Comparative Advantage and Productive Efficiency of Korea in the Textiles, Clothing and Footwear Industries

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I. Introduction

The purpose of this paper is to examine comparative advantage and productive efficiency of Korea in the textiles, clothing and footwear industries, respectively, for the period 1968-1977. These industries have significantly contributed to Korea's export-oriented development policies.[1] Korea's export values of textiles, clothing and footwear as a total have been increased at an average annual rate of 41% for the 1968-1977 period, explaining about 40% of Korea's total export values for the same period.[2] Korea's market shares have become about 10% of world total exports in these industries, respectively.[3] It seems, therefore, that Korea has had comparative advantages in the exports of textiles, clothing and footwear.

However, the question arises whether such a conspicuous expansion in exports has been mainly based on cost advantages from Korea's cheap labor cost or on efficiency in production. As the so-called light manufacturing sectors, Korea's textiles, clothing and

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1 For detailed expositions of Korea's export-oriented development policies, see Frank, Kim and Westphal (1975) and Westphal, Rhee and Pursell (1979).

2 See Appendix 2 for details.

3 See Appendix 3 for details.

footwear industries have led the growth of exports due to Korea's abundant labor endowment. By exporting to world markets, however, these industries should achieve productive efficiency in order to maintain comparative advantages in the future. If they do not achieve productive efficiency, their export increases have mainly resulted from cheap labor cost, so that comparative advantages would be jeopardized in the face of increasing wage levels.

Following Farrell's approach (Farrell (1957), Tyler, Lecraw (1979)) we interpret efficiency as composed of two distinct and separable components--technical efficiency and price efficiency. Technical efficiency will be analyzed in terms of economies of scale (increasing returns to scale). Using the Cobb-Douglas production functions of these industries, we define the industry as being technically efficient if there are economies of scale in production.

Price efficiency will be analyzed in relation to the world-wide energy crisis in 1974. The crisis, by increasing capital costs, would change the ratio of the prices of capital and labor. A price-efficient industry would change the ratio of its marginal products of capital and labor equal to the changed ratio of their prices after the crises. This means that a price-efficient industry would use relatively more labor in response to increased capital costs after the crisis.

The paper is organized as follows: In the second section, an overview of Korea's textiles, clothing and footwear industries is made and their comparative advantages are examined. In the third section, the Cobb-Douglas production function is used to estimate economies of scale for these industries. In the fourth section, the 1968-1977 period is divided into 1968-1973 and 1974-1977 subperiods to investigate price efficiency associated with the world-wide oil crisis. In the final section, we summarize the findings and propose further researches needed.

II. Overview of the Industries and Their Comparative Advantages

Textiles Industry

Korea's textiles industry was composed of 4176 establishments in 1977. The number of persons imployed was reported 398 thousand in 1977. Of these, 289 thousand or 72.6% were committed to spinning and weaving.

The production of yarns increased from 130, 714 metric tons (M/T) in 1968 to 610, 704 M/T in 1977 with an annual rate of increase of 18%. The production of fabrics increased to 1, 312, 112 thousand square meters (m^2) in 1977 from 206, 340 thousand m^2 in 1968, which yields an average annual rate of increase of 22%. The details are presented in Appendix 1.

Clothing Industry

A total of 2777 establishments was reported for Korea's clothing industry in 1977. The total number of persons employed was 205 thousand. The production of clothing has increased from 31.9 billion won (U.S.$ .1 billion equivalent) in 1968 to 806 billion won (U.S.$1. 67 billion equivalent) in 1977 at current prices. The details are also presented in Appendix 1.

Footwear Industry

Korea's footwear industry had 192 establishments with 20 thousand persons employed in 1977. Its production has increased more than five times for the period 1968-1977, which amounted to 127 million pairs in 1977. The details are also given in Appendix 1.

The export performance of Korea's textiles, clothing and footwear industries have also been remarkable. The export value of textiles increased from U.S. $61,233 thousand in 1968 to U.S. $1,093,373 thousand in 1977 with an annual rate of increase of 42.3%. The export value of clothing has increased from U.S. $112,232 thousand in 1968 to U.S. $2,069,459 thousand in 1977, which yields an average annual rate of increase of 39.4%. The export value of footwear has also increased to U.S. $487,626 thousand in 1977 from U.S. $11,044 thousand in 1968, which shows an average increase rate of 58.1% annually. The details of Korea's export performances are presented in Appendix 2. It seems, therefore, that Korea has comparative advantages in the exports of textiles, clothing and footwear.

So far we have referred to comparative advantage in general terms. A more precise specification of comparative advantage is needed. Ideally, comparative advantage should be measured by relative prices of bundles of goods traded by those countries whose advantage one seek to establish. Since price differences are extremely difficult to observe in a world characterized by heterogeneous industries and multiproduct firms, we follow Balassa and others who looked for 'revealed comparative advantage' in the form of an export performance index, assuming that commodities characterized by comparative advantage will exhibit a high export performance Balassa (1965), Kojima (1970), Hirsch (1975), Parry (1975).

There are two indices in this type of revealed comparative advantage measure: (1) a measure of the share of an industry in the country's total exports Hirsch (1975)[4]; and, (2) a measure of the relative export performance of an industry involving the relative share of a country in the world exports of individual commodities, suitably normalized by that country's total share in "world" exports Parry (1975).

According to the first measure, in the traditional two-country and two-commodity model, we expect country 1 where the price ratio of A to B goods is lower than in country 2 to have a higher export performance in A: The ratio of A exports to total exports will be higher in country 1 than in country 2. And the second approach argues that if country 1's relative share in "world" exports of commodity A is greater than its overall share in total "world" exports, then country 1 has a "revealed" comparative advantage in exporting commodity A.

The first measure is legitimate for making cross section comparisons between countries. It would be useless for comparing the export performance of different industries within a single country. In cases of time series comparisons for an industry, therefore, the index does not indicate comparative advantage unless it is compared with other countries. It simply represents the share of the industry in the country's total exports over time. Instead, it is im-

4 This is represented by the index.

$$E_{ij} = \frac{X_{ij}}{X_i} \times 100$$

where E_{ij} = index of country i export performance in industry j

x_{ij} = country i exports of industry j

X_i = country i's total exports.

portant to note the directions of changes and their variance. If the index has been increased over time, then comparative advantage of the industry has been relatively strengthened, and vice versa. And if the changes in the index have been smaller, this suggests that comparative advantage of the industry has been relatively stable.

The index is presented in Table 1 for Korea's three industries. The index of the textiles industry has decreased from 13.4 in 1968 to 10.9 in 1977. Except in 1973, the index has been lower than that in 1968. This suggest that its comparative advantage has been relatively weakened during the period 1968-1977, though it has shown a relatively moderate stability in terms of its standard

Table 1

RELATIVE EXPORT PERFORMANCES IN KOREA IN TERMS OF VALUES

(percentage)

Year	Textiles	Clothing	Footwear
1968	13.4	24.6	2.4
1969	10.6	25.8	1.7
1970	10.2	25.6	2.1
1971	12.9	28.5	3.5
1972	11.2	27.1	3.4
1973	13.9	23.2	3.3
1974	11.2	21.5	4.0
1975	13.0	22.6	3.8
1976	12.5	24.1	5.2
1977	10.9	20.6	4.9
Average	11.98	24.36	3.43
Standard deviation	1.24	2.35	1.08

Sources: Calculated from Appendix 2.
Note: The index represents the export share of the industry in Korea's total exports as a percentage. For details, see Note 4 in p. 23.

Table 2

KOREA'S RELATIVE SHARES IN WORLD EXPORTS IN TERMS OF VALUE

(percentage)

Relative Share in World Markets / Year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Textiles	.7	.6	.7	1.0	1.0	1.9	1.8	2.4	3.1	3.2
Clothing	3.2	3.6	4.2	5.0	5.7	7.6	8.1	8.5	11.2	10.7
Footwear	.9	.7	1.1	1.9	2.3	3.8	5.3	4.9	8.9	9.3
Total Exports	.2	.2	.3	.3	.4	.6	.5	.6	.8	.7

Sources: Calculated from Appendix 3.
Note: The index of the industry is Korea's export shares in total world exports of the commodity.
Total Exports represents Korea's total export values as a percentage of world total export values.

deviation. On the other hand, the index of Korea's footwear industry has been doubled for the same period. What is more, the index has been most stable. This could be interpreted as the fact that comparative advantage of Korea's footwear industry has been strengthened significantly and stably during the period 1968-1977. Lastly, the index for Korea's clothing industry has been mostly variable in terms of its standard deviation. This might indicate unstable comparative advantage of Korea's clothing industry. However, two related points should be noted. First, the index of Korea's clothing industry is much higher than those of the textiles and footwear industries. It turns out to be about 24, which means that about 24% of Korea's total exports has been performed by the clothing industry. As Korea's total exports increase rapidly, the index is possibly subject to higher variations relative to smaller ones. Second, the index has decreased since 1973-1974, when the world-wide oil crisis prevailed. This means that the relative share of Korea's clothing industry in Korea's total exports has diminished in the post-oil crisis period.

As mentioned before, Table 1 is incomplete measures of comparative advantages unless compared with other countries. For a complete measure of revealed comparative advantage, we will use the second index. As shown in Table 2, the relative export shares of Korea's three industries have been much greater than Korea's overall share in total world exports during the period 1968-1977. This means that Korea has comparative advantages in the exports of textiles, clothing and footwear.

III. Scale Economies of the Industries

In the previous section, we have found that Korea's textiles, clothing and footwear industries have comparative advantages in world exports, respectively. However, the question remains whether such comparative advantages have been based on increased efficiency. Of efficiency, this section deals with technical efficiency in terms of economies of scale. The industry is defined to be technically efficient if it has demonstrated economies of scale in production.

1. The Nature of Economies of Scale

The existence, nature and measurement of economies of scale have been the subjects of debate since the times of Adam Smith. The existence debate has long been resolved, but there remains an ongoing discussion regarding the nature of economies of scale and how they are best measured Pratten (1971).

Economies of scale are reductions in average costs attributable to increases in scale.[5] We can estimate directly the cost function, but it involves grave difficulties in application.[6] The traditional approach was to specify the production function which described the maximum output that can be obtained, with an existing state of technological knowledge, from given quantities of inputs. The production function approach describes the efficient techniques, i.e., those which produce the maximum output of a desired commodity for given inputs Walters (1963).[7]

The production function is a technological relationship confronting a firm. It is the entrepreneur who chooses factor proportions and output levels. Can we then proceed to construct useful production functions for an industry as a whole? One difficulty is that those factors which we regarded as fixed for the individual firm are not necessarily fixed for the industry, e.g., intrepreneurial ability. Other factors, such as the quantity of skilled labor, which were not fixed for the individual firm, may well be an important limitation for the industry.[8] Empirically the use of aggregate industry level data may mix fundamentally different production techniques. Again use of aggregate data mixes *ex post* and *ex ante* substitution in response to changing factor prices over time and may give spurious results if changing capacity utilization is not taken into account.[9]

We shall assume, therefore, that the distinguishing features of firm production for a given industry may be embodied in attained values for certain technical parameters in an "industry" production function, differences in them reflecting capacity utilization, scales of operation, organizational structures, etc. In the spirit of

5 See Pratten (1971), p. 3.

6 For a detailed discussion, see Walters (1963), pp. 41-52.

7 When the production function is estimated, it is assumed that the only error is in the disturbance term. This error is generally thought to arise from variables omitted from the relationship or errors in measurement of the dependent variable Johnston (1972), p. 281. If firms do not operate along the production frontier, for whatever reason, the production function that is estimated will be some "average" production function, not the efficient frontier Aigner and Chu (1968), Lecraw (1977).

8 Walters (1963), p. 8.

9 Lecraw (1979), p. 633.

Farrell (1957, 1962) who constructs an envelope isoquant for the industry, the "industry" production function is conceptually a frontier of potential attainment for given input combinations. The production function for any particular firm may conceptūrally be obtained from the industry function in terms of the firm's ability to implement optimal values of parameters in the industry.

We now define economies of scale for an industry in terms of the elasticity of the production function for the industry. The elasticity of a function f with respect to some decision variable x is defined as:

$$e_x^f = \frac{\text{proportionate change in f}}{\text{proportionate change in x}} \tag{1}$$

The function $f(x_1, x_2, \ldots, x_n)$ is defined as the production function, but the elasticity of f can not be defined without defining x, the variable with respect to which the elasticity is to be measured. If we assume that the other inputs are fixed, the elasticity of $f(x_1, x_2, \ldots, x_n)$ with respect to x_i is then:

$$e'^{f}_{x_i} = \frac{\partial f}{\partial x_i} \cdot \frac{x_i}{f} \tag{2}$$

This elasticity relates to the returns to a variable factor used in combination with other factors which are indivisible in the short run, and have no direct relevance to estimates of economies of scale for the industry.

Alternatively we might assume that other inputs are adjusted to maintain an optimal input mix, in which case the elasticity of f with respect to x_i is:

$$e''^{f} = \frac{df}{dx_i} \cdot \frac{x_i}{f} = \frac{\Sigma_j \, (\partial f/\partial x_j) \, dx_j}{dx_i} \cdot \frac{x_i}{f} \tag{3}$$

For each relative factor price regime we can identify the optimum input mix required to produce a given output. Hence we can device the elasticity of output with respect to each input:

$$e''^{f}_{x_i} = \frac{d \log [p(x^*)]}{d \log (x_i)} \quad (i = 1 \ldots\ldots n) \tag{4}$$

where P( ) = production function
x^* = optimum input mix for a particular factor price regime.

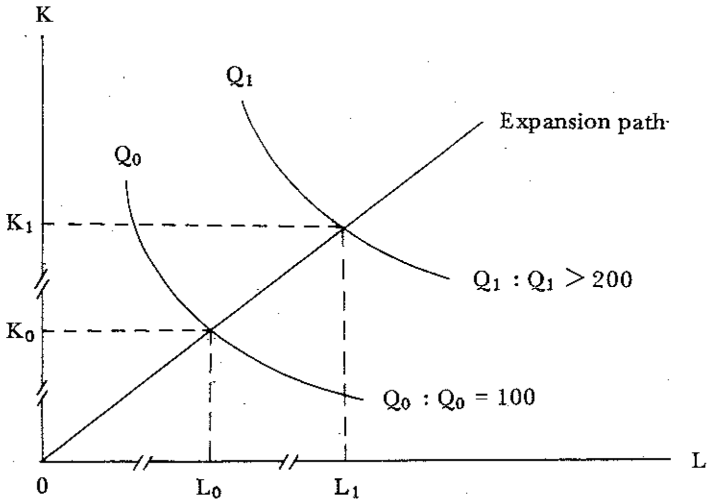
If the production function is homogeneous, then there exists a linear expansion path for each relative factor price regime and the elasticity of output with respect to all inputs is the degree of homogeneity of the production function.[10]

Economies of scale are said to exist with respect to all inputs, when the appropriate elasticity of the production function evaluated at constant relative factor prices and given technology is greater than unity over the range of attainable scales Griliches and Ringstad (1971).

Economies of scale can be schematically shown through the isoquants diagram. Point A in Figure 1 represents an industry producing at an observed combination of two factors--K_0 and L_0--to produce output Q_0 (for example, 100 pairs of footwear). The isoquant Q_0Q_0 depicts the combinations of K and L to produce 100

Figure 1

ECONOMIES OF SCALE



10 Layard and Walters (1978), p. 64.

pairs of footwear efficiently. If K and L are increased to K_1 and L_1 proportionally, say, are doubled, this will reach the new isoquant Q_1Q_1 for output Q_1. If the new output Q_1 is increased more than proportionally from Q_0, i.e., is greater than 200 pairs, there are economies of scale.

To estimate economies of scale, we will concentrate on the estimation of the Cobb-Doublas production functions of Korea's textiles, clothing, and footwear industries.[11] The elasticity of the function which is given by the sum of the output elasticities with respect to capital input (K) and labor input (L), measures the relative increases in output from a proportional increase in K and L. If there are economies of scale, the estimated elasticity of the function is above unity.

A coveat is in order. For sensible aggregation of the industry, the production function must be additively separable.[12] Output is then equal to a labor component plus a capital component.[13] The Cobb-Doublas production function does not satisfy the condition, but when transformed logarithmically the function is additively separable.[14]

2. *Methodology*

The methods used to etimate the production functions are single equation, ordinary least squares. They typically lead to econometric problems of simultaneity (endogeneous explanatory variable), multicollinearity and heteroskedasticity. Multicollinearity and heteroskedasticity problems are carefully examined in relation to actual data in Section 3, but the methods are still weak, in the sense that they do not take into account the fact that K and L are jointly determined with output K and L are not independent of the stochastic disturbance term, and our methods lead to a pro-

11 For the properties of the Cobb-Douglas production function, see Nerlove (1965), for example.

12 For discussion of additivity and separability, see Layard and Walters (1978), pp. 163-167.

13 In fact the function should be of the form

$$X^{w_0} = aL^{w_1} + bK^{w_2}$$

where the w's are constant weights.

14 This is the rationalization of Klein's use of geometric means. One of the practical problems is that the data are published in the form of arithmetic averages or totals, whereas our function requires geometric averages. However, if the relative variances of the variables, output, capital, and labor are approximately equal, the relative biases will be about equal.

blem of simultaneous estimation Intriligator (1978).[15]

However, it is dangerous to be pedantic about the superiority of simultaneous equations or single equation methods. The choice between the single and simultaneous equation models must depend on the purposes for which the estimates are required, the availability of data, and relative errors.

The function can be expressed as

$$Q_t = AK_t^{\alpha} L_t^{\beta} e^{U_t} \tag{5}$$

where Q_t = output at period t
K_t = capital input at t
L_t = labor input at t

The log-linear form is then

$$q_t = a + \alpha k_t + \beta l_t + U_t \tag{6}$$

denoting the logarithm of corresponding variables by lower case letters. The estimated α and β measure the elasticities of output with respect to capital and labor, respectively. The sum $\alpha + \beta$ gives information about returns to scale, that is, the response of output to a proportionate change in the inputs. If the estimated sum is greater than unity, there are economies of scale, which is considered technically efficient.

All data, presented in Appendix 4, are annual for the period 1968-1977 and are taken from the UN Yearbook of Industrial Statistics, supplemented by Korea Statistical Yearbook. Therefore, all data are generally in accordance with United Nations standards.

As a proxy for capital input, electricity consumption used, to avoid weaknesses of the book value of capital as a measure of capital input.[16] One of the dissatisfactions with the book value of assets as a measure of capital input is that while output is a flow concept applied to the period of time, the book value of assets is a stock at a particular point in time. The justification for using

15 The simultaneity problem refers to the possible confusion in causality: output depends on K and L, while K and L, in turn, depend on output. For possible solutions, see Griliches (1979).

16 For the excellent summary of the weaknesses, see Mason (1973).

electricity consumption is that within the textiles, clothing and footwear industries, respectively, the technologies are sufficiently similar, so that the capital input is proportional to electricity consumption Cohen (1973).[17]

3. Empirical Findings

The estimated parameters of the Cobb-Douglas are reported in Tabel 3. From Tabel 3, a test of the hypothesis of constant returns to scale can be conducted by the t test as follows:

$$t = \frac{(\alpha + \beta) - 1}{SE(\alpha + \beta)}$$

$$= \frac{(\alpha + \beta) - 1}{Var(\alpha) + Var(\beta) + 2Cov(\alpha,\beta)} \qquad (7)^{18}$$

Table 3

REGRESSIONS USING ELECTRICITY AS A PROXY FOR CAPITAL INPUT

	Intercept	α	β	R^2	F-ratio
Textiles Industry	-3.362	0.876	.142	.991	390.121[a]
	(-1.533)	(5.144)[a]	(.367)		
Clothing Industry	-6.193	.421	1.090	.990	353.83[a]
	(-6.121)[a]	(2.386)[b]	(5.073)[a]		
Footwear Industry	-3.974	-.265	1.643	.864	22.314[a]
	(-3.025)[b]	(-.731)	(4.386)[a]		

Note:
1. Numbers in parentheses are t-tests.
2. a, b, and c indicate significant difference from zero at 1 percent, 5 pecent, and 10 percent levels, respectively.
3. Assuming N = 15, the Durbin-Watson test indicates that while the test is inconclusive for the textiles industry, there is no positive or negative serial autocorrelation in the clothing industry and the footwear industry, respectively.

17 Electricity consumption possibly serves our purpose better in examining the effects of the energy crisis, which is dealt with in Section 4.

18 See Gujarati (1978), p. 325.

If increasing returns to scale prevails, the t value computed above exceeds the critical t value at the chosen level of significance on a one-tailed test, so that we may reject the hypothesis of constant returns to scale.[19] The result of the t test in equation (7) is given in Table 4.

As shown in Table 4, the sum of the estimated output elasticities $\alpha + \beta$ is significantly different from 1 in the clothing and footwear industries. This indicates that Korea's clothing and footwear industries have demonstrated increasing returns to scale for 1968-1977 period. On the other hand, the textiles industry is subject to constant returns to scale for the same period, since the estimated sum is not statistically different from unity.

Table 4

THE TESTS OF THE HYPOTHESIS OF CONSTANT RETURNS TO SCALE (H_{11}: $\alpha + \beta = 1$)

	$\alpha + \beta$	t-value	df	Decision
Textiles Industry	1.018	.082	7	Accept H_{11}
Clothing Industry	1.512	7.659[a]	7	Reject H_{11}
Footwear Industry	1.369	1.678[c]	7	Reject H_{11}

Note: a and c indicate the 1 percent and 10 percent significance level.

19 By imposing the restriction that $\alpha + \beta = 1$ on equation (6) directly, we can also use the F-test as follows:

Let

Σe_1^2 = the residual sum of squares (RSS) of the estimated equation (6)
Σe_2^2 = RSS of the estimated equation with the restriction
m = number of restriction (1 in this case)
K = number of parameters in equation (6)
N = number of observations

Then,

$$F = \frac{(\Sigma e_2^2 - \Sigma e_1^2) / m}{\Sigma e_1^2 / (N - K)}$$

follows the F-distribution with m, N–K df.
See Gujarati (1978), p. 326.

The test procedure in equation (7) is indirect, in the sense that we actually test the hypothesis of constant returns to scale. A direct approach would be to test the hypothesis of increasing returns to scale by incorporating the hypothesis into our function. According to the hypothesis, the sum of α and β is greater than 1, i.e., $\alpha + \beta > 1$. If we introduce a slack value h, we get

$$\alpha + \beta - h = 1 \qquad (8)^{20}$$

If we incorporate equation (8) into equation (5), the model becomes

$$Q_t = a_0 K_t^{\alpha} L_t^{h-\alpha+1} e^{U_t} \qquad (9)$$

If we divide both sides by L_t, we get

$$\frac{Q_t}{L_t} = a_o \left(\frac{K_t}{L_t}\right)^{\alpha} L_t^{h} e^{u_t} \qquad (10)$$

Its log-linear form becomes

$$\log \frac{Q_t}{L_t} = \log a_o + \alpha \log \frac{K_t}{L_t} + h \log L_t + U_t \qquad (11)^{21}$$

A primary advantage of this information is that it permits a direct t test of whether h is significantly different from zero. If the estimated h is significantly greater than zero on a one tailed test, we may accept the hypothesis of increasing returns to scale.

The empirical findings of equation (11) are presented in Table 5.

As shown in Table 5, h is significantly greather than zero in the clothing and footwear industries, thus leading to the conclusion of increasing returns to scale. On the other hand, h is not statistically different from zero in Korea's textiles industry. These results are same as in Table 4. Therefore, we conclude that Korea's clothing and footwear industries have demonstrasted technical

20 For detailed discussions, see Intriligator (1971).

21 This estimating equation has been used by Griliches and Ringstad (1971).

Table 5

REGRESSIONS FOR THE HYPOTHESIS OF SCALE ECONOMIES
(H_{12}: $\alpha + \beta > 1$)

	Intercept	α	h	R^2	F-value	Decision
Textiles Industry	-3.362 (-1.533)	.876 (5.144)[a]	.018 (.082)	.971	116.074[a]	Reject H_{12}
Clothing Industry	-6.193 (-6.121)[a]	.421 (2.386)[b]	.512 (7.656)[a]	.935	50.466[a]	Accept H_{12}
Footwear Industry	-3.974 (-3.025)[b]	-.265 (-.731)	.369 (1.679)[c]	.379	2.135	Accept H_{12}

Notes: 1. Numbers in parentheses are t-values.
2. a, b, and c indicate significant difference from zero at 1 percent, 5 percent, and 10 percent levels, respectively.

efficiency in production, while Korea's textiles industry has not achieved technical efficiency.

IV. Price Efficiency of the Industries

The world-wide oil crisis has caused capital costs to increase significantly.[22] In response to increased capital costs a price-

22 Actual prices per Kwh sold are reported as follows:

Year	Won/Kwh
1968	6.04
1969	5.85
1970	6.33
1971	6.40
1972	7.36
1973	7.30
1974	10.64
1975	17.10
1976	19.43
1977	21.81

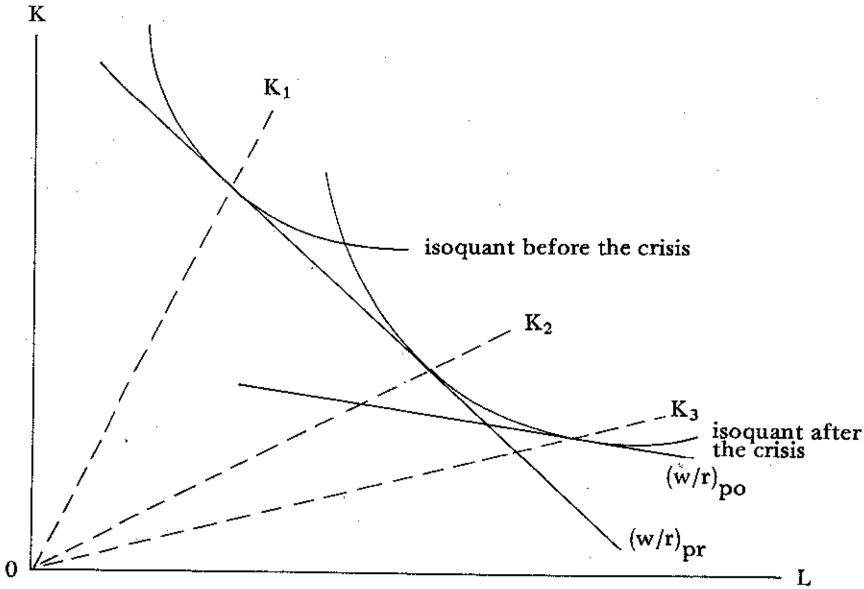
Source: Korea Electric Co.
Note that the prices was increased in 1974 by about 46 percent as compared with in 1973.

efficient industry will substitute labor for capital after the crisis.[23] To test the existence of substitution possiblities with production function estimates and observed capital-labor ratios, we divide the sample into two parts: pre-energy crisis and post-energy crisis, where the latter characterizes the 1974-1977 period. Then the production function in Equation (6) is estimated for both subperiods.

Figure 2 describes the substitution choices for the industry in pre-and post-energy crisis subperiods. The respective wage-electricity cost ratios are given by $(w/r)_{po}$ and $(w/r)_{pr}$; K_1 represents the capital (electricity consumption)-labor ratio before the energy crisis; K_3 represents the capital-labor ratio after the

Figure 2

FACTOR SUBSTITUTION



23 "An exmaple . . . comes from a project to reduce energy use in the finishing of textiles. Old way: cloth is treated with a liquid to make it, say, water-repellent or more resistant to wrinkling; then it takes a lot of heat to dry the cloth. New way: cloth is treated with a concentrated foam instead; with much less moisture, much less heat is needed for drying" (Fortune, March 9, 1981, p. 84).

energy crisis; and K_2 represents capital-labor ratio of the industry after the energy crisis if it were to face the wage-electricity cost ratio not significantly different from the pre-energy crisis period. K_1 and K_2 are selected by choosing the least cost capital-labor ratio.

By comparing k_2 and k_3 we can test for price efficiency after the crisis; if k_2 k_3, then the industry is selecting an activity on the isoquant which utilize relatively more labor after the crisis due to increased capital costs. Therefore, k_2 exceeds k_3 in the price-efficient industry.

Capital-labor ratios, k_1 and k_3, are taken to be the observed means in pre-and post-oil crisis. Assume that perfect competition prevails. To calculate, k_2, equate the least cost ratios of the pre-oil crisis and the post-energy crisis under the assumption of a common wage-electricity cost ratio, $(w/r)_{pr}$, and solve for k_2.[24]

Productive technologies differ between the pre-energy crisis and the post-energy crisis if, when facing the same wage-electricity cost ratio, the least cost capital-labor ratios differ, i.e., k_1 is different form k_2. The hypothesis that $k_1 = k_2$ can be tested by applying Chow's F-test of the equality of the coefficients of the two sub-period regressions, since, if the production functions are identical and factor price ratio is equal, the capital-labor ratios must be equal.

The estimated parameters are reported in Table 6. The Chow tests indicate the regression coefficients do not differ between the two sub-periods in Korea's textiles and clothing industries. In these industries, therefore, we can not say that k_1 and k_2 in Figure 2 differ significantly. There are thus no statistical differences in productive technologies between the pre-energy crisis and the post-energy crisis. However, the equality of production regression coefficients is rejected at the 5 percent level in Korea's footwear industry. This means that productive technologies differ between

24 To illustrate, letting pr and po be subscripts referring to the pre-energy crisis period and the post-energy crisis period, respectively, equate the least cost capital-labor ratio of the pre-energy crisis,

$$(\beta_{pr}/\alpha_{pr})\, k_1 = (w/r)_{pr}$$

with the least cost ratio of the post-energy crisis,

$$(\beta_{po}/\alpha_{po})\, k_2 = (w/r)_{pr}$$

and solve for K_2.

Notice that the calculation of k_2 does not require data on w/r.

the pre-energy crisis and the post-energy crisis in Korea's footwear industry. This in turn implies that at least two different technologies exist in Korea's footwear industry Courtney and Leipziger (1975).

Table 6

REGRESSIONS FOR FACTOR SUBSTITUTION

	Intercept	α	β	R^2	Chow-test F-ratio
Textiles Industry					
Pre-energy crisis	-3.346	1.066	-.007	.991	
	(2.152)	(8.412)[a]	(.027)		3.08
Post-energy-crisis	1.796	1.706	-1.154	.947	
	(.158)	(1.168)	(.458)		
Clothing Industry					
Pre-energy crisis	-5.237	.53	.905		
	(3.282)[b]	(2.81)[c]	(3.04)[c]	.973	
					2.36
Post-energy crisis	-.268	.687	.232	.996	
	(.287)	(5.77)	(1.307)		
Footwear Industry					
Pre-energy crisis	1.078	.152	.386	.518	
	(.738)	(.802)	(1.078)		
					13.19[b]
Post-energy crisis	.887	.749	.316	.977	
	(.874)	(1.946)	(.891)		

Notes: 1. Numbers in parentheses are t-values.
2. a, b, and c indicate significant difference from zero at 1 percent, 5 percent, and 10 percent levels, respectively.

As shown in Table 7, k_2 is less than k_3 in Korea's textiles industry. This means that the textiles industry is price-inefficient since it uses more capital after the crisis in spite of increased capital costs. This might be explained by the fact that Korea's textiles industry has made efforts to improve its product quality by relying on more capital-intensive uses. Since k_1 and k_2 are statistically the same in the textiles industry, however, its efforts have failed with the same technology available. On the other hand, k_2 exceeds k_3 in Korea's clothing and footwear industries, which implies that the chosen production process is run more labor-intensively after the energy crisis due to relatively lowered wage levels. This indicates that Korea's clothing and footwear industries are price-efficient.

Table 7

ESTIMATES OF K_1, K_2 AND K_3

	k_1	k_2	k_3
Textiles Industry	.17	.002	.30
Clothing Industry	.02	.10	.02
Footwear Industry	.08	.48	.05

However, the way to maintain price-efficiency differs in these two industries. Since k_1 and k_2 do not differ in Korea's clothing industry, the industry has basically used the same technology regardless of the energy crisis. Instead, the clothing industry has successfully substituted labor for capital where possible and employed more labor per unit of capital after the crisis than before the crisis. On the other hand, Korea's footwear industry has at least two different technologies available since k_1 differs statistically from k_2. After the crisis, therefore, Korea's footwear industry has chosen a different technology which is more labor-using.

V. Conclusion and Proposal

Korea has had comparative advantages in the exports of textiles, clothing and footwear for the period 1968-1977. Though Korea's textiles industry has a comparative advantage, it fails to achieve efficiency--neither technical efficiency nor price efficiency.

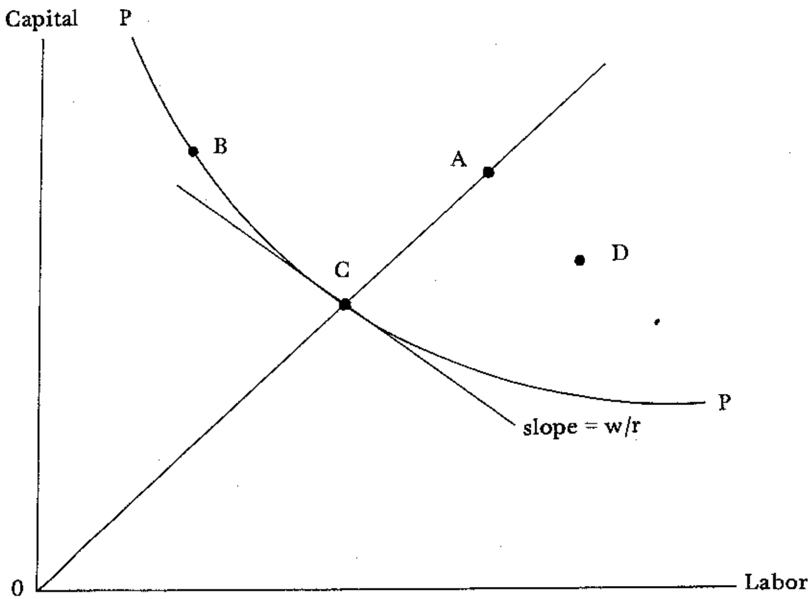
Its comparative advantage is simply based on Korea's cheap labor costs. Therefore, its comparative advantage would be jeopardized in the face of increasing wage levels. On the other hand, Korea's clothing and footwear industries have achieved efficiency--both technical efficiency and price efficiency. Therefore, their comparative advantages would be maintained in the future. What is more, the footwear industry has the flexibility in adapting the technology.

The usefulness of our studies lies in providing a criterion for judging the firm's chosen technology. If we get data about firms within the industry, we can judge the appropriateness of the technology chosen by the firm, using our results.

This is illustrated in Figure 3. The estimated function (6) is PP.

Figure 3

CHOICE OF TECHNOLOGY FOR A FIRM



For a given factor-price ratio w/r, an efficient firm would choose its technology at C. A technology is price-inefficient if it is on the production frontier, but the ratio of its marginal products of capital and labor is not equal to the ratio of their prices (point B in Figure 3). A technology is technically inefficient if it is to the northeast of the production frontier (point A). At point D, the chosen technology is both technically inefficient and price-inefficient. A firm that chooses technology at C uses appropriate technology; any other technology is inappropriate.[25]

25 A similar study has done on Thai economy by Lecraw (1977).

APPENDIX 1

Table 1

PRODUCTION OF TEXTILES AND FOOTWEAR IN KOREA

Year	Yarns		Fabrics		Footwear	
	M/T	% inc.	100 m^2	% inc.	1000 pairs	% inc.
1968	130,714	–	206,340	–	25,912	–
1969	200,721	53.6	314,468	52.4	31,695	22.3
1970	261,447	31.3	328,653	4.5	31,712	(3.1)
1971	289,177	10.6	405,217	23.3	43,148	40.5
1972	406,838	40.7	432,777	6.8	43,531	1.0
1973	586,001	44.0	632,271	46.1	67,644	55.4
1974	603,383	3.0	609,255	(3.6)	75,736	12.0
1975	568,581	(5.8)	720,562	18.3	71,536	(5.5)
1976	538,282	(5.3)	936,113	29.9	112,798	57.7
1977	601,704	11.8	1,312,112	40.2	127,104	12.7
1978	630,203	4.7	1,457,079	11.0	140,261	10.4

Source: Economic Planning Board, Korea.

Table 2

PRODUCTION OF TEXTILES, CLOTHING AND FOOTWEAR IN VALUES (Unit: Billion Won)

Year	Textiles	Clothing	Footwear
1968	129.0	31.9	3.3
1969	173.4	35.9	3.4
1970	197.5	46.3	3.6
1971	261.8	62.4	5.6
1972	378.1	94.5	11.1
1973	665.1	139.7	12.2
1974	806	251	14
1975	1,303	385	28
1976	1,813	666	39
1977	2,164	806	101

Source: Yearbook of Industrial Statistics, U.N. and The Growth of World Industry, U.N.

APPENDIX 2

Table 3

EXPORTS OF KOREAN TEXTILES, CLOTHING AND FOOTWEAR

(Unit: $ thousand)

Year	Textiles		Clothing		Footwear		Total Exports of Korea	
	Amount	% inc.	Amount	% inc.	Amount	% inc.	Amount	% inc.
1968	61,233	—	112,232	—	11,044	—	455,401	—
1969	65,700	7.3	160,770	43.2	10,476	(5.1)	622,516	36.7
1970	84,943	29.3	213.566	32.8	17,268	64.8	835,185	34.2
1971	137,834	62.3	304,265	42.5	37,436	116.8	1,067,607	27.8
1972	182,153	32.2	439,784	44.5	55,404	48.0	1,624,088	52.1
1973	448,133	146.0	749,598	70.4	106,371	92.0	3,225,025	98.6
1974	499,461	11.5	956,889	27.7	179,547	68.8	4,460,370	38.3
1975	659,128	32.0	1,147,848	20.0	191,213	6.5	5,081,016	13.9
1976	964,358	46.3	1,856,037	61.7	398,521	108.4	7,715,107	51.8
1977	1,093,373	13.4	2,069,459	11.5	487,626	22.4	10,046,457	30.2

Source: U.N. Commodity Trade Statistics and Economic Planning Board, Korea.

APPENDIX 3

Table 4

WORLD EXPORTS OF TEXTILES IN TERMS OF VALUE

Country of Origin	% of Total										
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
U.S.	5.7	5.1	4.9	4.4	4.7	5.4	6.4	6.1	6.4	5.8	5.5
Japan	15.7	14.4	14.1	14.4	12.9	10.5	11.0	11.0	10.8	11.0	9.4
France	8.3	7.2	7.4	7.2	7.2	7.3	6.8	6.9	6.3	6.6	6.5
Germany	11.0	11.1	12.0	12.8	12.5	11.8	12.9	12.3	12.5	12.1	12.1
U.K.	8.2	7.6	7.7	7.3	6.5	6.2	6.2	5.8	5.5	5.9	5.7
Korea	.7	.6	.7	1.0	1.0	1.9	1.8	2.4	3.1	3.2	3.8
World Total Exports (U.S. Millions)	9,115	11,400	12,391	14,294	16,999	23,224	27,956	26,512	30,727	33,857	40,706

Source: Calcualted from U.N. Commodity Trade Statistics and U.N. Yearbook of International Trade Statistics.

Table 5

WORLD EXPORT OF CLOTHING IN TERMS OF VALUE

Country of Origin	% of Total											$ million		
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1968	1973	1978
Hong Kong	13.7	13.8	13.7	14.8	14.1	14.4	14.3	15.0	17.5	15.5	14.8	488.6	1,418.2	3,328.2
Italy	17.3	17.8	16.9	15.7	15.9	13.2	13.0	13.7	12.7	13.5	14.8	617.0	1,296.4	3,328.2
Korea	3.2	3.6	4.2	5.0	5.7	7.6	8.1	8.5	11.2	10.7	11.2	112.3	743.5	2,518.6
W. Germany	8.6	8.2	8.2	8.5	8.3	9.0	8.1	8.3	8.5	8.9	9.1	304.9	882.0	2,046.4
France	8.0	7.7	8.2	9.1	10.2	10.2	9.7	9.8	7.4	7.6	7.5	285.0	1,004.7	1,686.6
U.K.	5.6	5.7	5.6	5.1	4.6	4.4	4.9	4.3	4.4	5.4	5.6	197.9	429.2	1,259.3
Belg-Lux	5.2	5.3	5.4	5.7	5.8	5.8	5.6	5.0	4.1	3.9	3.5	186.9	569.6	787.1
Netherlands	3.2	3.6	4.0	3.9	4.0	4.1	4.0	3.8	3.2	2.7	2.7	114.1	402.7	607.2
U.S.	4.9	4.6	4.0	3.4	3.1	2.8	3.4	3.0	3.0	3.1	n. a.	174.8	274.0	n. a.
Japan	10.9	10.0	9.1	7.7	5.6	3.8	2.8	2.5	2.5	2.4	2.2	387.0	369.3	494.7
Total	80.6	80.3	79.3	78.9	77.3	75.3	73.9	73.9	74.5	73.7	71.4	2,868.5	7,389.6	16,056.3
All other	19.4	19.7	20.7	21.1	22.7	24.7	26.1	26.1	25.5	26.3	28.6	698.1	2,431.7	6,431.2
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	3,566.6	9,821.3	22,487.5

Sources: Calculated from U.N. Commodity Trade Statistics and U.N. Yearbook of International Trade Statistics.

Table 6

World Export of Footwear in Terms of Value

Country of Origin	% of Total											$ Million		
	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1968	1973	1978
Italy	37.8	40.1	40.6	39.6	40.4	37.2	37.4	37.9	16.7	38.7	38.5	452.7	1,029.7	2,615.0
Korea	.9	.7	1.1	1.9	2.3	3.8	5.3	4.9	8.9	9.3	10.1	10.8	106.4	686.0
Spain	5.3	6.7	6.4	8.8	11.1	9.9	10.4	10.9	10.7	9.1	8.5	63.2	273.4	577.3
France	8.1	7.5	8.6	8.6	9.0	10.0	9.2	9.1	6.8	6.8	6.1	97.0	277.0	414.3
W. Germany	5.4	5.6	4.9	4.4	4.2	4.9	3.8	3.8	4.3	4.5	4.0	64.2	134.4	271.7
Yugoslavia	.6	3.6	3.4	3.6	4.0	4.2	4.3	4.6	4.9	4.4	n. a.	55.1	116.6	n. a.
Brazil	.0	.1	.5	1.5	2.3	3.4	3.6	4.2	3.9	3.3	4.1	.4	93.4	278.5
Austria	2.4	2.2	2.6	2.7	3.1	3.5	3.2	3.3	3.3	3.5	3.3	28.7	96.4	224.1
U.K.	5.3	5.7	5.2	4.5	3.4	3.2	3.3	3.0	2.7	3.4	2.8	63.5	87.3	190.2
Hong Kong	4.0	3.5	3.1	3.0	2.3	1.9	1.9	1.5	1.7	1.6	1.5	47.6	53.7	101.9
Total	73.8	75.7	76.4	78.6	82.1	82.0	82.4	83.2	83.9	84.6	78.9	883.5	2,268.3	5,359.0
All other	26.2	24.3	23.6	21.4	17.9	18.0	17.6	16.8	16.1	15.4	21.4	314.3	501.8	1,433.2
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1,197.8	2,770.1	6,792.2

Sources: Calculated from U.N. Commodity Trade Statistics and U.N. Yearbook of International Trade Statistics.

APPENDIX 4

Table 7

PRODUCTION INDEX, MAN-DAYS AND ELECTRICITY CONSUMPTION

1. Textile Industry

Year	Index of Production	Man-days (Thousand days)	Electricity Consumption (Million KW)
1968	24	4,193.5	478
1969	32	4,760	638
1970	38	4,622.8	740
1971	45.7	4,818.4	908
1972	60.8	5,643.5	1,093
1973	76.2	7,053.7	1,456
1974	78.4	6,510.2	1,718
1975	100	7,813.2	2,240
1976	131.0	8,466.7	2,677
1977	141.6	9,231.4	3,122

2. Clothing Industry

Year	Index of Production	Man-days (Thousand days)	Electricity Consumption (Million KW)
1968	12	904.2	15
1969	12.5	1,038.9	20
1970	15.3	1,064.3	24
1971	21.7	1,414.8	29
1972	32.2	1,958.0	33
1973	59.5	2,197.4	80
1974	78.1	2,738.4	58
1975	100	3,753.9	74
1976	141.9	4,666.0	118
1977	157.8	4,782.8	131

3. Footwear Industry

Year	Index of Production	Man-days (Thousand days)	Electricity Consumption (Million KW)
1968	23.1	128.4	5
1969	23.1	115.3	7
1970	23.1	94.3	8
1971	32.6	128.4	10
1972	31.1	186.7	22
1973	37.4	197.3	15
1974	60.6	142.2	9
1975	100	279.4	13
1976	139.2	368.3	20
1977	201.4	457.9	26

Sources: Yearbook of Industrial Statistics, U.N. and Economic Planning Board, Korea.

References

Aigner, D. J. and S. F. Chu, "On estimating the industry production function," *American Economic Review,* Vol. 58, Sep. 1968.

Balassa, B., "Trade Liberalization and 'revealed' Comparative Advantage," *The Manchester School of Economic and Social Studies,* May 1965.

Cohen, B. I., "Comparative Behavior of Foreign and Domestic Export Firms in a Developing Economy," *Review of Economics and Statistics,* Vol. 45, No. 2, 1973.

Courtney, W. H. and D. M. Leipziger, "Multinational Corporations in LDCs: The choice of technology," *Oxford Bulletin of Economics and Statistics,* Vol. 37, No. 4, Nov. 1975.

Farrell, M. J., "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society,* Series A, Vol. 120, 1957.

Farrell, M. J. and M. Fieldhouse, "Estimating Efficient Production under Increasing Returns to Scale," *Journal of the Royal Statistical Society,* Series A, Vol. 125, 1962.

Frank, C. R., Jr., K. S., Kim, and L. E. Westphal, *Foreign Trade Regimes and Economic Development: South Korea.* New York: National Bureau of Economic Research, 1975.

Griliches, Z. and V. Ringstad, *Economics of Scale and the Form of the Production Function,* Amsterdam: North-Holland, 1971.

Griliches, Z., "Issues in Assessing the Contribution of Research and Development to Productivity Growth," *Bell Journal of Economics,* Vol. 10, No. 1, Spring 1979.

Gujarati, D., *Basic Econometrics,* New York: McGraw-Hill, 1978.

Hirsch, S., "The Product Cycle Model of International Trade--A Multi-Country Cross-Section Analysis," *Oxford Bulletin of*

Economics and Statistics, Vol. 37, No. 4, Nov. 1975.

Intriligator, M., *Mathematical Optimization and Economic Theory,* Englewood Cliffs, N.J.: Prentice-Hall, 1971.

———, *Econometric Models, Techniques, and Applications,* Englewood Cliffs, N.J.: Prentice-Hall, 1978.

Johnston, J., *Econometric Methods,* New York: McGraw-Hill, 1972.

Kojima, K., "Structure of Comparative Advantage in Industrial Countries: A Verification of the Factor Proportions Theorem," *Hitotsobashi Journal of Economics,* Vol. 11, No. 1, June 1970.

Korea Economic Planning Board, *Korea Statistical Yearbook,* Seoul, Korea, various issues.

Layard, P. R. G. and A. A. Walters, *Microeconomic Theory,* New York: McGraw-Hill, 1978.

Lecraw, D. J., "Direct Investment by Firms from less Developed Countries," *Oxford Economic Papers,* Vol. 29, No. 3, 1977.

———, "Choice of Technology in Low-Wage Countries: A Non-neoclassical Approach," *Quarterly Journal of Economics,* Vol. XCIII, No. 4, Nov. 1979.

Mason, R. M., "Some Observations in the Choice of Technology by Multinational Firms in Developing Countries," *Review of Economics and Statistics,* Vol. 45, No. 3, Aug. 1973.

Nerlove, M., *Estimation and Identification of Cobb-Douglas Production Function,* Chicago: Rand McNally, 1965.

Norman, G., "Economies of Scale in the Cement Industry," *Journal of Industrial Economics,* Vol. 27, No. 4, June 1979.

Parry, T. G., "Trade and Non-Trade Performance of U.S. Manufacturing Industry: 'Revealed' Comparative Advantage," *The Manchester School of Economic and Social Studies,* June 1975.

Pratten, C. F., *Economies of Scale in Manufacturing Industry.*

Cambridge: Cambridge University Press, 1971.

Tyler, W. G., "Technical Efficiency and Ownership Characteristics of Manufacturing Firms in a Developing Country: A Brazilian Case Study," mimeo, undated.

______, "Technical Efficiency in Production in a Developing Country: An Empirical Examination of the Brazilian Plastics and Steel Industries," *Oxford Economic Papers,* Vol. 31, Nov. 1979.

United Nations, *Yearbook of Industrial Statistics,* New York, various issues.

Waters, A. A., "Production and Cost Functions: An Econometric Survey," *Econometrica,* Vol. 31, No. 1-2, Jan-Apr. 1963.

Westphal, L. E., Y. W., Rhee and G. Pursell, "Foreign Influences on Korean Industrial Development," *Oxford Bulletin of Economics and Statistics,* Vol. 41, No. 4, Nov. 1979.

Williamson, J. G. and G. P., Sicat, "Technical Change and Resource Allocation in Philippine Manufacturing: 1957-1965," University of the Philippines Discussion Paper, No. 68-21, June 1968.