The Diffusion of Technology and Growth of Factor Productivity in Korean Manufacturing Industries*

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I. Introduction

Since the early 1960s the Korean economy has grown rapidly at an average annual rate of 9.3%. The growth rate of output in the mining and manufacturing sector was even higher, 16.9%, during the period of 1962-1979.[1] What accounts for such phenomenal growth of the Korean economy?

In studies attempting to account for the growth of the Korean economy it has been shown that growth of factor productivity accounted for a significant share of the output growth. For instance, according to a study carried out by Hong, the average annual growth rate of output, capital stock and employment in the Korean manufacturing sector were 17.1%, 10.2% and 12.0%, respectively, during the 1960-1973 period.[2] Since the estimated share of labor income was 40% for this period, it follows that total factor productivity grew at an annual rate of 6.18% during the period. That is, a little over a third of the annual growth rate of output was due to growth in total factor productivity, the rest being attributable to growth in the factors of production. This

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1 See Economic Planning Board, *Economic Management Plan for 1980*.

2 See W. T. Hong (1976).

increase in total factor productivity is reduced, however, when the rate of growth in utilization of capital stock is taken into account.[3]

In a more recent study of factor productivity of the Korean economy Christensen and Cummings demonstrate that its real output grew at an average annual rate of 9.7% during the 1960-1973 period.[4] Taking into account changes in the rate of utilization of capital stock and changes in the educational attainment of the labor force, they estimate the average annual rates of growth of real input and total factor productivity at 5.5% and 4.1%, respectively. During the same period labor productivity grew, according to their estimate, at an average annual rate of 7.0%. As they point out, Korea's rate of growth of factor productivity, however it may be measured, is considerably higher than the rates experienced by many developed countries during the same period.

What then accounts for the high rate of growth of factor productivity in the Korean economy and especially in the manufacturing sector? In this paper we proffer an answer to this question. Specifically, we provide an explanation of the growth of factor productivity in the Korean manufacturing industries for the period of 1963 through 1979.

In his survey of international studies of factor inputs and factor productivity Nadiri identifies the following as the sources of growth in factor productivity:[5] an improvement in resource allocation primarily due to resource shifts out of agriculture, economies of scale due to the expansion of market, and advances in knowledge. In explaining the growth of factor productivity in the Korean manufacturing industries the first is, however, of no relevance as it refers to resource reallocation from agriculture to manufacturing. The second and the third may explain the growth of factor productivity since Korea has had increases in manufacturing exports and has imported foreign technology in one form or another. To these we should probably add what some call the "beneficial externality of export activity" Dahlman and Westphal argue that for Korea export activities have been a

[3] See Y. C. Kim and J. K. Kwon (1977).
[4] L. R. Christensen and D. Cummings (1979).
[5] M. I. Nadiri (1972).

very important means for improving technology.[6] Contact with foreign buyers has led, they point out, to increased production efficiency, improved product designs, upgraded quality, and improved management practices. Furthermore, X-efficiency increased as exporters tried to maintain and penetrate overseas markets.

In this paper we focus on the diffusion of "modern" or foreign technology throughout an industry as a determinant of advances in knowledge and thus as a causal factor for productivity increases. However it may be introduced, foreign technology cannot be adopted by all the firms in an industry at the same time. Growth of factor productivity therefore depends on the speed and the extent of the diffusion of technology throughout the industry. With no or little diffusion the introduction of foreign technology will have only a limited effect on productivity increases.

The conceptual beginning of this paper is a study carried out by Nelson to explain international differences in labor productivity.[7] In comparing labor productivity of Columbia, a developing country, and the United States, a developed country, he employs a "diffusion" model in which an industry is divided between a sector with "modern" technology and a sector with "craft" or traditional technology. Assuming that modern technology is more productive than craft technology and that technology is the same for each sector of an industry in both countries, Nelson derives the conclusion that international differences in labor productivity in manufacturing industries are due to differences in the share of employment in the modern sector. Park applied the "diffusion" model to the Korea-Japan and the Korea-U.S. match using 1972 data and found results supporting Nelson's hypothesis on international differences in labor productivity.[8] An extension of the "diffusion" model to explain the growth of factor productivity in Korea seems, therefore, highly promising.

Section II discusses the "diffusion" model and its intertemporal version. It is there demonstrated that growth in factor productivity is due to a relative expansion of the more productive

[6] C. J. Dahlman and L. E. Westphal (1981).
[7] R. R. Nelson (1968).
[8] A. S. K. Park (1977).

modern sector and technological improvement in the craft and the modern sectors. Section III presents empirical evidence of a higher labor productivity in the modern sector and a relative expansion of the modern sector in the Korean manufacturing industries during the 1963-1979 period. Section IV discusses a method of inferring changes in technological efficiency from changes in labor productivity. Section V presents empirical evidence on changes in the relative technological efficiency and on technological improvement in the craft and the modern sectors. This includes some of the possible reasons for the observed change in the relative technological efficiency. Section VI concludes the paper.

II. The Diffusion Model

Nelson's "diffusion" model may be summarized for the present purpose in the following two equations:

$$(1) \quad q = q_c \frac{L_c}{L} + q_m \frac{L_m}{L}, \quad q_c < q_m$$

$$(2) \quad \frac{L_m}{L} = \frac{1}{1 + [\frac{L_c}{L_m}]_o e^{-\gamma t}}, \quad L_c + L_m = L$$

where q is value added per worker (a measure of labor productivity) of a given industry,[9] q_c value added per worker in its craft sector, q_m value added per worker in its modern sector. L_c, L_m and L are the number of workers employed in the craft sector, the modern sector and the entire industry, respectively. L_c/L and L_m/L are, thus, the share of employment in the craft and the modern sectors, respectively. $(L_c/L_m)_o$ in equation (2) is the ratio of employment in the craft sector to that in the modern sector at

9 We assume here that labor services are proportional to stocks of labor, which are taken to be the number of employees.

some initial point in time, and γ is some parameter with a positive value.[10]

Equation (1) states that the labor productivity in the industry is a weighted average of labor productivity in the craft and the modern sectors. Equation (2) specifies that time path of the share of employment in the modern sector, which asymptotically approaches unity. Nelson assumes that higher labor productivity in the modern sector is due to higher technological efficiency of modern technology. Given this assumption the labor productivity of the industry will increase over time as relatively more and more workers are employed in the modern sector.

One aspect of diffusion which is not dealt with in Nelson's model is the possibility that firms in the craft sector become more productive as a result of technology transfer from the modern sector. If technology is defined broadly to include management and marketing know-how as well as production technique, the transfer of technology will improve the technological efficiency of craft firms even though they have yet to adopt modern technology in its entirety. When they have fully adopted modern technology, they can of course no longer be regarded as craft firms. But until then, they will remain as craft firms even though their technology is improving as a result of technology transfer from the modern sector. In other words, in our view of diffusion the technology of a craft firm improves until the time when it becomes *metamorphosed* into a modern firm. Since there are many craft firms and since they are progressing at different speeds to the *metamorphosis,* we will observe both an increase in the number of modern firms and an increase in technological efficiency of craft firms during a given span of time.

In this intertemporal version of the "diffusion" model the introduction of modern technology is followed by a relative expansion of the modern sector and technological improvement in the craft sector. The introduction of modern technology will, therefore, increase the factor productivity of the industry both because of a relative expansion of the more productive modern

10 According to Nelson γ is a function of some other parameters and the unit cost of craft technology, and it takes a positive value. In this paper the precise value of γ is of no relevance as we are only interested in finding out whether the modern sector expanded or not relative to the craft sector.

sector and because of technological improvement in the contracting craft sector. The modern sector itself expands both because the firms with modern technology expand and because the number of modern firms increases as some craft firms adopt modern technology and join the rank of modern firms.[11]

In the case of Korea there is good reason to believe that such a process was going on during the 60s and the 70s. As pointed by Westphal, Rhee and Pursell, modern industrial technology began to be imported on a significant scale in the early 1960s through direct foreign investment, official technical assistance, formal licensing, the return of individuals trained abroad, suppliers of equipment or materials, and foreign buyers of output.[12] It is likely that relatively large firms were the initial recipients of the imported foreign technology. Once imported into the country, however, it could have spread throughout the industry, improving the technological efficiency of the firms still remaining in the craft sector. The process described so far may be stated more formally in the following manner.

Both the craft and the modern sectors of an industry are characterized with a linear homogeneous production function so that the labor productivity of the respective sectors can be written as:

$$(3) \quad q_c = A_c(t)\, f(K_c/L_c),$$

$$(4) \quad q_m = A_m(t)\, g(K_m/L_m), \qquad A_m(t) > A_c(t)$$

where $A_c(t)$ and $A_m(t)$ are Hicks-neutral "technology functions" of the craft and the modern sectors, respectively, and $K_c/L_c = k_c$ and $K_m/L_m = k_m$ are capital-labor intensities of the craft and the modern sectors, respectively. The modern sector has higher labor productivity than the craft sector because it possesses superior technological efficiency. Substituting equations (3) and (4) in equation (1) we obtain:

11 In a later article Nelson recognizes these two distinct effects of technology transfer — the diffusion of technology from firm to firm and the growth of firms using superior technology. See Nelson (1981).

12 See Westphal, Rhee and Pursell (1979).

$$(5) \qquad q = A_c(t)\, f(k_c) \frac{L_c}{L} + A_m(t) g(k_m) \frac{L_m}{L},$$

Differentiating equation (5) with respect to time and dividing with q we obtain:[13]

$$(6) \qquad \hat{q} = [\theta_m \Pi_m \hat{k}_m + \theta_c \Pi_c \hat{k}_c] + [\frac{q_m - q_c}{q}]\, d(\frac{L_m}{L}) + [\theta_m \hat{A}_m + \theta_c \hat{A}_c],$$

where $\hat{q}$ is the proportionate rate of increase in the labor productivity of the industry. Π_m, $\hat{k}_m$ and $\hat{A}_m$ are the capital-share in output, the rate of increase in capital-labor intensity and the rate of technological improvement in the modern sector, respectively. Likewise for Π_c, $\hat{k}_c$ and $\hat{A}_c$ in the craft sector. θ_m and θ_c are the modern sector's and the craft sector's share of the industry output, respectively, and $d(L_m/L)$ is the time derivative of L_m/L. Note that equation (6) holds for the general case where the relative factor price may differ between the two sectors. Equation (6) can be further rearranged as:

$$(7) \qquad \hat{q} - [\theta_m \Pi_m \hat{k}_m + \theta_c \Pi_c \hat{k}_c] = [\frac{q_m - q_c}{q}]\, d(\frac{L_m}{L}) + [\theta_m \hat{A}_m + \theta_c \hat{A}_c]$$

Then, the left-hand side of equation (7) is the rate of change in labor productivity that is not accounted for by the rate of change in factor intensity. It is also the unexplained "residual." In principle a weighted average of residuals of all sectors in the economy should equal the growth in total factor productivity estimated by Christensen and Cummings using the aggregate data.

The right-hand side of the equation identifies two sources of growth in productivity: a relative expansion of the modern sector,

13 For a discussion of the assumptions necessary for equation (6) see M. I. Nadiri (1970)

$d(L_m/L)>0$, and a weighted average of improvement in technology, $\hat{A}_c$, $\hat{A}_m>0$. The hypothesis profferred in this paper is, therefore, that the productivity increase in the Korean manufacturing industries is accounted for by a relative expansion of the modern sector and technological improvement in the modern and the craft sectors.

III. The Labor Productivity in Modern Sectors

As shown in equation (7), one of the two sources of growth in productivity in an industry is a relative expansion of employment in the modern sector, which has higher labor productivity than the craft sector. To verify whether this source can account, in part, for the productivity growth in the Korean manufacturing industries, we calculated value added per worker in the craft and the modern sectors. In our calculation we identified small firms as craft firms and large firms as modern firms. Small firms are those employing fewer than 50 workers per establishment and large firms are those employing 50 or more. In 1963, when rapid industrialization barely began in Korea, there were 18,310 establishments in the manufacturing sector. Of these, 17,065 establishments, 93%, employed fewer than 50 workers. in other words a typical Korean manufacturing firm that had existed before the rapid industrialization began in the early 1960s was a small firm employing fewer than 50 workers. It seems, therefore, reasonable to assume that such a firm used craft or traditional technology.

The results of our calculation are reported in Table 1 for nine KSIC (Korean Standard Industrial Classification) two-digit industries and for five years between 1963 and 1979. Clearly, value added per worker was greater in most of the cases for the modern sector than for the craft sector.[14]

In Table 2 we report the share of employment of the modern sector for the five years. The broad pattern that emerges is that the modern sector expanded relatively between 1963 and 1977 but stabilized or contracted relatively between 1977 and 1979.

14 Since value added is a function of labor services, the larger value added per worker in the modern sector could be due to greater manhours per worker in that sector than in the craft. There seems to be however, no reason for this to be the case in Korea.

Table 1

THE RATIO OF VALUE ADDED PER WORKER IN THE MODERN SECTOR FOR THAT IN THE CRAFT SECTOR IN KOREAN MANUFACTURING INDUSTRIES

Industry Code	Classification	1963	1967	1971	1977	1979
31	Food, Beverage & Tobacco	3.7	4.1	4.3	3.8	3.8
32	Textile, Wearing Apparel & Leather	1.5	1.5	1.6	1.4	1.4
33	Wood & Wood Products	2.3	1.3	2.6	1.2	1.0
34	Paper, Paper Products, Printing & Publishing	1.9	2.4	2.4	2.0	1.8
35	Chemicals, Chemical Products, Petroleum, Coal Rubber & Plastic	1.5	2.8	3.4	2.0	1.8
36	Non-Metallic Mineral Products	2.0	4.0	5.0	3.2	2.7
37	Basic Metal	1.3	1.6	2.9	2.5	2.6
38	Fabricated Metal Products, Machinery & Equipment	1.2	1.4	2.0	1.9	1.5
39	Other Manufacturing	1.1	0.9	1.3	1.2	1.0

Source: Calculated from data published in various issues of *Report on Mining and Manufacturing Survey,* Economic Planning Board, the Republic of Korea.

Note: The craft sector employs fewer than fifty workers per establishment, whereas the modern sector employs fifty or more workers per establishment.

In our intertemporal version of the "diffusion" model the modern sector expands both because of the growth of modern firms and because of an increase in their number. Although the share of employment in the modern sector increased between 1963 and 1977, this increase could be due to the growth of modern firms with no increase in their number. The fact is, however, that the number of modern firms increased in all industries during the 1963-1979 period with only one exception in Industry 39 between 1977 and 1979 (Table 3).

We further checked whether the size of modern firms grew.

Table 2

THE SHARE OF EMPLOYMENT OF THE MODERN SECTOR IN KOREAN MANUFACTURING INDUSTRIES

Industry Code	Classification	1963	1967	1971	1977	1979
31	Food, Beverage & Tobacco	.43	.47	.60	.74	.74
32	Textile, Wearing Apparel & Leather	.66	.68	.77	.88	.86
33	Wood & Wood Products	.32	.43	.59	.70	.68
34	Paper, Paper Products, Printing & Publishing	.52	.56	.66	.70	.67
35	Chemicals, Chemical Products, Petroleum, Coal Rubber & Plastic	.61	.71	.83	.87	.85
36	Non-Metallic Mineral Products	.51	.51	.61	.78	.75
37	Basic Metal	.67	.81	.83	.87	.87
38	Fabricated Metal Products, Machinery & Equipment	.45	.59	.68	.86	.85
39	Other Manufacturing	.47	.73	.86	.85	.81

Source: See Table 1.

The size, measured in terms of the number of workers per establishment, increased in most industries between 1963 and 1977 but decreased between 1977 and 1979 (Table 3). The figures in Table 3 thus indicate that the modern sector of the Korean manufacturing industries expanded between 1963 and 1977 both because of the growth of modern firms and because of an increase in their number.

To summarize, our findings are that labor productivity was generally higher in the modern sector than in the craft sector in the Korean manufacturing industries during the 1963-1979 period and that the modern sector experienced a relative expansion in employment between 1963 and 1977. It, therefore, follows that a relative expansion of the modern sector contributed to the

Table 3

THE NUMBER OF ESTABLISHMENTS AND THE AVERAGE NUMBER OF WORKERS PER ESTABLISHMENT IN THE MODERN SECTOR OF KOREAN MANUFACTURING INDUSTRIES

Industry Code	Classification	Number of Establishments				Average Number of Workers			
		1963	1967	1977	1979	1963	1967	1977	1979
31	Food, Beverage & Tobacco	148	174	470	550	177	229	265	249
32	Textile, Wearing Apparel & Leather	407	653	2,142	2,156	208	221	269	256
33	Wood & Wood Products	32	45	128	144	175	302	386	359
34	Paper, Paper Products, Printing & Publishing	106	125	323	347	134	169	183	179
35	Chemicals, Chemical Products, Petroleum, Coal Rubber & Plastic	162	182	600	712	224	276	345	305
36	Non-Metallic Mineral Products	103	140	280	371	118	171	216	205
37	Basic Metal	64	75	223	259	138	282	276	301
38	Fabricated Metal Products, Machinery & Equipment	162	333	1,394	1,709	167	187	288	296
39	Other Manufacturing	61	117	322	308	92	188	213	197

Source: See Table 1.

increase in productivity in the Korean manufacturing industries during the 1963-1977 period.

Our story for the 1977-1979 period is different. The modern sector contracted in seven industries while remaining the same in two. At the same time, however, there was either a decrease in the gap between labor productivities of the two sectors or equalization of their productivities. We would therefore expect that the contraction of the modern sector had an adverse effect on productivity growth in certain industries but no effect in others.

IV. Labor Productivity and Technological Efficiency

The second term on the right-hand side of equation (7), which is a weighted average of the rate of technological improvement in the craft and the modern sectors, is the other source of productivity growth. In our model the number of modern firms increases as craft firms improve their technology and eventually join the rank of modern firms. We have seen in the preceding section that the number of firms in the modern sector in fact increased during the 1963-1979 period. We would then expect that there was a positive rate of technological improvement in the craft sector during the same period.

How do we test the hypothesis that the rate of technological improvemnt in the craft sector was positive? One method is to measure capital and labor services in the craft sector and then calculate Kendrick's arithmetic measure of total factor productivity. This method is, however, practically impossible here due to lack of data on capital services at the disaggregate level.

An alternative method is adopted in this paper. Instead of estimating total factor productivity directly we investigate a minimum set of sufficient conditions under which a change in the relative labor productivity of the modern sector, which is observable, is equal to a change in the relative technological efficiency. If these conditions are reasonable, we can draw some inference, with the help of other evidence, about the rate of technological improvement from observations of the relative labor productivity.

Now, using equations (3) and (4) we obtain the relative labor productivity of the modern sector at tim t as:

$$(8) \quad G(t) \equiv [\frac{q_m}{q_c}]_t = [\frac{A_m(t)}{A_c(t)}] \, [\frac{g(k_m)}{f(k_c)}]_t$$

$$\equiv A(t) \; F(t)$$

where $A(t) \equiv A_m(t)/A_c(t)$ and $F(t) \equiv (g(k_m)/f(k_c))_t$.
Then, the ratio of the relative labor productivity at t_1 to that at t_0 is

$$(9) \quad \frac{G(t_1)}{G(t_0)} = \frac{A(t_1)}{A(t_0)} \cdot \frac{F(t_1)}{F(t_0)} \quad , \quad t_1 > t_0$$

The ratio of the relative labor productivity depends on the change in the relative technological efficiency and the change in the relative factor-intensity between t_0 and t_1.

Given the assumption of the Hicks-neutral, disembodied "technological function" and the assumption of a linear homogeneous production function the relative factor-intensity (k_m/k_c) changes only if the relative factor price changes for both or for either of the two groups of firms. It is widely recognized that craft and modern firms in Korea do not pay the same factor prices.[15] It can be shown, however, that if both groups of firms experience an equiproportional change in the relative factor price and if the production function has a unitary elasticity of substitution, then $(g(k_m)/f(k_c))_{t_1} = (g(k_m)/f(k_c))_{t_0}$; i.e., $F(t_1) = F(t_0)$. What is necessary for this result is, therefore, that even though segmental factor markets exist for craft and modern firms they both experience the same rate of change in the relative factor price. Although this is an assumption which may not hold for all the years we are investigating, it is nonetheless a weaker assumption than a customary assumption of a unified factor market where a single price prevails.

15 See B. K. Min (1976).

If we make the assumption discussed above, we can conclude that an observed change in the relative labor productivity in the Korean manufacturing industries is a change in the relative technological efficiency. That is:

$$(10)\quad \frac{G(t_1)}{G(t_0)} = \frac{A(t_1)}{A(t_0)}\ ,\ t_1 > t_0$$

If $G(t_1)/G(t_0) = 1$, it can be inferred that there was no change in the relative technological efficiency between t_0 and t_1. If $G(t_1)/G(t_0) < 1$, the relative technological efficiency declined between t_0 and t_1, and the converse holds if $G(t_1)/G(t_0) > 1$.

V. Relative Technological Efficiency in Modern Sectors

The figures reported in Table 4 are $G(t_1)/G(t_0)$ for nine two-digit industries for various subperiods. They are calculated by dividing the relative labor productivity of the modern sector in a given year with that in an earlier year. During the 1963-1967 period the technological efficiency of the modern sector increased relative to that of the craft sector in some industries but decreased or remained the same in others. But, during the 1967-1971 period it increased in all nine industries, then decreased uniformly between 1971 and 1977. The general pattern during the 1977-1979 period is a decrease in the relative technological efficiency of the modern sector. What we therefore observe is the fact that between 1963 and 1971 there was a general tendency for the relative technological efficiency of the modern sector to increase but a tendency to decrease between 1971 and 1979.[16]

[16] As pointed out by Kim and Kwon, and Min, liberal financial policies were adopted in Korea during the 1965-1972 period. As a result the annual real rate of interest for commercial bank loans, for example, increased from -4.5% during 1961-1964 to 16.1% during 1965-1971. There was, however, *volte-face* from liberal financial policies in 1972 with the reintroduction of restrictive financial policies. Since in Korea restrictive financial policies favored primarily large firms and not small firms, the financial liberalization and the *volte-face* of 1972 would have affected large firms and not small firms. If we accept the argument of Kim and Kwon that financial liberalization led to an increase in the rate of utilization of capital stock during the 1962-1971 period, this increase must have been due to an increase in the rate of utilization among large firms. Also, to be consistent, we must argue that the

Table 4

CHANGES IN THE RELATIVE TECHNOLOGICAL EFFICIENCY OF THE MODERN SECTOR IN KOREAN MANUFACTURING INDUSTRIES: $G(t_1)/G(t_0)$

Industry Code	Classification	1963-1967	1967-1971	1971-1977	1977-1979
31	Food, Beverage & Tobacco	1.11	1.05	0.88	1.00
32	Textile, Wearing Apparel & Leather	1.00	1.07	0.88	1.00
33	Wood & Wood Products	0.57	2.00	0.46	0.83
34	Paper, Paper Products, Printing & Publishing	1.26	1.00	0.83	0.90
35	Chemicals, Chemical Products, Petroleum, Coal Rubber & Plastic	1.87	1.21	0.59	0.90
36	Non-Metallic Mineral Products	2.00	1.25	0.64	0.84
37	Basic Metal	1.23	1.81	0.86	1.04
38	Fabricated Metal Products, Machinery & Equipment	1.17	1.43	0.95	0.79
39	Other Manufacturing	0.82	1.44	0.92	0.83

Source: See Table 1.

There is an additional piece of evidence supporting the observation that there was a switch in the trend of the relative technological efficiency around 1971. As the firms experiencing a—

rate would have decreased since 1972. It is conceivable then that value added per worker in the modern sector increased during 1965-1971 but decreased since 1972 relative to that in the craft sector. Such a change could account for the figures reported in Table 4. Before we accept this explanation, we need to test the hypothesis that the rate of utilizatin of capital stock in fact decreased since 1972 and the hypothesis that a change in the rate of utilization does not require a concomitant change in employment.

high rate of technological improvement would pay more for their factors of production than those experiencing a low rate, we would expect that the wage rate paid by modern firms increased more than that paid by craft firms during the earlier period but conversely during the later period.

In order to verify this expectation we first calculated the relative employee compensation of the modern sector for the industries. We then calculated changes in the relative employee

Table 5

CHANGES IN THE REATIVE EMPLOYEE COMPENSATION OF THE MODERN SECTOR IN KOREAN MANUFACTURING INDUSTRIES

Industry Code	Classification	1963-1967	1967-1971	1971-1977	1977-1979
31	Food, Beverage & Tobacco	1.16	0.96	0.85	0.97
32	Textile, Wearing Apparel & Leather	0.82	1.20	0.84	0.95
33	Wood & Wood Products	1.04	0.96	0.88	0.85
34	Paper, Paper Products, printing & Publishing	0.85	1.24	0.69	0.98
35	Chemcials, Chemical Products, Petroleum, Coal Rubber & Plastic	1.03	1.23	0.76	0.90
36	Non-Metallic Mineral Products	1.35	1.26	0.68	0.96
37	Basic Metal	0.93	1.46	0.90	0.83
38	Fabricated Metal Products, Machinery & Equipment	0.92	0.96	1.01	0.87
39	Other Manufacturing	0.84	1.58	0.81	0.91

Source: See Table 1.

compensation by dividing the relative employee compensation in a given year with that in an earlier year. As reported in Table 5, the general pattern for the first two subperiods is an increase in the relative employee compensation of the modern sector. Between 1971 and 1977 and between 1977 and 1979 the pattern is, however, clearly a decrease in the relative employee compensation. This evidence is consistent with our hypothesis regarding the change in the relative technological efficiency around 1971.

It was demonstrated in Section I that one source of productivity growth is a weighted average of the rate of technological improvement in the craft and the modern sector, the weights being the sectoral shares of industry output. Given the evidence presented above we may now conclude that during the 1963-1971 period the modern sector contributed more to the growth of productivity than the craft sector. During the 1971-1979 period it was, however, the craft sector that made a greater contribution to productivity growth.

VI. Cocluding Remarks

The data we have presented here indicate that there was a change in the relative technological efficiency around 1971. What accounts for this change? As noted above, in Korea the inflow of modern industrial technology began on a significant scale in the early 1960s and it took various forms such as official technical assistance, licensing, etc. Whichever form the inflow may have taken, the initial recipients of technology are likely to have been relatively large firms. In fact, some of these large firms are foreign subsidiaries or joint-venture firms, whose number of workers is in excess of 50.[17]

Thus, immediately following the introduction of modern technology the technological efficiency of large firms increased relative to that of small firms. As modern technology filtered down to small firms, their technological efficiency increased relative to that of large firms. The observed change in the relative labor productivity is a result of this sequential diffusion of modern technology.

[17] See C. H. Lee (1981).

This process is essentially what Dahlman and Westphal has observed in Korea, although they use slightly different terminology to describe it:[18]

> A wide variety of transfer modes has been used, with machinery imports and turnkey contracts predominating over licensing agreements and direct foreign investment in the initial acquisition of technology. But transfers have been no more than an initial step in the exploitation of available knowledge. *Assimilation* has been achieved through a succession of technological efforts over time, largely undertaken by domestic firms to extend their technological mastery and accomplish minor technological changes. These efforts have resulted in continual and significant increases in the productivity of resources employed in the industrial sector and have been reflected in Korea's sustained rapid industrial growth.

It is likely, as with other modes of technology transfer, that machinery imports and turnkey contracts were made by large indigenous firms. There is no reason, however, why assimilation (or diffusion) should have been confined to large firms. The initial acquisition of technology by large firms, its widespread assimilation and a time lag between initial acquisition and assimilation are the factors that can account for the observed change in the relative technological efficiency.

The purpose of this paper has been to explain the growth in factor productivity in the Korean manufacturing industries since the early 1960s. The explanation is that the growth in factor productivity was due to a relative expansion of the more productive modern sector, an increase in technological efficiency of large indigenous firms as modern technology was introduced from abroad, and an increase in technological efficiency of small firms as it subsequently filtered down.

When viewed from a more aggregated level of an industry, the introduction of modern technology appears simply as advances in knowledge for the entire industry. In the case of Korea, advances in knowledge did not occur evenly throughout an industry but ocurred first among large firms and then among small firms. Admittedly, the evidence presented in this paper is too crude to provide a rigorous test of the hypothesis. It has,

[18] See Dahlman and Westphal, p. 25. Italics added.

nevertheless, provided a highly plausible explanation of the growth of factor productivity and its pattern in the Korean manufacturing industries for the period of 1963 through 1979.

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