PATTERNS OF PRODUCTIVITY GROWTH IN SOUTH KOREAN MANUFACTURING INDUSTRIES, 1963-1979

by David Dollar and Kenneth Sokoloff*

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*Assistant Professor and Associate Professor, respectively, Department of Economics, UCLA, Los Angeles, CA 90024. We thank Hakchung Choo for helping us collect data, Fangyi Wang and Sangkyun Park for excellent research assistance, and Jeffry Frieden and participants in a workshop at the Korea Development Institute for helpful comments on an earlier draft. This research is supported by the Institute of Industrial Relations and ISOP at UCLA.

ABSTRACT

Despite interest in the spectacular growth of several newly industrialized countries in East Asia, there have been few systematic studies of their productivity at the disaggregated level. This paper begins to remedy the deficiency by examining the experience of 25 Korean manufacturing industries between 1963 and 1979. The findings include the estimate that less than half of the 11 percent annual increase in overall manufacturing labor productivity can be attributed to capital deepening, but that the importance of this factor and total factor productivity advance varied sharply across industries. Heavy industries accumulated capital per worker at a faster pace, and realized total factor productivity growth at a much slower rate, than others did. This contrast may be related to the extensive capital subsidies provided to the former as part of an import-substitution program.

1. Introduction

Since World War II, industrialization has spread beyond the core western nations and Japan, and taken root in many other countries. Progress has been most marked in East Asia, where a group of societies, the largest of which are South Korea and Taiwan, have astounded observers with extraordinarily high rates of sustained growth. The pace of advance achieved by these countries has far exceeded any case in previous experience. Although scholars were well acquainted with notions that follower economies enjoyed some advantages, largely associated with the opportunity to learn from the experiences of those who had trod the path before, they have nevertheless been puzzled by this remarkable performance.

Many hypotheses have been advanced to explain why the countries in question have been able to realize such rapid rates of development.[1] Some of these theories appear to be influenced by presumed parallels with the Japanese experience, which may also not be well understood, and are introduced with only casual or limited evidence offered in support. Among factors commonly identified as playing important roles are rapid rates of physical capital accumulation and the existence of a relationship between exports and growth. Although the mechanism underlying this latter source of advance has generally not been precisely delineated, one such interpretation of "export-led" growth is that exportation provides an opportunity for, and a stimulus to, the acquisition of information, and hence both process and product innovation.[2]

Despite the interest in establishing the basis for this

spectacular growth record, there have as yet been few systematic studies of productivity change in these societies beyond those conducted at the aggregate level.[3] This paper begins to remedy this deficiency by focusing on South Korea, the largest of the "gang of four" economies, and employing a conventional growth accounting approach within a translog production framework to investigate the patterns of productivity change in 25 manufacturing industries. Owing to the current inaccessibility of information on firm behavior, this study is confined to industry-level data encompassing the period from 1963 to 1979. Nevertheless, our analysis yields several striking findings about the record of productivity growth in South Korean manufacturing.

In the context of previous work on the subject, perhaps the most surprising aspect of our estimates is that the contribution of capital deepening in this sector, though certainly large in absolute terms, appears to have been modest compared to that of total factor productivity growth. Indeed, less than half of the average 11 percent per annum increase in manufacturing labor productivity over the 17 years seems to be attributable to increases in the amount of capital utilized per worker. Furthermore, the significance of capital deepening varies considerably among individual manufacturing industries. Whereas capital deepening does indeed seem to have been the dominant factor in the highly capital-intensive or "heavy" industries, total factor productivity growth was the major contributor to gains in labor productivity in the rest of manufacturing. This contrast results, in an accounting sense, from the "heavy" industries both accumulating capital per worker at a faster pace and realizing total factor productivity

growth at a slower rate, relative to their counterparts. It may be related to the extensive capital subsidies provided to these industries as part of a limited import-substitution program that was in place over much of the period.

2. Growth Accounting Framework

In carrying out our investigation of the sources of labor productivity growth in South Korean manufacturing, we have employed the conventional growth accounting framework introduced by Solow and since further elaborated by Denison and other scholars.[4] In its simplest form, this framework decomposes the rate of growth of output into the contributions of increases in labor and capital inputs, plus a residual, typically referred to as the rate of growth of total factor productivity (TFP). TFP growth is then defined as

$$(1) \qquad \hat{TFP} = \hat{Y} - \alpha\hat{K} - (1-\alpha)\hat{L}$$

where Y is output, L is labor input, K is capital input, α is a constant between 0 and 1, and $\hat{}$ denotes relative rate of change.

This framework derives from a constant-returns-to-scale production function with neutral technical progress occurring at a constant rate over time. The parameter α is the elasticity of output with respect to capital. If factors are paid their marginal products, then this elasticity is equal to capital's distributional share; in empirical studies of growth, the distributional share of capital is often adopted as the estimate for α. We prefer, however, to estimate the output elasticity directly from the data, as discussed in the next section.

For our purposes it is useful to rewrite equation (1) in the

following way:

$$(2) \qquad \hat{(Y/L)} = \alpha \hat{(K/L)} + \hat{TFP}.$$

Equation (2) is a decomposition of labor productivity growth into the contribution of capital deepening plus a residual. The first term on the right-hand side of equation (2) is the rate of growth of labor productivity attributable to the increase in capital utilized per unit of labor. The residual is the difference between the actual growth in labor productivity and the amount of the advance that can be accounted for by capital deepening.

In Sections 3 and 4 we use this framework to investigate the record of productivity growth in individual manufacturing industries in South Korea. There are potentially many factors that can account for the residual, and we begin by establishing in which industries it was of importance before considering what may have contributed to it in Section 5.

3. Characteristics of South Korean Manufacturing Industries

Our study of the sources of labor productivity growth in South Korea employs industry-level data pertaining to performance of the 25 manufacturing industries included in Table 1 over the period from 1963 to 1979. This body of evidence was constructed from several sources, and contains information on output measured in terms of value added, the total number of employees, the net capital stock, and the wage bill.[5] Industry output price indexes were retrieved in order to deflate the value added figures. Wages were deflated to constant *won* with a Wholesale Price Index. The estimates of the net capital stock data were prepared and supplied by the Economic Planning Board, and were already

expressed in terms of constant prices.

Some basic descriptive statistics on the manufacturing industries are presented in Table 1. In addition, weighted averages are reported for all of manufacturing, and for each of four sub-sectors identified. After separating out the natural-resource-based industries, whose data manifest some anomalies, probably owing to the existence of state-run monopolies in this sector, the composition of the remaining three categories was determined on the basis of the capital-labor ratio in 1979. The particular division of individual industries between the "heavy", "medium", and "light" categories is admittedly somewhat arbitrary, but the use of such classifications in examining the patterns in the data does facilitate both analysis and exposition. Moreover, the qualitative findings seem robust to reasonable changes in the lines demarcating the groups.

It is immediately apparent from the index of capital intensity that there is enormous variation across manufacturing industries in this variable--measured by the net value of capital stock per worker. Iron and steel, for example, is nearly six times as capital-intensive as the manufacturing sector average, and nearly thirty-three times as much as clothing and footwear. The categories of industries, which were of course defined by capital intensity, exhibit considerable variation as well, with the "heavy" industries exceeding the capital intensity of the manufacturing average by 250 percent, and the "light" falling 40 percent short. It is not at all surprising that labor productivity, as measured by value added per worker, is positively correlated with capital intensity and varies less across industries than the latter ratio. It

is interesting, however, that the capital intensity of the "heavy" industries relative to labor productivity is much higher than the correponding figures in the other sub-groups.

The capital intensity index divided by the labor productivity index in fact provides an index of the capital-output ratio, which is also reported in Table 1. Production theory implies that the capital-output ratio will increase with the capital-intensity of an industry, but the dispersion in Korea is unusually great. When combined with any plausible estimates for the elasticities of output with respect to capital in individual industries, the capital-output ratios suggest that the marginal revenue product of capital is much lower in the "heavy" industries, especially iron and steel, than in the "medium" and "light" industries. This follows from the observation that the marginal product of capital equals the output elasticity of capital divided by the capital-output ratio. A second implication is that in 1979 the level of total factor productivity was significantly lower among the industries classified as "heavy" than in Korean manufacturing as a whole.

Industry shares of the total value added and employment in manufacturing are reported in Table 2. They suggest that at least in quantitative terms, the "light" and "medium" industries dominated the manufacturing sector in the Republic of Korea during this period. Both of these classes of industries surpassed the "heavy" category in shares of value added and employment. Together, they accounted for nearly 60 percent of manufacturing value added between 1963 and 1979, and nearly 79 percent of employment; in contrast, the highly capital-intensive

industries captured shares of only 15.2 and 9.2 respectively. Even at the individual industry level, many of those classified as "light" or "medium", such as textiles, clothing and footwear, electrical goods, and transport equipment, exceeded the largest of the "heavy" industries - iron and steel. Although their value added share may be inflated by rather implausible figures for tobacco products, the data indicate that just over a quarter of manufacturing value added originated from the natural resource industries.

The industry-specific shares of gross output exported are also reported in Table 2 over the period as a whole. These figures reveal that the "light" industries not only registered the largest shares of value added and employment, but they were even more disproportionately represented among exports of manufactures. Whereas the manufacturing average shipped 22.5 percent of its output abroad, with the "medium" and "heavy" sub-sectors recording shares of 16.9 and 14.4, respectively, the "light" industries exported 43.5 percent of their output. This "light" sub-sector alone accounted for roughly three-quarters of all exports of Korean manufactures. Although textiles were most responsible for the predominance of "light" goods among manufactured exports, other industries of this class, such as electrical goods and clothing and footwear, also surpassed iron and steel and transport equipment, which led the "heavy" and "medium" categories in the share of output exported. The natural resource sub-sector was not at all oriented toward foreign markets, as none of these industries exported more than 3 percent of output.

The rate of growth of real value added for each industry is

reported in Table 3. It is clear that this first phase of economic growth from 1963 to 1979 was marked by an extremely rapid expansion of manufacturing production, with real output for the sector as a whole increasing at an extraordinary pace of about 22 percent per annum. Furthermore, the advance was quite balanced across the four classes of industries identified, though the natual resource sub-sector did lag somewhat behind the others. A traditional conception of the early stages of industrial development might lead one to expect the share of the "heavy" industries to rise. But, on the contrary, the opposite tendency is evident, with the rate of growth of the "light" industries exceeding those of the "medium" and "heavy" by 24.2 percent per annum to 21.8 and 21.9 respectively. Throughout the period, therefore, the bulk of manufacturing value added originated from the less capital-intensive industries, classified here as "light" or "medium", such as textiles, clothing and footwear, electrical goods, and transport equipment. The highly capital-intensive "heavy" industries, such as iron and steel and industrial chemicals, certainly grew substantially in an absolute sense, but remained small relative to the manufacturing sector as a whole.

4. Sources of Labor Productivity Growth

Estimates of the annual rates of growth of labor productivity and capital intensity are presented for individual industries and sub-sectors in Table 3. As is apparent, labor productivity rose rapidly in every manufacturing industry between 1963 and 1979, ranging from a low of 6.6 percent per annum in wood products to a high of 22.0 percent in petroleum and coal products. Over three-quarters of the industries realized double-digit rates of advance, and a weighted average for

manufacturing, constructed by aggregating all of the deflated values across industries, yields a figure of 11.0 percent per annum, approximately one-half of the rate of increase in total manufacturing value added over the period. The pace of advance for the entire manufacturing sector falls a bit short of that for each of the sub-sectors; this is the result of manufacturing industries with lower labor productivity, many of which were classfied as "light", expanding relative to those with higher labor productivity. It is curious that the growth of labor productivity seems to have been virtually the same, within a range of 11.7-12.4 percent per annum, in all of the industry classes. One would not have expected such a pattern, particularly since the "heavy" industries experienced much more substantial capital deepening over the period, with an increase of 11.7 percent per annum in capital per worker that was nearly double the rates of the "medium", "light", and "natural resource" categories.

As indicated in the growth accounting framework presented above, the increase in labor productivity can be decomposed into the component that can be ascribed to capital deepening, and the remainder which is attributed to advances in total factor productivity. The precise division depends on the estimate of the output elasticity of capital, α, that is employed. Qualitative conclusions can sometimes be sensitive to the choice of this parameter, but it is clear from the figures reported in Table 3 that at least one basic finding about the sources of labor productivity growth in Korean manufacturing is robust. In particular, given the pattern of significantly lower rates of capital deepening than labor productivity growth in the "light", "medium", and "natural

resource" industries, no reasonable output elasticity for capital could reverse the conclusion that the bulk of the advance in labor productivity in those sub-sectors must stem from increases in total factor productivity. It is also apparent that the accumulation of capital per worker is much more important, and total factor productivity growth less so, in the "heavy" industries than in the other manufacturing sub-sectors.

Estimates of the amount of labor productivity growth attributable to capital deepening and total factor productivity growth are reported in Table 4. They are derived from the growth accounting framework treated above, and were computed with the estimates of α presented in the table. These estimates indicate a markedly different pattern in the "heavy" sub-sector than in the other classes of manufacturing industries. In the former case, over 70 percent of the labor productivity growth of 12.0 percent per annum between 1963 and 1979 can be explained by capital deepening. There is of course variation in the experience of the individual industries in this sub-sector, with the figure being just under 80 percent in iron and steel and about 90 percent in industrial chemicals, but nonferrous metals is the only one in which the qualitative conclusion does not hold. It should be noted that the economic performance of the Korean iron and steel industry appears to have been better in the 1980s, so that adding more recent data may increase the measured rate of TFP growth.

In contrast, although they realize labor productivity growth at a similar rate of 11.7 percent per annum overall, the "light" industries enjoy a much more rapid advance in total factor productivity, 7.4

percent versus 3.3 for the "heavy" industries, and less of a contribution from capital deepening. Hence, in this sub-sector, capital accumulation per worker plays a more modest role, with less than 40 percent of the advance in labor productivity over the period being accounted for by this factor. Not all of the "light" industries had experiences that match the class average, with textiles being the prominent exception, but most, such as electrical goods, rubber products, leather products, and clothing and footwear, did have their progress largely driven by total factor productivity growth.

The "medium" industries, in general, resemble those categorized as "light" in their record of the sources of productivity growth. Total factor productivity in this sub-sector rose virtually as fast as in the "light" industries, 7.3 versus 7.4 percent per annum, accounting for over 60 percent of the labor productivity growth.[6] Here, three of the seven industries in the class, paper products, glass products (whose figures seem implausible), and machinery do diverge from the general pattern, but they are outweighed by the remaining four, such as transport equipment, that realize rapid total factor productivity increase and relatively limited capital deepening. Although their data appear less reliable, the record of the "natural resource" industries is similar to that of the "light and medium" classes with total factor productivity growing over the period at 7.6 percent per annum, and "explaining" more than 60 percent of the advance in labor productivity.

What emerges from this industry-level examination is a sense of a dual manufacturing sector. Although there was remarkable homogeneity in the achievement of rapid labor productivity growth, classes of

industries varied significantly in the sources of this progress. On the one hand, the "heavy" industries, identified by their capital intensity at the end of the period, increased their capital utilized per worker much more sharply, and relied more on this accumulation in the realization of gains in labor productivity than did the other sub-sectors. Conversely, they realized significantly lower rates of total factor productivity increase than did their counterparts. This class of industries, which maintained a rather constant share of about 15 percent of manufacturing value added over the period, focused more on the production of inputs for other industries and exported a relatively small fraction of their output.

Although differing substantially from the "heavy" sub-sector, the other classes of manufacturing industries exhibit, on average, virtually identical records of productivity growth among themselves. Their rates of total factor productivity increase vary between 7.3 and 7.6 percent per annum, and the gains in labor productivity attributable to capital deepening between 4.3 and 4.8 percent. Several of the individual industries in these less capital-intensive categories do deviate from the pattern, but nearly all register markedly higher rates of advance in total factor productivity, and smaller increments to the amount of capital employed per worker than do the "heavy" industries.

Before considering the implications of these findings, one might ask whether the record of productivity growth presented here is robust to reasonable alternative estimates of the output elasticity of capital, since the results of growth accounting studies are sometimes sensitive to the choice of this parameter value. In this study we have

deliberately employed estimates derived from production functions that were near the upper part of the feasible range, especially for the "light" industries. It is important to recognize that to the extent that the output elasticity of capital is overestimated, the contribution of capital in accounting for the growth in labor productivity will also be exaggerated. Our capital coefficients for the "light" industries are likely to be overstated, particularly relative to the "heavy"; if so, the reported figures may understate the degree of contrast between the latter and former sub-sectors in the relative significance of capital deepening and total factor productivity increase.[7] Since errors in our choice of capital coefficients would, accordingly, seem likely to bias the estimates against our case, the qualitative results appear robust.

5. Interpretation of the Results

There has been much speculation about the sources of Korea's remarkable economic performance since the onset of growth in the 1960s. Considerable attention has been directed to the importance of capital deepening in driving the extraordinary surge in labor productivity. Although the final resolution of the issue may require micro data, our analysis of manufacturing industry-level data suggests that the focus on capital accumulation has been excessive. Even the aggregate numbers, computed by summing the industry figures deflated with industry-specific price indexes, indicate that over half of the rise in labor productivity between 1963 and 1979 can be attributed to total factor productivity or the residual. Moreover, an examination of the experiences of individual industries, or sub-sectors based on grouping industries by factor proportions, supports the view that the chief engine for change was

total factor productivity growth. Aggregation over industries has the effect of exaggerating the role of capital deepening.

The manufacturing sector seems to have been composed of two parts. Accounting for roughly 15 percent of sector value added and less than 10 percent of employment are the "heavy" industries that undertook much more rapid capital deepening and realized slower growth of total factor productivity than the other sub-sectors. These latter industries, classified as "light", "medium", and "natural resource", added capital per worker at about half the rate of the former, and achieved total factor productivity advance at more than twice the rate. TFP growth for these industries averaged more than 7 percent per year, extraordinarily high relative to the standards of other countries.

A rigorous study of the sources of total factor productivity growth in South Korean manufacturing would require a more substantial and detailed body of evidence than we currently have access to. Nevertheless, the industry-level data analyzed here reveal some interesting patterns and suggest directions for future research. To facilitate exposition, it is useful to refer to Table 5, which reports the correlation, across the 25 industries, of TFP growth with other industry-level variables.

Among the most salient features in the variation across industries in the rate of TFP growth is the negative association, already mentioned, between total factor productivity growth and the amount of capital deepening. This shows up clearly in the correlation coefficient between industry TFP growth and the rate of growth of the capital-labor ratio, which is -.70. There are at least two explanations,

not mutually exclusive, for this strong, negative relationship. First, throughout the period under examination the Korean government was actively involved in directing investment funds to different industries. Of particular importance was the so-called HCI Policy, aimed at building up the "heavy and chemical industries" in the 1970s. Massive amounts of capital were directed into these industries, through loans at preferential rates, and this is no doubt one reason why the "heavy" industries were able to manage such an enormous increase in the capital to labor ratio. One interpretation is that the program resulted in capital being directed to uses in which its marginal product was low, leading to a poor record of TFP growth in the subsidized industries. Other analysts have also questioned the economic wisdom of this import-substituting policy.[8] It is important to add, however, that not all of the industries supported by the HCI program are included in our "heavy" industry category. The prominent exceptions are transport equipment and electrical goods, industries which were supported by the HCI program and realized above-average TFP growth over the period.

The negative correlation between TFP growth and capital deepening persists even when the "heavy" industries are excluded from the calculation, suggesting that misguided aspects of the HCI program cannot be the sole basis of our finding. Another plausible hypothesis is that there are major advances in productivity that can be realized at the beginning of industrialization, especially in traditional or labor-intensive industries, through relatively modest changes in the organization of production or technique. The notion is that the opening up of such producers to wider markets during the early phase of economic

growth stimulates many changes in the production process that do not require major adjustments in factor proportions, and yet can cumulatively have a substantial impact on productivity. It is clear, for example, that there was a marked decline in the relative importance of small shops or handicraft production within "light" manufacturing industries; although the larger establishments that displaced them retained labor-intensive methods, it is plausible that a significant increase in productivity accompanied this transition.[9] Highly capital-intensive industries would already have undergone most of the analogous alterations to the production process in accommodating to the greater capital intensity and scale of their operations.

It should also be pointed out that the results run counter to the notion that technological change is embedded in physical capital, a hypothesis which predicts a positive relationship between the rate of capital accumulation and the growth of total factor productivity. Along with the demonstrated limits of the direct contribution of capital deepening to the rise in manufacturing labor productivity, this finding further diminishes the importance of the rate of capital accumulation in explaining the remarkable economic performance of South Korea during the period.

Table 5 also indicates that there is a significant positive correlation, across industries, between the growth rates of exports and total factor productivity. One must be cautious about drawing inferences from this finding however. It may be tempting to conclude that the relationship stems from some favorable influence on the acquisition of technology, and hence on productivity, exerted by the

growth in exports. Although this reaction does provide content to the rather murky notion of "export-led growth", the causation could as easily run in the other direction. Instead, one might explain the empirical correspondence as arising from the tendency for industries with especially rapid growth in total factor productivity to expand output for the elastic world demand associated with an open trading system. This hypothesis would suggest a different interpretation of "export-led growth" in Korea and other newly industrialized countries in East Asia. From this alternative perspective, the tapping of important sources of total factor productivity growth by "light" industries, in which these nations surely had a comparative advantage, and the availability of an effectively unrestricted world market, allowed them to vastly increase their output and perhaps fuel the advance of the rest of their economies. We ourselves lean toward this view, but further work with firm-level data is needed to establish the sources of TFP growth in the "light" industries before one can embrace this position with much confidence.

It can also be seen in Table 5 that there is a positive correlation between TFP growth and value added growth, as well as between export growth and value added growth. Those relationships are consistent with a line of causality running from TFP growth to output growth, with much of the output being exported.[10]

Finally, there is no doubt that at least some human capital accumulation occurred on average over the period under study, and that such a development would be captured by the residual in the growth accounting exercise. It seems highly unlikely, however, that

improvements in human capital could be of such magnitude as to explain much of the 6.1 percent per annum rise in total factor productivity which is estimated for the manufacturing sector as a whole. Moreover, differential rates of human capital accumulation cannot explain interindustry variation in TFP growth rates. We would expect differential rates of human capital accumulation across industries to be reflected in differences in the rate of growth of industry wages. In Korea, however, there is very little variation in wage growth across industries. Table 5 reports the correlation between TFP growth and wage growth, which is low (.20). It can also be seen in Table 5 that wage growth has no strong correlation with any of the industry-level variables, reflecting the fact that it varies little across industries.

6. Conclusions

What emerges most clearly from our results is that the rate of total factor productivity growth in Korean manufacturing has been extraordinarily high compared to the experiences of other countries, both developing and advanced. The use of industry-level data results in estimates of total factor productivity growth for Korea that are generally higher than those derived using more aggregated data.[11] A second important finding is that the experience of the "heavy" industries differs from the rest of Korean manufacturing. In particular, capital deepening is the principal source of labor productivity growth in the "heavy" sub-sector, where it accounts for over 70 percent of the advance. In "light" and "medium" industries, on the other hand, total factor productivity growth accounts for more than 60 percent of the gain in labor productivity.

For much of the period under examination, 1963 to 1979, the South Korean government had a deliberate industrial policy of building up "heavy" industries through various forms of subsidies, including access to capital at low rates of interest.[12] Our analysis raises some questions as to whether the cost of this program, in terms of inputs, was justified by the output. For the "heavy" industries, value added per worker increased at a rate of 12.0 percent per year over this period. In the "medium" and "light" industries, in contrast, labor productivity growth was almost as impressive, while the rate of growth of the capital-labor ratio was less than half as great as that of the "heavy" industries. Our analysis suggests that by 1979 the marginal value of capital in "heavy" industries was well below its marginal value in "light" and "medium" industries.

These results indicate that other sources of advance, reflected in total factor productivity growth and distinguished from the direct contribution of capital deepening, played the major role in most of the manufacturing sector. Our examination of the evidence, however, has uncovered no simple explanation for the sources of total factor productivity growth. Human capital accumulation is undoubtably part, but not all, of the story. Furthermore, there is a positive relationship between TFP growth and the rate of growth of exports; but it is not clear here what is cause and what, effect.

We favor the view that Korea, as well as other East Asian economies, have enjoyed important sources of labor productivity growth in the relatively labor-intensive industries, other than capital deepening. Having an open world economy contributed indirectly to

aggregate TFP growth in this case by enabling the "light" and "medium" sub-sectors to expand and maintain a large share of manufacturing output and employment. The specific sources of rapid total factor productivity growth in these industries remain to be determined, but such an investigation will require richer bodies of evidence that encompass the experience of firms. Only when such materials are available, can researchers have any hope of resolving the puzzle of how Korea has been able to sustain such a remarkable economic record.

Notes

1. In the case of Korea, a number of excellent studies of post-war economic development are available in English, including Jones and Sakong (1980), Krueger (1979), Kuznets (1977), Mason et al. (1980), and Westphal (1978). It is more often the casual observer who is prone to make explicit reference to the Japanese standard.

2. Westphal, Rhee, and Pursell (1981) report specific cases of such export-based technological advance.

3. For the case of Korea, see Christensen and Cummings (1981) or Kim and Park (1985) for examples of careful studies conducted with even more highly aggregated data than examined here.

4. See, for example, Denison (1967), Christensen, Cummings, and Jorgenson (1980), Maddison (1987), and Solow (1962).

5. Value added, employment, and wage data come from the United Nations *Yearbook of Industrial Statistics*. Industry capital stock data was provided by the Economic Planning Board of the Republic of Korea.

6. These rates of TFP growth are extraordinarily high. If the WPI, rather than industry-specific price indexes, is used to deflate value added for each industry, then the estimated rates of TFP growth decline by about 2 percentage points. The pattern of interindustry variation remains the same, however, with TFP growth low for heavy industries and high for medium and light industries.

7. The various estimates we obtained, from both translog and Cobb-Douglas production functions, of the output elasticities of capital for individual industries, as well as for manufacturing on average, were generally well below those implied by the conventional calculations of labor's distributional share. Working from wage data, Mason and his colleagues (1980) employed 0.75 for their estimate of the capital coefficient in manufacturing; Kuznets (1977) reported a labor share in manufactures of 0.235, with higher figures for "light" industries on average than for "heavy". The distributional shares that we have computed show a similar manufacturing average, but with the implied capital coefficients being somewhat higher for the "heavy" industries than for the "light" and "medium" [See Dollar and Sokoloff (1987).] The estimates we derived from production functions generally ranged from 0.45 to 0.80, depending on industry, specification, and year. Given our desire to both respect the evidence on the capital coefficient provided by the distributional shares, and present conservative figures, we opted for the set derived from a modified translog production function estimated over pooled cross-sections of the data. This set was about the highest we estimated, and also has relatively small discrepancies between the "heavy" and "light" coefficients. If the coefficients implied by the distributional shares were substituted in the growth accounting exercise, the relative importance of total factor productivity growth would be marginally less, but the path of the "heavy" industries would seem to depart even more from the remainder of the sector. We chose to employ the estimates obtained from production functions, rather than distributional shares, because of skepticism

about the comprehensiveness of the available information on compensation to labor.

8. Han (1987) describes the HCI Program in detail. Virmani (1984) presents financial data that demonstrate that the economic results of the program were poor.

9. Kuznets (1977), p. 165.

10. The results of the simple correlations that are treated in this discussion are robust to the estimation of reduced-form multivariate regressions which incorporate the same limited number of variables already mentioned. Although the statistical correlations may not be an artifact, the questions of causality remain relevant.

11. Christensen and Cummings (1981), for instance, estimate aggregate TFP growth to be 4.1 percent per year in the 1960-1973 period. Kim and Park (1985) estimate an annual rate of TFP growth of 3.1 percent for the whole economy over the 1963-1982 period.

12. In addition to the promotion of certain "heavy" industries such as iron and steel and chemicals, there were also some subsidies to exports in general. The latter may have helped foster the growth of the "light" industries since they were so oriented toward the foreign market. See Han (1987) and Kuznets (1977), chapter 6 for detailed discussions.

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Table 1

CHARACTERISTICS OF SOUTH KOREAN MANUFACTURING INDUSTRIES

	Index of Capital Intensity, 1979 (Mfg=100)	Index of Value Added per Worker, 1979 (Mfg=100)	Index of Capital Stock per Won of Value Added, 1979 (Mfg=100)
Heavy Industries[a]	342	185	182
Iron and Steel	590	198	298
Industrial Chemicals	245	219	112
Nonferrous Metals	210	129	163
Nonmetal Products, n.e.c.	169	140	121
Medium Industries[a]	106	122	97
Transport Equipment	139	105	132
Machinery	127	97	131
Glass Products	107	109	98
Paper Products	96	94	102
Other Chemicals	88	203	43
Metal Products, n.e.c.	79	81	98
Printing	78	106	74
Light Industries[a]	57	69	81
Textiles	76	72	106
Wood Products	69	65	106
Electrical Goods	53	75	71
Rubber Products	51	72	71
Leather Products	50	73	68
Plastic Products	48	91	53
Pottery	43	60	72
Furniture	40	72	56
Manufactures, n.e.c.	33	58	57
Clothing and Footwear	18	50	36
Natural Resource Industries[a]	197	419	68
Petroleum and Coal Products	324	361	90
Tobacco Products	204	991	21
Beverages	200	247	81
Food Products	88	106	83
All Manufacturing	100	100	100

Sources:

The information on value added, gross output, wages, and employment were drawn from the relevant years of the United Nations *Yearbook of Industrial Statistics*. The estimates of the net value of the capital stock were prepared by the Economic Planning Board, and appear in *Preliminary Data on Korean Capital Stock By Industry, 1960-1979*, Seoul: KDI, 1987.

[a]Weighted average, using value added shares from Table 2, Column 2.

Table 2

CHARACTERISTICS OF SOUTH KOREAN MANUFACTURING INDUSTRIES

	Exports as a Share of Gross Output 1963-1979 (percent)	Value Added Share 1963-1979 (percent)	Employment Share 1963-79 (percent)
Heavy Industries	14.4[a]	15.2	9.2
Iron and Steel	23.1	5.3	2.9
Industrial Chemicals[b]	7.1	4.9	2.4
Nonferrous Metals	8.6	0.8	.7
Nonmetal Products, n.e.c.[c]	13.1	4.2	3.2
Medium Industries	16.9[a]	21.7	20.9
Transport Equipment	23.2	5.7	4.6
Machinery	18.2	3.0	3.5
Glass Products[c]	13.1	0.9	.9
Paper Products[d]	7.2	2.3	2.2
Other Chemicals[b]	7.1	4.8	2.8
Metal Products, n.e.c.	36.1	2.8	4.1
Printing[d]	7.2	2.2	2.7
Light Industries	43.5[a]	37.4	57.8
Textiles[e]	53.8	14.8	22.5
Wood Products	44.4	2.6	3.2
Electrical Goods	36.7	7.4	8.4
Rubber Products	16.0	2.6	4.4
Leather Products[b]	6.5	0.7	1.0
Plastic Products[c]	7.1	1.3	1.5
Pottery	13.1	0.3	.7
Furniture	22.3	0.4	.8
Manufactures, n.e.c.	47.7	2.7	5.5
Clothing and Footwear[e]	53.8	4.6	9.7
Natural Resource Industries	1.4[a]	25.4	12.1
Petroleum and Coal Products	2.7	5.8	1.3
Tobacco Products	0.0	6.4	1.1
Beverages	0.5	5.8	2.1
Food Products	2.4	7.4	7.5
All Manufacturing	22.5[a]	100.0	100.0

Sources:

See the note to Table 1. The sectoral price indices and estimates of exports were drawn from Bank of Korea, *Monthly Economic Statistics* and Bank of Korea, *Economic Statistics Yearbook* respectively.

[a]Weighted average, using value added shares from Column 2.
[b]In the trade statistics, Industrial Chemicals, Other Chemicals, and Plastic Products are aggregated together.
[c]In the trade statistics, Nonmetal Products, Glass Products, and Pottery are aggregated together.
[d]In the trade statistics, Paper Products and Printing are aggregated together.
[e]In the trade statistics, Textiles, Clothing, and Footwear are aggregated together.

Table 3

RATES OF GROWTH OF LABOR PRODUCTIVITY, CAPITAL INTENSITY, AND REAL VALUE ADDED IN 25 SOUTH KOREAN MANUFACTURING INDUSTRIES, 1963-1979

	Annual Rates of Growth, 1963-1979		
	Valued Added Per Worker	Net Capital Per Worker	Real Value Added
Heavy Industries	12.0	11.7	21.9
Iron and Steel	14.1	15.4	25.7
Industrial Chemicals	12.1	14.7	23.4
Nonferrous Metals	14.9	9.3	25.6
Nonmetal Products, n.e.c.	10.0	13.4	17.7
Medium Industries	12.0	6.5	21.8
Transport Equipment	14.5	7.9	25.6
Machinery	13.6	10.2	25.3
Glass Products	8.7	17.8	19.4
Paper Products	7.5	9.2	16.9
Other Chemicals	12.6	0	20.2
Metal Products, n.e.c.	15.3	6.9	26.4
Printing	9.6	5.0	15.6
Light Industries	11.7	6.1	24.2
Textiles	10.4	8.3	19.2
Wood Products	6.6	5.1	15.9
Electrical Goods	14.7	6.1	36.1
Rubber Products	11.2	4.2	23.7
Leather Products	12.6	- .1	34.6
Plastic Products	9.4	-1.1	31.6
Pottery	14.5	15.8	19.4
Furniture	10.4	1.7	15.9
Manufactures, n.e.c.	13.9	8.6	27.6
Clothing and Footwear	9.9	.9	26.9
Natural Resource Industries	12.4	6.6	18.8
Petroleum and Coal Products	22.0	14.9	23.2
Tobacco Products	14.2	8.5	18.9
Beverages	12.7	8.6	15.2
Food Products	10.1	4.1	19.0
All Manufacturing	11.0	6.8	21.9

Sources:
See the notes to Tables 1 and 2.

Table 4

SOURCES OF LABOR PRODUCTIVITY GROWTH IN 25 SOUTH KOREAN MANUFACTURING INDUSTRIES, 1963-1979

	Contribution of Capital Deepening	Rate of TFP Growth (Residual)	Output Elasticity of Capital
	(percent per annum)		
Heavy Industries	8.7	3.3	.74
Iron and Steel	11.6	2.5	.76
Industrial Chemicals	10.9	1.2	.74
Nonferrous Metals	6.8	8.1	.74
Nonmetal Products, n.e.c.	9.9	0.1	.74
Medium Industries	4.7	7.3	.72
Transport Equipment	5.8	8.7	.73
Machinery	7.4	6.2	.72
Glass Products	12.8	-4.1	.72
Paper Products	6.6	0.9	.72
Other Chemicals	0	12.6	.72
Metal Products, n.e.c.	4.9	10.4	.71
Printing	3.6	6.0	.71
Light Industries	4.3	7.4	.70
Textiles	5.9	4.5	.71
Wood Products	3.6	3.0	.71
Electrical Goods	4.3	10.4	.70
Rubber Products	2.9	8.3	.70
Leather Products	-0.1	12.7	.72
Plastic Products	-0.8	10.2	.71
Pottery	10.9	3.6	.69
Furniture	1.2	9.2	.69
Manufactures, n.e.c.	5.9	8.0	.68
Clothing and Footwear	.6	9.3	.68
Natural Resource Industries	4.8	7.6	.73
Petroleum and Coal Products	11.2	10.8	.75
Tobacco Products	6.2	8.0	.73
Beverages	6.2	6.5	.72
Food Products	2.9	7.2	.72
All Manufacturing	4.9	6.1	.72

Notes and Sources:

See the notes to Tables 1 and 2. The decomposition of the growth in labor productivity between the amounts attributable to changes in the capital to labor ratio and in total factor productivity respectively, was based on the accounting framework presented in equation (2) above. The estimated growth rates of value added per worker and net capital per worker employed in the calculations were reported in Table 3. The industry-specific estimates of α, or the output elasticity of capital, were computed from the parameters of a modified translog production function estimated over a pooled cross-section of the industry data over the years from 1963 to 1979. The production function was of the form:

$$\text{Ln}(Y/L)_{it} = \gamma_i d_i + \beta_1 \text{Ln}(K/L)_{it} + \beta_2 [\text{Ln}(K/L)_{it}]^2.$$

In this specification, there are individual intercept terms for each industry, but the estimated coefficients β_1 and β_2 hold for all. Since the function includes a quadratic term, however, the output elasticity of capital, or α, varies across industries with capital intensity. The estimates of α reported above and utilized in the decomposition were computed according to the expression $\alpha_i = \beta_1 + 2\beta_2 \text{Ln}(K/L)_i$, with the weighted average of each industry's capital to labor ratio over the entire period from 1963 to 1979. It is evident from examination that the estimated elasticities are generally high, relative to the standards of work on other countries, and increase with the capital intensity of the industry. These features are consistent with the implications of the evidence on distributional shares in Korea, as well as with estimates obtained from translog or Cobb-Douglas production functions estimated over data from single years. For example, the share of value added distributed to capital, from our data, is 0.59 in clothing, 0.67 in textiles, and 0.78 in steel. As discussed in footnote 7, these figures are in line with the work of other investigators.

Table 5

CORRELATION OF TOTAL FACTOR PRODUCTIVITY GROWTH WITH OTHER VARIABLES FOR 25 SOUTH KOREAN MANUFACTURING INDUSTRIES

(Correlation Coefficients)

	Growth Rate of				
	TFP	REAL EXPORTS	WAGES	VALUE ADDED	K/L
Rate of Growth of TFP, 1963-1979					
Rate of Growth of Real Exports, 1963-1979	.46				
Rate of Growth of Average Real Wage, 1963-1979	.20	.21			
Rate of Growth of Real Value Added, 1963-1979	.50	.32	-.08		
Rate of Growth of Capital-Labor Ratio, 1963-1979	-.70	-.13	.07	-.13	

Sources:
See the notes to Tables 1 and 2.