .37		

N = Numerator; D = Denominator; NA - The Hong Kong government has yet to develop constant price estimates of GDP by sector. GDP measures are at market prices, i.e. including indirect taxes and import duties.

Table 1-2: Educational Attainment of the Working Population (%)								
	Hong Kong		Singapore		South Korea		Taiwan	
	1966	1991	1966	1990	1966	1990	1966	1990
None	19.2	5.6	55.1	⇓	31.1	6.4	17.0	4.5
Primary	53.6	22.9	28.2	33.7	42.4	18.5	57.2	28.0
Secondary+	27.2	71.4	15.8	66.3	26.5	75.0	25.8	67.6

Notes: Self taught are included under primary. Hong Kong, Korean and Taiwanese data refer to highest level of education "attended" rather than completed. All percentages calculated net of those reported as "unknown".

Figure 1: I/GDP Ratios



Human capital accumulation in the East Asian NICs has also been quite rapid. As shown in table 1-2 above, over the past two and a half decades the proportion of the working population with a secondary education or more doubled in Hong Kong and Taiwan, tripled in Korea and quadrupled in Singapore. By 1990/1991, some 18% to 20% of the working population in each economy had some tertiary education.[4] In weighting labour input by sex, age and educational characteristics (discussed further below), I have found that the improving educational attainment of the workforce contributes to about 1% per annum additional growth in labour input in each of these economies.

All of the influences noted above, rising participation rates, intersectoral transfers of labour, improving levels of education, and expanding investment rates, serve to chip away at the productivity performance of the East Asian NICs, drawing them from the top of Mount Olympus down to the plains of Thessaly. In a companion paper (Young 1993), I use simple back of the envelope calculations and large international data sets to show that, as regards productivity growth in the aggregate economy and in manufacturing in particular, the NICs cannot be considered to be strong outliers in the post-war world economy. This paper concentrates on a more careful analysis of these four economies, making use of the extensive statistical record embodied in their national accounts, population censuses, and sectoral, wage and labour force surveys.

The remainder of this paper is organized as follows: Section II presents a short review of methodology. Sections III-VI then provide a country by country analysis of aggregate and sectoral total factor productivity growth. Section VII contrasts this research with earlier work on

[4] Defined as junior college and above in Korea and Taiwan and matriculation/A levels and above in Hong Kong and Singapore.

productivity growth in the NICs, while section VIII summarizes and concludes. An appendix provides a description of sources and some of the problems encountered in linking different data series.

II. Methodology

The Translog Index of Total Factor Productivity Growth

Consider the translogarithmic value added production function:

$$(2.1)\quad Q = \exp[\alpha_0 + \alpha_K \ln K + \alpha_L \ln L + \alpha_t t + \frac{1}{2}B_{KK}(\ln K)^2$$
$$+ B_{KL}(\ln K)(\ln L) + B_{Kt}\ln K \cdot t + \frac{1}{2}B_{LL}(\ln L)^2 + B_{Lt}\ln L \cdot t + \frac{1}{2}B_{tt}t^2]$$

where K, L and t denote capital input, labour input and time, and where, under the assumption of constant returns to scale, the parameters α_i and B_{jk} satisfy the restrictions:

$$(2.2)\quad \alpha_K + \alpha_L = 1 \qquad B_{KK} + B_{KL} = B_{LL} + B_{KL} = B_{Kt} + B_{Lt} = 0$$

First differencing the logarithm of the production function provides a measure of the causes of growth across discrete time periods:

$$(2.3)\quad \ln\left(\frac{Q(T)}{Q(T-1)}\right) = \overline{\Theta}_K \ln\left(\frac{K(T)}{K(T-1)}\right) + \overline{\Theta}_L \ln\left(\frac{L(T)}{L(T-1)}\right) + TFP_{T-1,T}$$

$$\text{where}\quad \overline{\Theta}_i = \frac{\Theta_i(T) + \Theta_i(T-1)}{2}$$

and where the Θ_i's denote the share of each factor in total factor payments. The translog index of TFP growth ($TFP_{T-1,T}$) provides a measure of the amount the log of output would have increased had all inputs remained constant between two discrete time periods. In essence, the translog production function provides a theoretical justification for the use of average factor shares and log differences as a means of extending the continuous time Divisia analysis of productivity growth to data based upon discrete time periods.

To allow consideration of more finely differentiated inputs, one can assume that aggregate capital and labour input are, in turn, constant returns to scale translog indices of sub-inputs:[5]

$$(2.4)\quad K = \exp[\alpha_1^K \ln K_1 + \alpha_2^K \ln K_2 + \ldots + \alpha_n^K \ln K_n + \frac{1}{2}B_{11}^K(\ln K_1)^2 + B_{12}^K(\ln K_1)(\ln K_2) + \ldots + \frac{1}{2}B_{nn}^K(\ln K_n)^2]$$

$$L = \exp[\alpha_1^L \ln L_1 + \alpha_2^L \ln L_2 + \ldots + \alpha_m^L \ln L_m + \frac{1}{2}B_{11}^L(\ln L_1)^2 + B_{12}^L(\ln L_1)(\ln L_2) + \ldots + \frac{1}{2}B_{mm}^L(\ln L_m)^2]$$

First differencing the logarithms of these translog indices provides a measure of the growth of aggregate capital and labour input as weighted averages of the growth rates of their sub-inputs:

$$(2.5)\quad \ln\left(\frac{K(T)}{K(T-1)}\right) = \sum_i \bar{\theta}_{K_i} \ln\left(\frac{K_i(T)}{K_i(T-1)}\right) \qquad \ln\left(\frac{L(T)}{L(T-1)}\right) = \sum_j \bar{\theta}_{L_j} \ln\left(\frac{L_j(T)}{L_j(T-1)}\right)$$

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

and where the θ_i's denote the share of each sub-input in total payments to its aggregate factor. In a manner analogous to the continuous time Divisia analysis, these indices adjust for improvements in the "quality" of aggregate capital and labour input by, to a first order approximation, weighting the growth of each sub-input by its average marginal product.

The appropriate measure of capital and labour input is the flow of services emanating from those inputs. For labour, one can reasonably assume that the flow of services is proportional to total hours of work, i.e. $L_j(T) = \lambda_{L_j} H_j(T)$, with:

[5] With similar restrictions on parameter values.

$$(2.6)\quad \ln\left(\frac{L(T)}{L(T-1)}\right)=\sum_j \bar{\theta}_{L_j}\ln\left(\frac{H_j(T)}{H_j(T-1)}\right)$$

Since data on capital utilization are rare, it is customary to assume that the flow of capital services is proportional to the measured capital stock (denoted by $A_i(T)$), with $K_i(T) = \lambda_{K_i} A_i(T)$ and:

$$(2.7)\quad \ln\left(\frac{K(T)}{K(T-1)}\right)=\sum_i \bar{\theta}_{K_i}\ln\left(\frac{A_i(T)}{A_i(T-1)}\right)$$

Measuring Factor Supplies

My analysis focuses on two aggregate inputs, capital and labour, subdivided into finer sub-input categories. In general, I divide capital input into five categories: residential buildings, non-residential buildings, other durable structures, transport equipment and machinery. With the exception of my analysis of Singaporean manufacturing, I do not include land input, which is difficult to measure. To minimize any error, I focus my analysis of Taiwan and Korea on the non-agricultural economy, where land input accounts for only a small percentage of total payments to factors of production.[6,7] Labour is distinguished on the basis of sex (two categories), age (nine to eleven categories, depending upon the country and time period under consideration), and education (two to seven categories).

The stock of each capital input is measured using the perpetual inventory method with

[6] For example, Kim & Park (1985, table 5-13) estimate that during the 1960s and 1970s land input accounted for only about 4% of Korean non-agricultural non-residential income.

[7] I also do not include inventories. I have found that the "changes in stocks" series published by most of the NICS are either (i) outright gross fabrications used to conceal large discrepancies between the production and expenditure accounts; and/or (ii) based upon the flimsiest of data. In Young (1992) I made use of unpublished stocks data provided to me by the Singaporean and Hong Kong governments. Problems with the existence of accurate stocks data for the other economies, combined with a growing suspicion as to the accuracy of the Hong Kong numbers, have led to me to drop consideration of stocks from the analysis.

geometric depreciation,[8] where I initialize the capital stock by assuming that the growth rate of investment in the first five years of the investment series is representative of the growth of investment prior to the beginning of the series.[9,10] Given positive rates of depreciation and a sufficiently long investment series prior to the first date of the analysis, the perpetual inventory approach is fairly insensitive to the level of capital used to initialize the series. For Hong Kong, the published investment series begins in 1961. I use my own estimates of capital formation, which mimic the methodology of the Hong Kong government, to extend the series on all asset types back to 1947. For Singapore the published investment series begins in 1960. I use data on the construction of one-family equivalent residential units and retained imports of cement[11] to extend the residential and non-residential durable structures investment series back to 1947.[12] For

[8] The depreciation rates are based upon the Hulten-Wykoff estimates of geometric depreciation rates for detailed asset types. I derive the depreciation rate for each of the five broad asset types used in my analysis as the unweighted average of the depreciation rates of the detailed asset types likely to be found in each industry. This approach is crude, but the results are, in any case, not sensitive to moderate adjustments in the depreciation rates (see, for example, Young 1992).

[9] Specifically:

$$K_0^j = \sum_{i=0}^{\infty} I_{-i-1}^j (1-\delta_j)^i = I_0^j/(g_j+\delta_j)$$

where I_0^j is the first year of investment data for asset j, δ_j is the depreciation rate for asset j, and g_j is the average growth of investment in asset j in the first five years of the investment series.

[10] An exception is Singaporean manufacturing, where, because of a lack of lengthy (and consistent) historical series, I use the Net Fixed Assets reported in the Census of Industrial of Production to initialize the capital stock in 1969.

[11] Singapore did not produce cement prior to 1961. See the Malayan Digest of Statistics.

[12] The estimates using retained imports of cement are, admittedly, rather crude. These data, however, suggest a large surge in construction activity in the mid-1950s (which I have not been able to corroborate), with the real value of investment in durable structures in the mid-1950s exceeding the levels recorded in the early-1960s. Although I feel these data are suspect, I make use of them in order to bias the results in favour of Singapore.

Taiwan the published investment series begins in 1951 and for South Korea in 1953.[13] In general, I focus my analysis on the post-1966 period, allowing each economy 13 or more years of investment data to establish the capital stock.[14]

Turning now to the measurement of labour inputs, my task is to estimate the working population, cross-classified by up to seven attributes, i.e., industry, sex, age, education, income, hours of work, and class of worker. Census and survey data frequently contain information on row and column sums in lower dimensions. Under the assumption that there are no interactions across attributes other than those present in the available sub-dimensional tables, I derive an approximation of the maximum likelihood estimate of each cell using the iterative proportional fitting technique suggested by Bishop, Fienberg and Holland (1975). In general, I make use of the information provided by additional worker characteristics, e.g. occupation, which, in their cross-tabulation with attributes of interest to me provide additional information. Thus, for example, I actually estimate the 1990 Singaporean working population cross-classified by industry x occupation x class of worker x sex x age x education x income, using all available census tabulations.[15] For my TFP estimates, I then sum across occupational categories to derive a reduced six-dimensional table of the variables of interest to me.

All four economies conduct occasional censuses and, on a more regular annual basis,

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[13] I have found extensive Japanese data on pre-war investment in Korea and Taiwan. I have yet to find, however, an appropriate deflator with which to link the pre and post-war series, as well as a means of adjusting for wartime damage in Korea.

[14] To analyze the sensitivity of the results to the value of capital used to initialize the series, I also tried initial values of (i) zero capital and (ii) double the capital implied by the procedure described above. The impact of these (substantial) adjustments on average total factor productivity growth during the 1966-1990 period was (-.1%,+.1%) per annum in Hong Kong and Taiwan, (-.1%,+.2%) per annum in Singapore, and (-.4%,+.3%) per annum in Korea (where the pre-1966 investment series is shorter).

[15] Hours of work data are drawn from other, non-Census, sources.

surveys of labour force conditions. The labour force surveys are, however, subject to an enormous margin of error. Thus, for example, the 1989 Singaporean Labour Force Survey estimated the working population at 1,277,254, with 51.2% having completed a secondary education or more. The 1990 Census, however, found that the actual working population numbered 1,537,011 (i.e 20% more than reported in the previous survey), with 66.3% having completed a secondary education or more. Similarly, the 1980 Korean Economically Active Population Survey estimated the non-agricultural working population at 9,048,000, whereas the 1980 Census put the number at 7,887,308, or 13% less. Aside from their small sample sizes,[16] the principal problem underlying the inaccuracy of the labour force surveys is the fact that their scaling factors are drawn from the previous census. Since these economies are experiencing rapid transformation, these scaling factors tend to be grossly inaccurate. As the surveys are updated with the new census scaling factors, their estimates become consistent with the most recent census results. Thus, for example, the 1991 Singaporean Labour Force Survey estimated the working population at 1,524,315. In the estimates below, I confine myself to census years, treating the census results as the appropriate measure of the "population" and the survey results as a "sample", making use of these, when they contain cross-tabulations which are unavailable in the census, by conforming the survey row and column totals to those given by the census. Since, over the long run, the labour force surveys track (with large variance) the census, the long-term average rates of productivity growth reported below are not dependent on this choice of

[16] For example, 25000 housing units in the case of the 1989 Singaporean labour force survey and less than 15000 households in the case of the 1980 Korean economically active population survey.

sources.[17]

Finally, I should note that to improve the accuracy of my labour force estimates I have acquired thousands of pages of unpublished census tabulations from the governments of Hong Kong and Singapore, while, in the case of Taiwan, I have made use of the Chinese language area and district census tabulations, which contain additional tabulations over and beyond those reported in the summary English language volumes. These additional tabulations provide valuable information. Thus, for example, unpublished Hong Kong tabulations relate income by class of worker (e.g. self-employed, employee, etc.) cross tabulated by attributes such as age, sex and education. In contrast, the published tabulations rarely cross tabulate income with class of worker. Consequently, relying on the published tabulations alone pollutes one's estimates of the returns to different types of labour input with non-labour capital income.

Measuring Factor Shares

In order to estimate the share of labour and capital in total payments to factors of production, it is necessary to measure value added from the point of view of the producer. This requires removing all indirect business taxes on the value of output (including all sales and excise taxes), while retaining all subsidies and taxes on factors of production (such as license fees and profits taxes), a concept of value added midway between GDP at factor cost and GDP at market prices. In the case of Hong Kong and Singapore, where indirect and sales taxes are minimal, I simply take as my measure of output the national accounts estimates of GDP at current factor cost. In Korea and Taiwan, however, "indirect taxes", as reported in the national accounts, are enormous and defined in an extraordinarily broad manner, including items such as

[17] In fact, during the period emphasized in this paper (1966-1990) the labour force surveys actually imply faster growth in the non-agricultural working population in both South Korea and Taiwan (the labour force surveys for Hong Kong and Singapore began in the mid to late 1970s and hence do not cover the entire period of analysis).

taxes on the monopoly profits of producers of ginseng and cigarettes and land and building property taxes. In these cases I use government financial statistics and unpublished data provided to me by statistical authorities to separate out the "admissable" indirect taxes, i.e. those which are part of the value of output from the point of view of the producer, and allocate them to the different economic sectors. Of these adjustments, the principal one is the allocation of monopoly profits taxes to value added in the manufacturing sector, so that the reader who makes this adjustment (to GDP at factor cost) will arrive at estimates of value added from the point of view of the producer close to those used in the analysis below.

To estimate the share of labour in total factor payments, I begin by constructing estimates of the hourly incomes of employees cross-tabulated by industry, sex, age and education. I then use these compensation data, and my estimates of hours of work cross-tabulated by industry, sex, age, education and class of worker, to estimate the incomes of employees and the implicit labour income of employers, unpaid family workers and the self-employed. To determine the share of labour in each sector, I then multiply the sectoral compensation of employees data reported in the national accounts by one plus my sectoral estimates of the ratio of implicit to explicit labour income.[18] Combining my measures of implicit and explicit income provides an estimate of sectoral labour income cross-classified by the sex, age and educational characteristics of workers and, hence, an estimate of the share of each labour sub-input in total payments to labour by sector.

Turning to capital input, under the assumption of perfect competition and constant returns

[18]This rescaling using the national accounts data corrects for underreporting of income on the part of workers and, also, adjusts for labour taxes and non-monetary compensation, all of which form a part of cost of labour input from the point of view of the producer.

to scale, I take the aggregate share of capital by sector to be simply one minus the estimated share of labour. To allocate capital income by asset type, I note that with geometric depreciation, and perfect foresight, the rental price of a capital good k_i is given by:[19]

$$(2.8) \quad P_{k_i}(T) = P_{I_i}(T-1)r(T) + \delta P_{I_i}(T) - [P_{I_i}(T) - P_{I_i}(T-1)]$$

where P_{I_i} denotes the investment price of capital good i and $r(T)$ is the nominal rate of return between periods T-1 and T. Under the assumption that all assets earn the same nominal rate of return, I vary r(T) until total payments to capital equal my estimate of the aggregate share of capital. This yields estimates of the rental price of each asset category and, by extension, its share of payments to capital.

[19] This equation can be modified to take into account taxes and depreciation allowances.

III. Hong Kong

Table 3-1 below presents estimates of total factor productivity growth in Hong Kong. With the exception of the 1981-1986 period, when business activity was depressed by the Anglo-Chinese negotiations over the future of the colony, Hong Kong sustained total factor productivity growth rates of 2% or more in each of the five year periods, averaging 2.3% over the 1966-1991 period as a whole. As one would expect, given the constancy of the post-1966 investment to GDP ratio, there is little evidence of capital-deepening, with weighted capital input growing only .7% faster per annum than output during the 1966-1991 period. Surprisingly, the weighting of capital and labour input has little effect on the estimates of the growth of these factors of production, with the growth rate of the "raw" inputs (the simple sum of the sub-components) closely approximating that of the weighted inputs (weighting each sub-component by its average factor share). In the case of labour input, this is simply due to the fortuitous cancelling of various effects, with adjustments for sex, hours of work and age (prior to 1976) lowering the growth rate of labour input, and adjustments for education and age (after 1976) raising the growth rate of labour input. The net effect is, however, important in individual sub-periods and, in particular, is substantially positive during the late 1980s, when the stabilization of female participation rates, ageing of the labour force, and rising educational attainment, all served to increase measured labour input. This pattern is repeated in the other economies and, for reasons of space, will, in general, not be commented upon further.[20]

[20] Tables detailing the impact of each adjustment (age, sex, etc) in each sub-period for the four economies are available upon request from the author.

Table 3-1: Total Factor Productivity Growth - Hong Kong							
	Annual Growth of:						
Time Period	Output	Raw Capital	Weighted Capital	Raw Labour	Weighted Labour	TFP	Labour Share
61-66	0.109	0.169	0.162	0.032	0.025	0.035	0.643
66-71	0.065	0.075	0.078	0.025	0.024	0.023	0.660
71-76	0.081	0.075	0.080	0.033	0.024	0.039	0.662
76-81	0.099	0.093	0.098	0.051	0.064	0.022	0.617
81-86	0.058	0.078	0.079	0.019	0.027	0.009	0.593
86-91	0.063	0.062	0.066	0.005	0.022	0.024	0.609
66-91	**0.073**	**0.077**	**0.080**	**0.026**	**0.032**	**0.023**	**0.628**

"Raw" inputs - the arithmetic sum of sub-components, with no adjustment for hours of work; "Weighted" - translog indices of factor input growth, with labour services measured by hours of work.

IV. Singapore

Table 4-1 below presents estimates of total factor productivity growth in Singapore. Although the late 1960s appear to have been a period of rapid productivity growth, these gains were lost (and then some) during the 1970s and 1980s. With weighted capital input growing an average of 3.0% per annum faster than output and output per unit of effective labour input growing only 2.8% per annum, the total factor productivity residual for the aggregate economy averages an extraordinary -0.3% per annum *over a twenty-four year period*, a virtually unprecedented record of productivity regress.[21] Interestingly, although the growth of capital input has slowed down over time (as the investment rate has stabilized around 40% of GDP), the growth of human capital has accelerated. While weighted labour input grew 2.1% slower than raw labour in the late 1960s, it rose 3.0% faster in the 1980s (due to large increases in the age and educational attainment of the workforce). The changing role of physical and human capital accumulation in sustaining growth is reflected in the decline in the growth of output per effective worker, which went from 9.2% in the late 1960s, to 2.7% in the 1970s, to .2% in the 1980s.

[21] I should emphasize to the reader that, as noted in section II above, I use data on cement imports to estimate extremely high levels of investment in durable structures during the 1950s (estimates which I have not been able to corrobate using other sources). If anything, the total factor productivity growth rates presented in table 4-1 are likely to be overestimates.

Table 4-1: Total Factor Productivity Growth - Singapore							
	Annual Growth of:						
Time Period	Output	Raw Capital	Weighted Capital	Raw Labour	Weighted Labour	TFP	Labour Share
Economy:							
66-70	0.125	0.119	0.133	0.054	0.033	0.039	0.467
70-80	0.085	0.122	0.138	0.050	0.058	-0.016	0.466
80-90	0.068	0.091	0.084	0.036	0.066	-0.007	0.477
66-90	**0.085**	**0.108**	**0.115**	**0.045**	**0.057**	**-0.003**	**0.470**
Manufacturing:*							
70-80	0.103	0.123	0.130	0.086	0.089	-0.009	0.423
80-90	0.067	0.090	0.094	0.021	0.051	-0.011	0.385
70-90	**0.085**	**0.107**	**0.112**	**0.054**	**0.070**	**-0.010**	**0.404**
(*) Only covering firms recorded in the Census of Industrial Production.							

Although the Singaporean national accounts do not estimate capital formation by sector, it is possible to make use of the annual Census of Industrial Production (CIP), which contains data on fixed assets, capital formation, employment, value added, output and production costs, to derive total factor productivity growth estimates for the manufacturing sector. The CIP is the principal source of information on Singaporean manufacturing and, along with departmental data on prices, forms the basis of Singapore's Index of Industrial Production (IIP), which in turn is the basis of the national accounts estimates of the constant price growth of manufacturing value added. I regret to inform the reader, however, that (i) 40% or more of the output recorded in the IIP is *undeflated*, i.e. for many manufacturing sub-sectors the "index" is simply the growth of nominal output; and (ii) the Singaporean national accounts use this *undeflated output index* as their measure of the constant price growth of manufacturing value added. Following the lead of the Singaporean statistical authorities, I use the IIP as my measure of the growth of value added in the CIP firms.[22]

As shown in table 4-1, over the 1970 to 1990 period as a whole total factor productivity growth in Singaporean manufacturing averaged -1.0% per annum, a performance approximately equal to that of the aggregate economy during the same period. As in the case of the aggregate economy, the principal source of low productivity growth in Singaporean manufacturing is the combination of a slow growth of output per weighted worker (1.6% per annum) and a rapid fall in output per unit of capital input (-2.7% per annum).[23] Given the IIP's questionable (i.e. non-existent) deflators, these estimates are clearly grossly inaccurate and are simply meant to show what can be accomplished at the sectoral level given the current state of Singaporean data.

[22] Although much of manufacturing output is undeflated, the reader should not jump to the conclusion that the IIP overstates the growth of the manufacturing sector. While the undeflated items include many products whose prices have probably been increasing (e.g. printing and transport equipment), they also include many electronics products, whose prices have undoubtably been declining. Interestingly, at one point the Singaporean statistical authorities, who were concerned about their methodology, sought the assistance of the Japanese on this issue, but were assured that non-deflation of manufacturing output was also common practice in that economy (!).

[23] Since the CIP does not contain any information on the age or educational characteristics of the workers in the firms surveyed, I use census data to adjust for the age and educational characteristics of the workforce under the assumption that the workers in the CIP shared the same age and education characteristics as similar sex persons reported as manufacturing workers in the census.

V. South Korea

Table 5-1 below presents total factor productivity growth estimates for South Korea. Although South Korea exhibits even more capital deepening than Singapore, with output per unit of effective capital input falling 3.3% per annum, the larger labour share and faster growth of output per worker (4.0%) combine to give the economy a considerably larger total factor productivity residual (1.6%). Productivity growth in the Korean economy appears to have improved over time, with the average 2.5% growth of the 1980s well above the .8% and 1% growth experienced during the 1960s and 1970s, respectively. Turning to the industry level analysis,[24] we see that manufacturing has had the highest average level of productivity growth. Productivity growth in manufacturing fluctuates dramatically from period to period, but averages 2% to 3% per decade. Productivity growth in other industry and services, while also volatile, has improved on a decade by decade basis, with, in particular, a dramatic rise in other industry from -2.2% in the 1960s to 1.9% in the 1970s and 4.0% in the 1980s. Although the results are not reported in the table, I should note that I have estimated productivity growth in the subsectors of other industry and services, finding average total factor productivity growth rates (during the 1966-1990 period) of -1.1% in mining, 5.1% in electricity, gas & water, 2.1% in construction, 3.3% in transport, storage & communications, and -0.1% in finance, insurance, real estate & business services (1970-1990).[25]

[24] The Korean national accounts include data on capital formation by asset type and by industry, but not by asset type *and* industry. Consequently, my industry level estimates are based upon an aggregate (unweighted) capital input, undifferentiated by asset type, with depreciation rates based upon the average non-residential depreciation rate in the non-agricultural economy.

[25] The detailed tables are available upon request from the author.

Table 5-1: Total Factor Productivity Growth - South Korea

Time Period	Output	Raw Capital	Weighted Capital	Raw Labour	Weighted Labour	TFP	Labour Share
	Annual Growth of:						
Economy - excluding agriculture							
60-66	0.077	0.069	0.069	0.062	0.072	0.006	0.673
66-70	0.144	0.167	0.197	0.095	0.103	0.010	0.673
70-75	0.096	0.121	0.118	0.052	0.055	0.018	0.644
75-80	0.094	0.158	0.176	0.040	0.052	0.001	0.670
80-85	0.087	0.102	0.100	0.031	0.047	0.024	0.701
85-90	0.109	0.105	0.107	0.061	0.072	0.026	0.713
66-90	**0.104**	**0.129**	**0.137**	**0.054**	**0.064**	**0.016**	**0.680**
Manufacturing:							
60-66	0.123	0.108	NA	0.115	0.115	0.011	0.504
66-70	0.204	0.213	NA	0.104	0.108	0.044	0.504
70-75	0.165	0.136	NA	0.084	0.088	0.052	0.477
75-80	0.127	0.210	NA	0.047	0.062	-0.009	0.503
80-85	0.106	0.076	NA	0.019	0.039	0.051	0.547
85-90	0.118	0.147	NA	0.069	0.082	0.008	0.572
66-90	**0.141**	**0.154**	NA	**0.063**	**0.074**	**0.029**	**0.521**
Other Industry:							
60-66	0.127	0.191	NA	0.082	0.097	-0.013	0.537
66-70	0.176	0.263	NA	0.165	0.166	-0.035	0.537
70-75	0.085	0.104	NA	0.006	0.014	0.028	0.528
75-80	0.117	0.181	NA	0.051	0.071	0.009	0.672
80-85	0.089	0.132	NA	0.051	0.051	0.014	0.693
85-90	0.119	0.058	NA	0.040	0.050	0.066	0.674
66-90	**0.115**	**0.143**	NA	**0.058**	**0.067**	**0.018**	**0.624**
Services:							
60-66	0.059	0.054	NA	0.040	0.054	0.005	0.804
66-70	0.118	0.147	NA	0.079	0.089	0.017	0.804
70-75	0.083	0.127	NA	0.043	0.042	0.023	0.782
75-80	0.073	0.141	NA	0.033	0.045	0.008	0.796
80-85	0.074	0.108	NA	0.034	0.047	0.017	0.828
85-90	0.099	0.097	NA	0.060	0.069	0.025	0.821
66-90	**0.088**	**0.123**	NA	**0.048**	**0.057**	**0.018**	**0.806**

Other Industry combines mining, electricity, gas & water and construction. Services combines wholesale & retail trade, restuarants & hotels, transport, storage & communications, finance insurance, real estate & business services and community & social services.

VI. Taiwan

Table 6-1 below presents total factor productivity growth estimates for Taiwan. With output per unit of capital input falling 2.7% per annum, but output per effective worker rising 4.5% per annum (the fastest growth in this sample of four economies, Taiwan exhibits an average rate of productivity growth comparable to that of Hong Kong (2.4%). As table 6-1 shows, the sectoral pattern of productivity growth in Taiwan is markedly different from that in Korea. In the Taiwanese economy manufacturing and other industry appear to be productivity laggards (with average growth rates of 1.5% and 1.2%, respectively), while services seems to have played the role of the productivity powerhouse (with an average growth of 3.4% per annum). Strong differences in the performance of Taiwan and Korea are also apparent within the more detailed sectors of "other industry". Thus, over the 1966-1990 period total factor productivity rose 3.7% per annum in Taiwanese mining (as compared with a decline of -1.1% per annum in Korea) and fell -0.3% per annum in Taiwanese electricity, gas & water (as compared with rapid growth of 5.1% per annum in Korea). Elsewhere, the performance of the two economies was more similar, with productivity in Taiwan rising 1.2% per annum in construction (2.1% Korea), 4.5% per annum in transport, storage & communications (3.3% Korea), and .1% per annum in finance, insurance, real estate & business services (-.1% Korea).[26]

[26] The detailed sectoral estimates are available upon request from the author.

Table 6-1: Total Factor Productivity Growth - Taiwan

	Annual Growth of:						
Time Period	Output	Aggregate Capital	Weighted Capital	Aggregate Labour	Weighted Labour	TFP	Labour Share
Economy (excluding agriculture):							
66-70	0.113	0.152	0.170	0.043	0.044	0.033	0.720
70-80	0.106	0.137	0.143	0.068	0.069	0.015	0.708
80-90	0.080	0.085	0.083	0.024	0.036	0.030	0.701
66-90	**0.096**	**0.118**	**0.123**	**0.046**	**0.051**	**0.024**	**0.710**
Manufacturing:							
66-70	0.168	0.207	0.214	0.078	0.075	0.031	0.558
70-80	0.121	0.145	0.146	0.100	0.103	-0.001	0.566
80-90	0.072	0.078	0.079	0.012	0.027	0.025	0.613
66-90	**0.108**	**0.128**	**0.130**	**0.059**	**0.067**	**0.015**	**0.579**
Other Industry							
66-70	0.104	0.177	0.190	0.100	0.096	-0.020	0.702
70-80	0.112	0.165	0.169	0.063	0.066	0.014	0.691
80-90	0.059	0.058	0.060	0.012	0.025	0.023	0.692
66-90	**0.088**	**0.122**	**0.127**	**0.048**	**0.054**	**0.012**	**0.695**
Services:							
66-70	0.087	0.145	0.162	0.018	0.023	0.040	0.828
70-80	0.094	0.134	0.139	0.049	0.051	0.028	0.827
80-90	0.090	0.094	0.092	0.036	0.041	0.037	0.777
66-90	**0.091**	**0.119**	**0.123**	**0.038**	**0.042**	**0.034**	**0.811**

Other Industry combines mining, electricity, gas & water and construction. Services combines wholesale & retail trade, restuarants & hotels, transport, storage & communications, finance insurance, real estate & business services and community & social services.

It is important to note that part of the extraordinary performance of Taiwanese services is due to the unusual approach taken by the Taiwanese national accounts to the measurement of public sector output. Whereas most national accounts authorities deflate public sector output by the wages of different types of public sector employees, leading to an approximately zero growth in output per effective worker, the Taiwanese national accounts incorporate a "quality adjustment", allowing for the growing (unmeasurable) productivity of public sector employees. According to my estimates, between 1966 and 1990 output per effective worker in the Taiwanese public sector grew 4.4% per annum (6.5% per annum if one includes military personnel in the denominator).[27]

Table 6-2 provides additional total factor productivity measures for Taiwan, where I have adjusted the national accounts measure of public sector output to conform to the more standard (zero growth) deflation technique. As the reader can see, this adjustment has a large impact on the aggregate non-agricultural economy, where productivity growth falls to an average of 1.9%, and an even stronger impact on services, where productivity growth now appears to have averaged 2.5% (which nevertheless remains higher than manufacturing and other industry). Table 6-2 also presents estimates for the non-public sector non-agricultural Taiwanese economy,

[27] The reason the Taiwanese national accounts make this adjustment is fairly obvious. With public sector employment stagnating and output per worker in all other sectors of the economy growing rapidly, backward extrapolation (at constant prices of the mid-1980s) using the standard deflation technique implies that the share of government in total output was about 50% in 1966. A similar problem exists in the U.S. national accounts, but is ameliorated by the fact that public sector employment is expanding rapidly, while the growth of the other sectors of the economy is more gradual than in Taiwan. The solution I employ (in table 6-2), is to estimate the growth of aggregate output as a Tornqvist index of the growth of the one-digit ISIC sectors (plus the public sector), with the (chain-linked) current price share of each sector taken as its weight. This approach is analogous to that used by Griliches and Jorgenson (1967) for the measurement of the output of the U.S. economy.

which side-steps these measurement issues by excluding the public sector from consideration.[28] I find that total factor productivity growth in the non-agricultural private sector Taiwanese economy averaged 2.1% per annum between 1966 and 1990. Interestingly both sets of estimates for the aggregate economy in table 6-2, both with and without the public sector, show a substantial improvement in productivity growth during the 1980s, which is reminiscent of the results for Korea.

[28] This approach is not entirely satisfactory either, since the public sector provides many unpriced services (e.g. roads & bridges) to the private sector. Variations across economies and across time in the quantity of capital and labour services provided (free of charge) by the public sector could potentially bias estimates of private sector productivity.

Table 6-2: Taiwan - Adjustment of Public Sector Output							
	Annual Growth of:						
Time Period	Output	Aggregate Capital	Weighted Capital	Aggregate Labour	Weighted Labour	TFP	Labour Share
Economy (excluding agriculture & with adjustment of public sector output):							
66-70	0.094	0.152	0.170	0.043	0.044	0.015	0.720
70-80	0.106	0.137	0.143	0.068	0.069	0.015	0.708
80-90	0.075	0.085	0.083	0.024	0.036	0.025	0.701
66-90	**0.091**	**0.118**	**0.123**	**0.046**	**0.051**	**0.019**	**0.710**
Services (with adjustment of public sector output):							
66-70	0.050	0.145	0.162	0.018	0.023	0.003	0.828
70-80	0.094	0.134	0.139	0.049	0.051	0.028	0.827
80-90	0.082	0.094	0.092	0.036	0.041	0.029	0.777
66-90	**0.082**	**0.119**	**0.123**	**0.038**	**0.042**	**0.025**	**0.811**
Economy (excluding agriculture & official public sector):							
66-70	0.121	0.173	0.187	0.069	0.072	0.013	0.678
70-80	0.115	0.141	0.145	0.072	0.074	0.017	0.660
80-90	0.082	0.083	0.081	0.024	0.037	0.030	0.662
66-90	**0.102**	**0.122**	**0.125**	**0.052**	**0.058**	**0.021**	**0.667**

Finally, I remind the reader that in the results reported above I have excluded the large conscript armies of Korea and Taiwan in measuring the growth of labour input in these economies on the grounds that the measured output of these military personnel (i.e. their wages) is a negligible proportion of total output. In the case of Taiwan, census sources provide information on the sex, age and educational characteristics of military personnel. To analyze the sensitivity of my results I make use of this information to incorporate military personnel into my estimates. As shown in table 6-3, including military personnel raises the rate of total factor productivity growth in the aggregate economy by .4%, to an average of 2.8% per annum.[29] However, if one considers military personnel as part of public sector employment, then the "quality adjustment" of public sector output in the Taiwanese national accounts appears to be even more exaggerated. Adjusting public sector output to standard deflation techniques yields an average total factor productivity growth rate of 2.1% (table 6-3), i.e. only .2% higher than that reported earlier (excluding military personnel) in table 6-2. Similiar estimates for services yield average rates of productivity growth of 3.7% and 2.3%, which are only .3% greater and .2% less, respectively, than the comparable figures reported earlier above. In sum, the estimates for Taiwan are not extremely sensitive to the inclusion of military personnel, particularly once one adjusts the growth of public sector output to international norms. The impact of military personnel in Korea, where they constitute a much smaller percentage of the working population, should be even smaller.

[29] The reader may note that including military personnel lowers slightly the estimated share of labour. This follows from the fact that including the military lowers the ratio of the self-employed to the employed in the economy, implying (for a given aggregate wage bill) a lower implicit wage for the self-employed.

Table 6-3: Taiwan - Inclusion of Military Personnel							
	Annual Growth of:						
Time Period	Output	Aggregate Capital	Weighted Capital	Aggregate Labour	Weighted Labour	TFP	Labour Share
Economy (exc. agriculture, inc. military):							
66-90	0.096	0.118	0.122	0.039	0.042	**0.028**	0.677
Economy (exc. agri., inc. mil., with adj. of public sector output):							
66-90	0.089	0.118	0.122	0.039	0.042	**0.021**	0.677
Services (inc. military):							
66-90	0.091	0.119	0.122	0.029	0.030	**0.037**	0.738
Services (inc. military, with adj. of public sector output):							
66-90	0.077	0.119	0.122	0.029	0.030	**0.023**	0.738

VII. Comparison with Earlier Research

Several total factor productivity studies of the East Asian NICs, some of them quite rigorous, have preceeded this one. Tsao's (1982) detailed study of Singapore has generally been ignored or dismissed as unbelievable. The methodology used in this paper is similar to hers, as are the results. Tsao estimates a total factor productivity growth rate for the economy as a whole of -.3% per annum for the 1966-1980 period and an average rate of -1.2% per annum for twenty-eight manufacturing industries between 1970-1979.[30] With regards to Singapore, this paper's principal contribution is to extend Tsao's analysis to the 1980s.

Turning to Korea, Kim and Park's (1985) study provides an impressively cataloged analysis of total factor productivity growth in Korea, estimating average annual rates, for the entire economy, of 4.03% during 1963-72 and 1.47% during 1972-1982.[31] Similarly, Christensen and Cummings (1981) estimate an annual economywide total factor productivity growth rate of 4.1% for the 1960-1973 period. Both studies fail to separate out the agricultural sector. Table 7-1 below reproduces the capital stock estimates used by Christensen and Cummings. As can be seen, land input (most of which was in agriculture) and agricultural inventories accounted for 68% of their measured capital stock in 1959, but only 45% in 1973. Thus, while their aggregate capital stock was growing by only 3.4% per annum, the components of greatest importance to the non-agricultural economy, i.e. non-residential structures and equipment, were growing at rates well in excess of ten percent per annum.[32] Similarly, for 1961

[30] Tsao (1982), pp. 91 & 149.

[31] Kim & Park (1985), p. 62.

[32] I have serious doubts about their measures of non-farm inventories. According to their estimates, the ratio of non-farm inventories to value added in manufacturing and wholesale & retail trade (at constant prices) fell from 1.23 in 1959 to .35 in 1973. As noted earlier, I have found the inventory series published by these economies to be largely fictional.

Kim & Park allocate land a share of one-half of all capital income, with inventories receiving an additional quarter,[33] and structures and equipment, which were growing at an explosive rate, receiving only one quarter of capital income, or 9% of national income.[34] And yet, Kim and Park's study contains several tables indicating the small share of land in non-agricultural assets and factor income. In sum, it is probably fair to say that the work of Kim and Park and Christenson and Cummings, if disaggregated, would indicate extraordinary productivity growth in agriculture, with low productivity growth in the non-agricultural sectors of the economy.

[33] Kim & Park's inventory series is also suspicious, with the inventory to GDP ratio (in manufacturing and wholesale & retail trade) falling from 4.17 in 1961 to .50 in 1981.

[34] By the early 1980s, however, they allocate over half of capital income to structures & equipment, as the growth of these inputs leads them to dominate their capital stock measures. This is why Kim & Park have lower estimated productivity growth rates for 1972-1982.

Table 7-1: Estimated Composition of the Korean Capital Stock (Billions of 1970 won)							
	Non-resid. structures	Producer durables	Residential structures	Non-farm inventories	Farm inventories	Consumer durables	Land
1959	168.6	252.0	933.3	298.1	113.1	118.8	3627.3
1973	1495.3	1305.0	1288.8	485.1	341.0	269.0	3632.5
Avg. Growth	15.6%	11.7%	2.3%	3.5%	7.9%	5.8%	0.0%
Source: Christensen and Cummings (1981), table 7.							

Finally, I turn to a recent study by Dollar and Sokoloff (1990), which found total factor productivity growth rates in Korean manufacturing between 1963 and 1979 of 6.1% per annum. This study does not make the best use of the available data, relying on the United Nations' Yearbook of Industrial Statistics for its estimates of output and labour input and on the Economic Planning Board and the Bank of Korea for its capital stock estimates and output deflators, while estimating the share of labour using regression techniques. The most severe problem with Dollar and Sokoloff's study, however, is that their measure of manufacturing output grows 3.5% faster per annum for *16 years* than the measure of manufacturing output reported by the Korean national accounts![35] If one subtracts three and a half percent excess (overestimated) output growth per annum from their series, one arrives, immediately, at an estimated total factor productivity growth rate of around two and a half percent per annum, which is close to that reported in this paper.

[35] The origin of the problem seems to be the output data taken from the UN Yearbook of Industrial Statistics. These data are drawn from Korea's annual Survey of Mining and Manufacturing. The output of the firms covered by this survey does, indeed, grow some 3.5% faster than the national accounts. I have repeatedly questioned the Korean national accounts authorities on this issue and they steadfastly maintain that the Survey is not representative of the entire manufacturing sector. Apparently their adjustment of the survey data, using alternative sources, leads to a considerably lower estimate of the growth of the manufacturing sector.

VIII. Summary and Conclusions

Underlying the pervasive influence of the East Asian NICs on both theoretical and policy oriented research in the economics profession lies a common premise: that productivity growth in these economies, particularly in their manufacturing sectors, has been extraordinarily high. The results of this paper, as summarized in table 8-1, suggest that this premise is largely incorrect. Over the past two and a half decades, productivity growth in the aggregate non-agricultural economy of the NICs ranges from a low of -0.3% in Singapore to a high of 2.3% in Hong Kong, whereas in manufacturing productivity growth ranges from a low of -1.0% in Singapore to a high of 2.9% in South Korea. For the purposes of comparison, table 8-2 reproduces the results of two detailed cross-country studies of productivity growth, with methodologies similar to that used in this paper. As the reader can see, it is not particularly difficult to find either developed or less developed economies whose productivity performance, over time periods spanning two decades or more, has matched or rivaled that of the NICs. Although, with the possible exception of Singapore, productivity growth in the NICs is not particularly low, it is also, by post-war standards, not particularly high.[36]

The results of this paper should be heartening to economists and policy makers alike. If the remarkable post-war rise in East Asian living standards is primarily the result of one-shot increases in output brought about by the rise in participation rates, investment to GDP ratios, and educational standards and the intersectoral transfer of labour from agriculture to other sectors (e.g. manufacturing) with higher value added per worker, then economic theory is admirably well-equipped to explain the East Asian experience. Neo-classical growth theory, with its

[36] In this regard it is interesting to note that Lau and Kim (1992), using an econometric approach to the study of productivity growth, find that productivity growth in the NICs in the 1970s and 1980s was not significantly different from zero.

Table 8-1: Average Total Factor Productivity Growth (% per annum)				
	Hong Kong (1966-1991)	Singapore (1966-1990)	South Korea (1966-1990)	Taiwan (1966-1990)
Economy:*	2.3	-0.3	1.6	1.9
Manufacturing#	NA	-1.0	2.9	1.5
Other Industry	NA	NA	1.8	1.2
Services	NA	NA	1.8	2.5
Private Sector:*	NA	NA	NA	2.1

Notes: (*) In the case of Korea and Taiwan, excluding agriculture; (#) In the case of Singapore, 1970-1990.

Table 8-2: Comparative Total Factor Productivity Growth (% per annum)					
Country	Period	Growth	Country	Period	Growth
Canada	1947-1973	1.8	Argentina	1940-1980	1.0
France	1950-1973	3.0	Brazil	1950-1980	2.0
Germany	1950-1973	3.7	Chile	1940-1980	1.2
Italy	1952-1973	3.4	Colombia	1940-1980	0.9
Japan	1952-1973	4.1	Mexico	1940-1980	1.7
Netherlands	1951-1973	2.5	Brazil (M)	1960-1980	1.0
United Kingdom	1955-1973	1.9	Mexico (M)	1940-1970	1.3
United States	1947-1973	1.4	Venezuela (M)	1950-1970	2.6

Notes: M = manufacturing alone; developed economies from Christensen, Cummings and Jorgenson (1980), less developed economies from Elias (1990).

emphasis on level changes in income and its well-articulated quantitative framework, can explain most, if not all, of the difference between the performance of the NICs and that of other post-war economies.

Appendix I: Sources

Hong Kong: Estimates of Gross Domestic Product 1966 to 1992, Estimates of Gross Domestic Product 1961 to 1975, and unpublished tabulations from the Hong Kong government[37] provided data on GDP and GFCF by asset type at current and constant 1980 market prices for the period 1961-1991.[38] Estimates of 1947-1960 investment by asset type were derived from data on retained imports of machinery and equipment, private construction expenditures and government capital expenditure published in Hong Kong Statistics 1947-1967, deflated to 1961 prices using the non-food retail price index (the only price index available) and then linked to 1980 prices using the 61/80 deflators by asset type from the national accounts. Compensation of employees as a percentage of GDP for all years except 1966[39] were taken from current and historical issues of Estimates of Gross Domestic Product, data provided by the Hong Kong government, and the pilot national income survey of Hong Kong (Report on the National Income Survey of Hong Kong).

Estimates of the working population cross-tabulated by class of worker, sex, age, education, income and hours of work were derived from published and unpublished census tabulations. For earlier years hours of work and relative income's by worker characteristic were assumed to be constant at the levels reported in the 1971 and 1976 censuses, respectively, the earliest dates for which detailed data of each type were available.

[37] The 1961-1975 GDP estimates lacked several components introduced in the later series (e.g. adjustment for the profit margins of real estate developers). The data provided by the Hong Kong government allowed me to adjust the old series.

[38] The Hong Kong national accounts measure of GFCF includes the transfer (i.e. transactions) cost of (used and new) buildings and an adjustment for the profit margins of private real estate developers. I exclude the transfer cost from my measures of investment and capital, but include the margins of real estate developers (which I distribute across different types of private sector construction in proportion to their value).

[39] Where the value was taken as the average of the 1961 and 1971 percentage shares.

Singapore: Singapore National Accounts 1987 and Yearbook of Statistics Singapore 1991 provided data on GDP and GFCF by asset type at current and constant 1985 prices for the period 1960-1990.[40] 1947-1959 investment in buildings and structures was estimated from data on the construction of one-family equivalent residential units and retained imports of cement (linked to 1985 prices using the overlap of these data with the 1960-1962 GFCF data) taken from the monthly issues of the Malayan Digest of Statistics. Unpublished data on compensation of employees as a percentage of GDP for 1972-1991 were provided by the Singaporean government. I assume that the labour share for earlier years equals the estimated share in 1972.

Estimates of the working population cross-tabulated by industry, class of worker, sex, age, education and income were derived from the published and unpublished tabulations of the Sample Household Survey 1966 and 1970, 1980 and 1990 censuses. The 1966 Sample Survey and 1970 Census provide little data on the income of workers.[41] Average incomes by worker characteristic, for use in computing the income weights for these years, were derived from the 1972/73 Household Expenditure Survey and 1973 Labour Force Survey. Average hours of work by industry for 1972-1990 were taken from annual issues of the Yearbook of Statistics, with hours of work prior to 1972 assumed to be constant at the level reported in 1972.

South Korea: National Accounts 1990 and National Accounts 1991 provided data on GDP and GFCF at current and constant 1985 prices for the period 1970-1990 (the "New System" accounts), while National Income in Korea 1982 provided the same data (at 1975 constant

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[40] The Singaporeans rebased the 1960-1977 estimates at 1968 prices to 1985 prices using the 78/85 and 78/68 deflators for each item. Consequently, the reported constant 1985 price category totals (e.g. GFCF) do not equal the sum of their components (e.g. GFCF by asset type). I take as my measure of aggregate GDP the sum of GDP by industrial sector while, for the purposes of figure I, I take as my measure of GFCF the sum of GFCF by asset type.

[41] The 1966 Sample Survey collected some data on the employee income of heads of households, but the published tabulations only cross-tabulate this with occupation, which is of little use in estimating the full array by industry, sex, age and education.

prices) for the period 1953-1981 (the "Old System" accounts). Although the (revised) New System accounts should be superior to the Old System accounts in their measures of output and capital formation, they unfortunately follow the 1968 SNA in classifying capital formation by industry of ownership, rather than industry of use (as was the case in the Old System accounts, which followed the 1953 SNA). Provided the ratio of ownership to use remains roughly constant over time, the New System accounts still provide a reasonable measure of the growth of capital input by industry. A problem arises, however, in linking the Old and New System accounts, when the change in definition induces a dramatic change in measured capital input by sector. To ameliorate this problem, I use the Old System accounts to measure the growth of capital and output by industry for the 1960-1975 period and the New System accounts (initializing the capital stock with the 1969 Old System values) for the period 1975-1990.[42] Measures of indirect taxes, and their distribution by type, were taken from the national accounts sources and the annual issues of the Economic Statistics Yearbook. Data on compensation of employees by economic sector are provided in National Accounts 1990. Since the Old System accounts do not provide data with similar detail, I assume that the share of labour by sector in 1960 and 1966 equalled the ratio estimated for 1970.

Estimates of the working population cross-tabulated by class of worker, sex, age, and education were derived from published census tabulations, supplemented with data from the Economically Active Population Survey (where this contained tabulations unavailable in the census). Incomes and hours of work by worker characteristic were estimated from the published tabulations of the Occupational Wage Survey for the period 1971-1990. For earlier years hours of work and relative income's by worker characteristic were assumed to be constant at the levels

[42] For the analysis of the aggregate non-agricultural economy, where the distinction between user and owner is less significant, I use the Old System for 1960-1970 and the New System (initialized with the Old System values of 1969) for 1970-1990.

reported in 1971.[43]

Taiwan: Unpublished data provided by the Taiwanese government included information on capital formation and output in current and constant 1986 prices, as well compensation of employees and indirect taxes. The publication National Income in Taiwan Area of the Republic of China 1991 summarizes much of these data. Estimates of the working population by class of worker, industry, sex, age and education were derived from English and Chinese language census sources.[44] Employee incomes by worker characteristic for the years 1976, 1980 and 1990 were estimated from the data tapes of the Survey of Personal Income Distribution (summarized in the publication of the same name), with labour force estimates prior to 1976 weighted with the relative wages of that year.[45]

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[43] Both the Economically Active Population Survey and the Monthly Wage Survey (reported in the Yearbook of Labour Statistics) contain data on hours of work (in the former case extending back to the early 1960s). The hours of work data reported by both sources, however, are uncorrelated with movements in output (and with each other), which is not the case with the occupational wage survey, which also provides considerably greater detail. In any case, no source shows any substantial trend in non-agricultural hours of work.

[44] Since the national accounts data cover only the "Taiwan Area", I excluded those listed as working in Fujian province from my estimates of the working population.

[45] At this time, I have not made any adjustment for hours of work for Taiwan. The employee earnings survey (most recently reported in the Yearbook of Earnings and Productivity Statistics) provides data on monthly hours of work, but these series have historically been subject to enormous revisions. I am currently trying to a compile a consistent historical series on hours of work from the labour force survey (most recently reported in the Yearbook of Manpower Survey Statistics), which I hope to make use of in a later draft.

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