NBER WORKING PAPER SERIES

DO MULTINATIONAL FIRMS ADAPT FACTOR PROPORTIONS TO RELATIVE FACTOR PRICES?

Robert E. Lipsey

Irving B. Kravis

Romualdo A. Roldan

Working Paper No. 293

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

October 1978

NBER Working Paper No. 293
October 1978

DO MULTINATIONAL FIRMS ADAPT FACTOR PROPORTIONS TO RELATIVE FACTOR PRICES?

Robert E. Lipsey, Irving B. Kravis, and Romualdo A. Roldan

Abstract

It has been alleged that multinational firms fail to adapt their methods of production to take advantage of the abundance and low price of labor in less developed countries and therefore contribute to the unemployment problems of these countries. This paper asks two questions: do multinational firms adapt to labor cost differences by using more labor-intensive methods of production in LDC's than in developed countries and do multinational firms' affiliates in LDC's use more capital-intensive methods than locally-owned firms?

We concluded that both U.S.-based and Swedish-based firms do adapt to differences in labor cost, using the most capital-intensive methods of production at home and the least capital-intensive methods in low-wage countries. Among host countries, the higher the labor cost, the higher the capital intensity of production for manufacturing as a whole, within individual industries, and within individual companies.

When we attempted to separate the capital-intensity differences into choice of technology and method of operation within a technology we found that firms appeared to choose capital-intensive technologies in LDC's but then responded to low wage levels there by substituting labor for capital within the technology. Similarly, U.S. affiliates appeared to use technologies similar to those of locally-owned firms but to operate in a more capital-intensive manner mainly because they faced higher labor costs.

Dr. Robert E. Lipsey
National Bureau of Economic Research
261 Madison Avenue
New York, N.Y. 10016
(212)682-3190

Dr. Irving B. Kravis
Department of Economics
University of Pennsylvania
Philadelphia, Pennsylvania 19174
(215)243-5692

Mr. Romualdo A. Roldan
Wharton Econometric Forecasting
Associates, Inc.
4025 Chestnut Street
Philadelphia, Pennsylvania 19104
(215)386-9000

Contents

DO MULTINATIONAL FIRMS ADAPT FACTOR PROPORTIONS TO RELATIVE FACTOR PRICES?[1]

Introduction

A major issue in the discussion of the effects of multinational firms' operations on host country employment has been whether these firms use "inappropriately" capital-intensive methods of production and are therefore responsible in some degree for underutilization of the presumably abundant labor, or unskilled labor, resources of less developed countries. We attempt here to answer two questions about factor use by multinational firms. One is whether they respond to the comparatively low labor costs in LDC's by using more labor-intensive methods of production there than in developed countries. The second is whether the LDC affiliates of multinationals are more capital-intensive than locally-owned firms. In contrast to the numerous case studies which have examined both of these questions our work investigates the pattern that emerges from an analysis of several manufacturing industries across many countries. We make particular use of data on multinational firms collected by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce for 1966 and 1970 and similar data for Swedish-based multinational firms collected by the Industriens Utredningsinstitut of Stockholm for 1970 and 1974.

---

[1]This paper was prepared as one of several special studies that were part of the National Bureau project on Trade Policy and Employment in Less Developed Countries, directed by Anne Krueger. The study was supported by a contract with the U.S. Agency for International Development, but the views expressed do not necessarily represent those of that agency **or the NBER.**

We are indebted for statistical calculations and programming to Dennis Bushe and Linda O'Connor, helped in the later stages by Stanley Lewis, and to Arnold Gilbert and Michael Liliestedt for programming and advice on U.S. Department of Commerce data. We are also grateful to Birgitta Swedenborg for the information and calculations on Swedish multinational firms, from

The question of the degree of adaptation to LDC factor costs has received the greatest amount of attention. Unfortunately there are many possible definitions of adaptation and a good deal of effort has been spent, often unprofitably we believe, in attempting to distinguish one from another.

A question frequently raised is whether any observed differences between production methods in developed countries and those in LDC's are the result of factor substitution within a single technology (along a single production function), as in Figure 1 or the result of the use of a

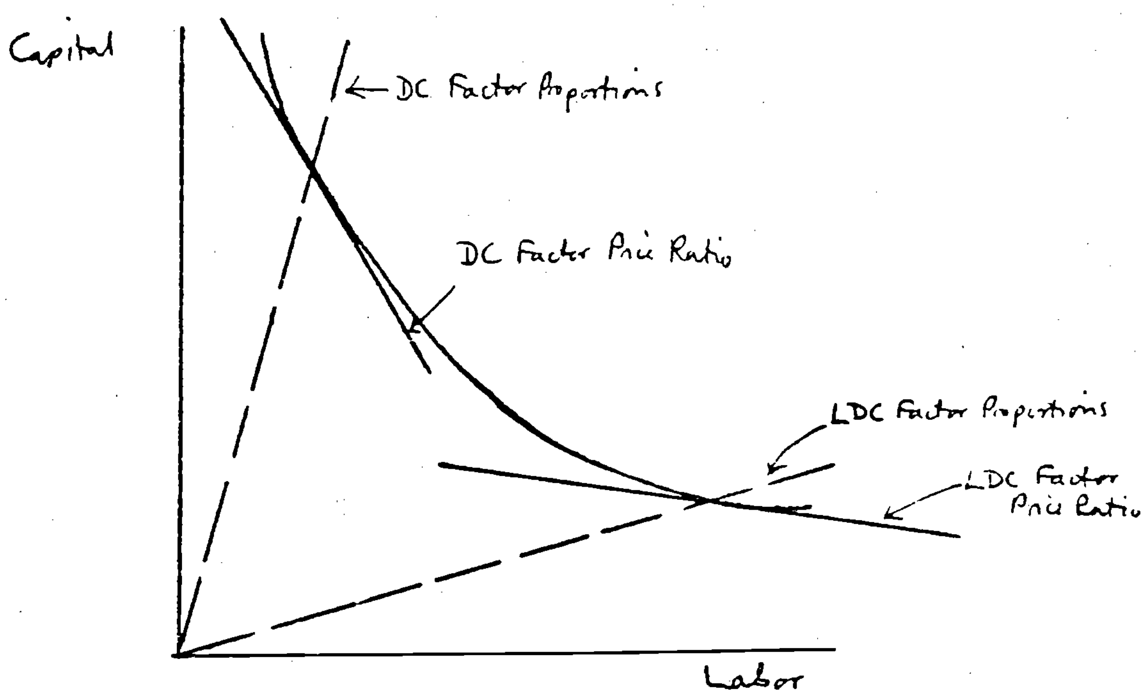

Figure 1

Substitution of Capital for Labor
Within a Single Technology

more labor-intensive technology in LDC's: one which would be more labor-intensive under any set of factor price ratios, as in Figure 2, or a combina-

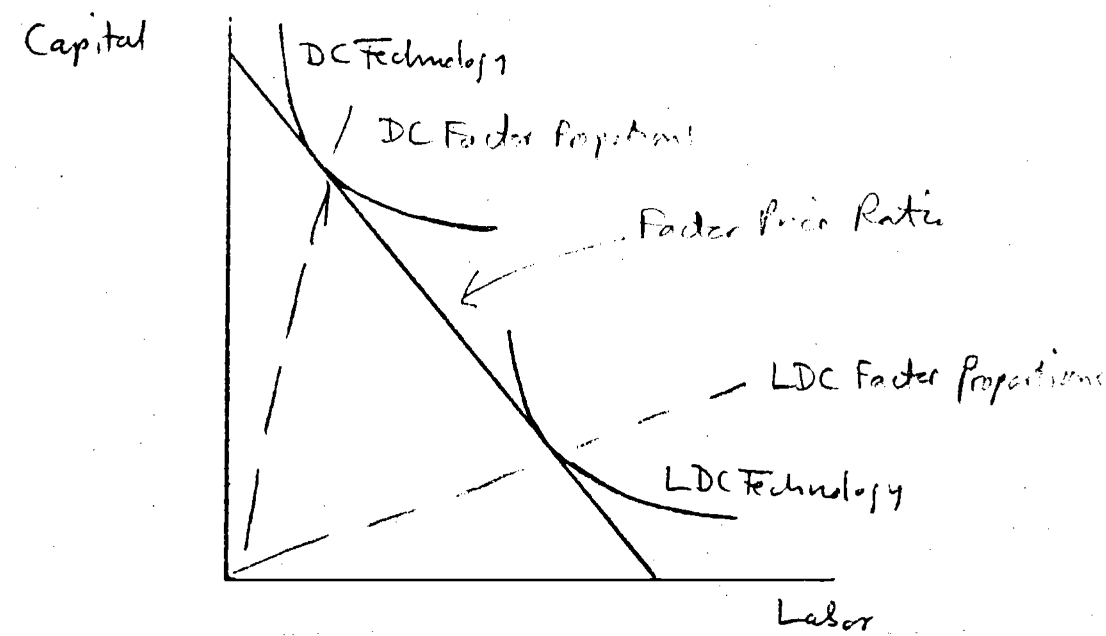

Figure 2

Substitution of Labor-intensive for Capital-intensive Technology

tion of the two, as in Figure 3. Courtney and Leipziger [1975], for example,

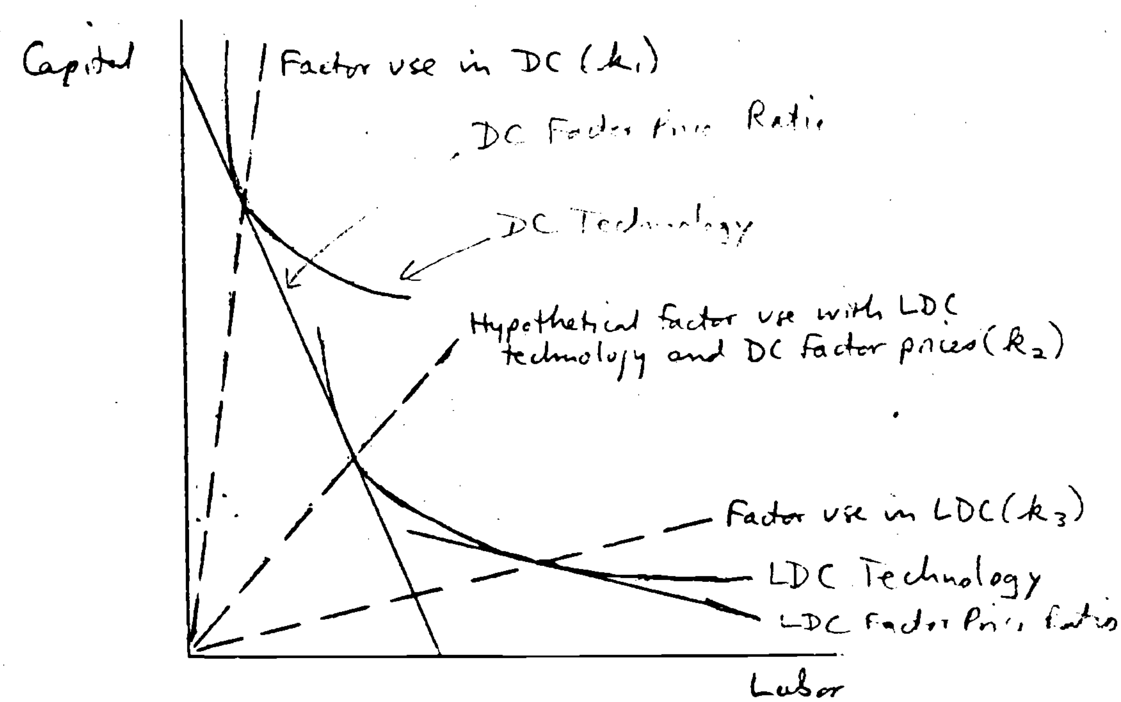

Figure 3

Substitution of Labor for Capital Between and Within Technologies attempt to divide the observed differences between DC and LDC factor use ratios (k_1 and k_3) into the unobserved differences between k_1 and k_2 (ex ante substitution in their terms) and between k_2 and k_3 (ex post substitution). "By ex ante factor substitution we refer to choices of plant design and by ex post factor substitution, we refer to the way in which the plant is run."[2] Courtney and Leipziger assume two technologies in

[2] Op. cit., p. 297.

each industry, one for developed country affiliates of each firm and one for affiliates in LDC's, and fit production functions accordingly.

In our study we have fitted production functions to data for individual affiliates in an industry across all countries, treating the degree of development as a continuum rather than as a dichotomy. The framework can be described as viewing the parent firm as having a technology set consisting of knowledge of a variety of ways of producing which differ in their capital intensity. The question is whether the parent firm's choices from this technology set for use in different countries reflect differences in factor costs.

Even this viewpoint is most appropriate for a single product rather than for the heterogeneous industries of any available collection of data. Production functions fitted to aggregate data or to heterogenous firm or establishment data may be regarded as fictions which provide insights into factor substitution but which must be taken with some reservations as explanations of aggregate production relationships. We therefore concentrate first on the observed differences in factor proportions (the difference between k_1 and k_3 in Figure 3), and relate them to differences in factor prices. We examine the relationships, taking as our units of observation for a country, in turn, manufacturing as a whole, broad industries, and individual firms. We ask, in this part of the paper, what adaptation there is to host-country factor prices, how much of it takes place through the selection of labor-intensive industries and how much through the selection of labor-intensive firms for production in low-wage countries, and finally, how much takes place through the choice of factor proportions within industries or firms.

At the most aggregative level, broad industries, adaptation by selection (Figure 4) means that labor-intensive industries establish production abroad, especially in low-wage countries, more frequently or, at a higher level relative to home output, than do capital-intensive industries. In other words, if there is adaptation by selection, the share of labor-intensive industries will be higher among affiliates, particularly among affiliates in low-wage countries, than among home-country industries.

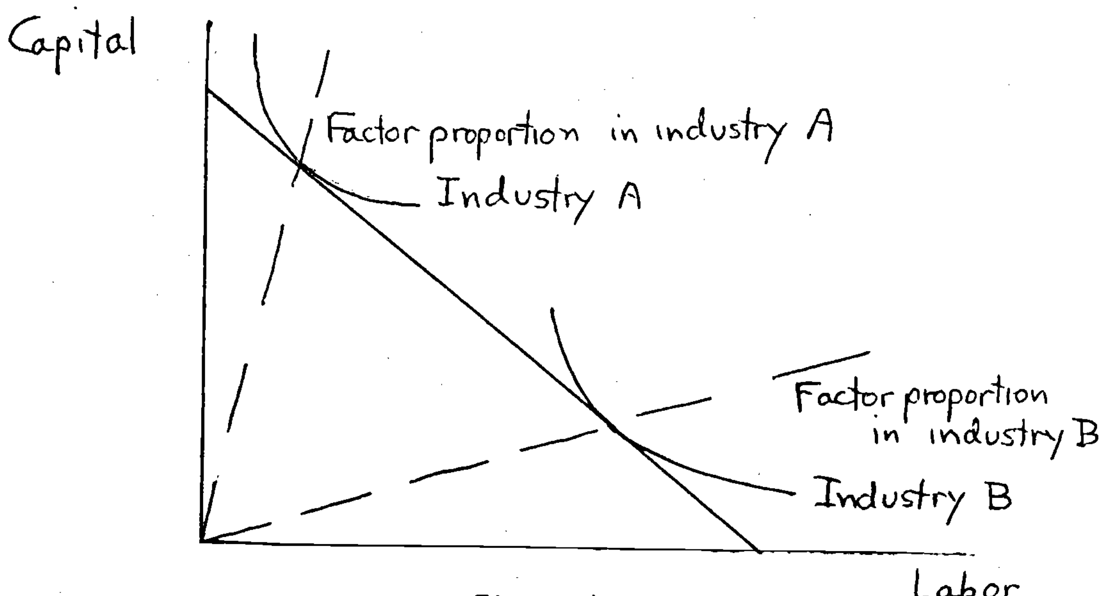

Figure 4

Selection of Investing Industries

Since virtually all industries defined by statistical classifications are heterogeneous, in the sense that they include firms producing a wide range of products, the more labor-intensive firms might choose to relocate their production to foreign countries with low labor costs while more capital-intensive firms did not (Figure 5).

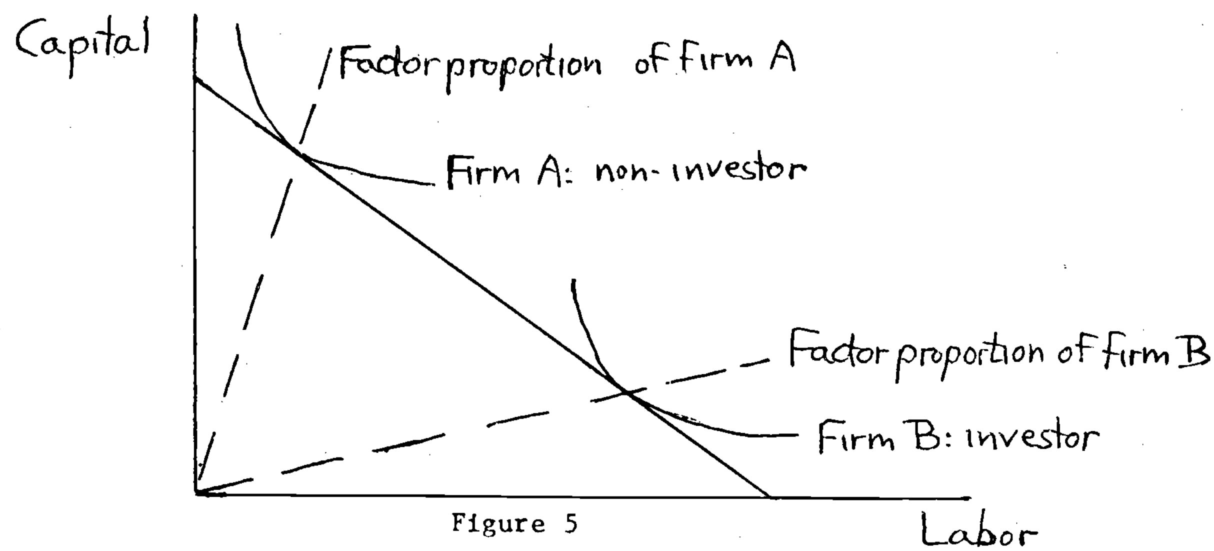

Figure 5
Selection of Investing Firms

That would be adaptation by selection of firms within an industry.

In the cases of selection of investing industries and investing firms there are, of course, influences on location other than labor cost. It has been suggested, in fact, that the typical advantage of U.S. firms, which enables them to compete effectively in foreign markets with host-country and other foreign firms, is technological skill. If high technology is associated with high capital-intensity there will be a tendency for capital-intensive firms and industries to locate abroad that will operate in the opposite direction to the influence of labor costs.

Even within the firm there could be differences in the type of operation carried on in different countries. Since the typical firm produces more than one final or intermediate output and can supply one market by production from another market, it will have an incentive to produce the labor-intensive product in LDC's and the capital-intensive product in developed countries or at home (Figure 6). This phenomenon would appear in the statistical data as substitution of labor for capital in LDC's even if each product were produced in exactly the same way at home and abroad. Since most large

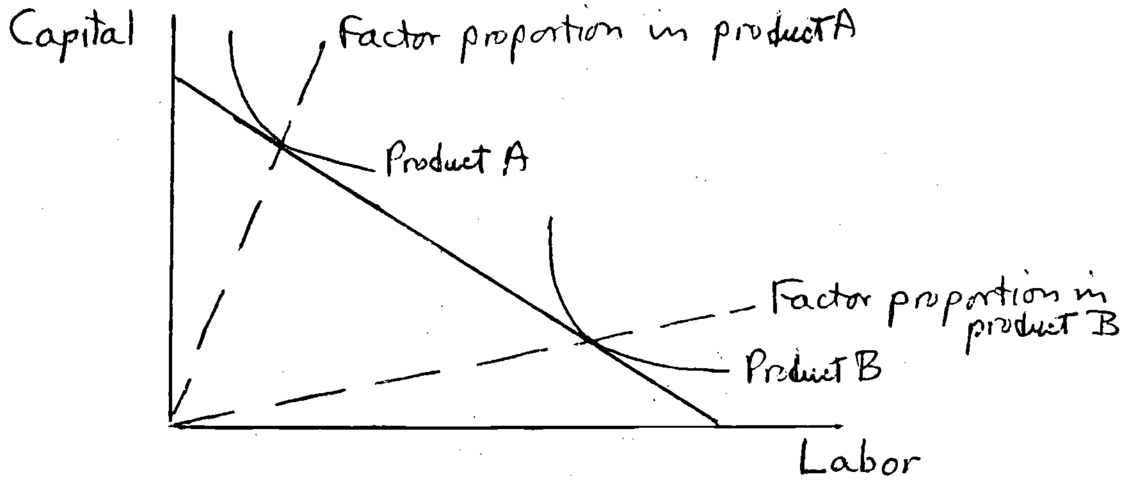

Figure 6
Selection of Product Within Firm

firms' home-country operations extended over several industries, the selection of products within the firm depicted in Figure 6 may be a selection not only among the products of a single industry but also among the industries of the parent.

Also embedded in statistical comparisons among countries are any possible differences in capital intensity due to differences in scale of production (Figure 7). Frequently this possibility is obscured in the fitting of production functions because homotheticity is assumed. Differences in factor use due to scale of production are then attributed to factor prices, since these are generally related to scale of production, the least developed countries having both low labor costs and small plants. In our direct comparisons of capital intensities between developed countries and LDC's we are, in effect, treating low capital intensities that result from small scale operations as one more form of adaptation. The low labor cost may permit the operation of small labor-intensive plants that would be hopelessly uneconomic at high labor costs.

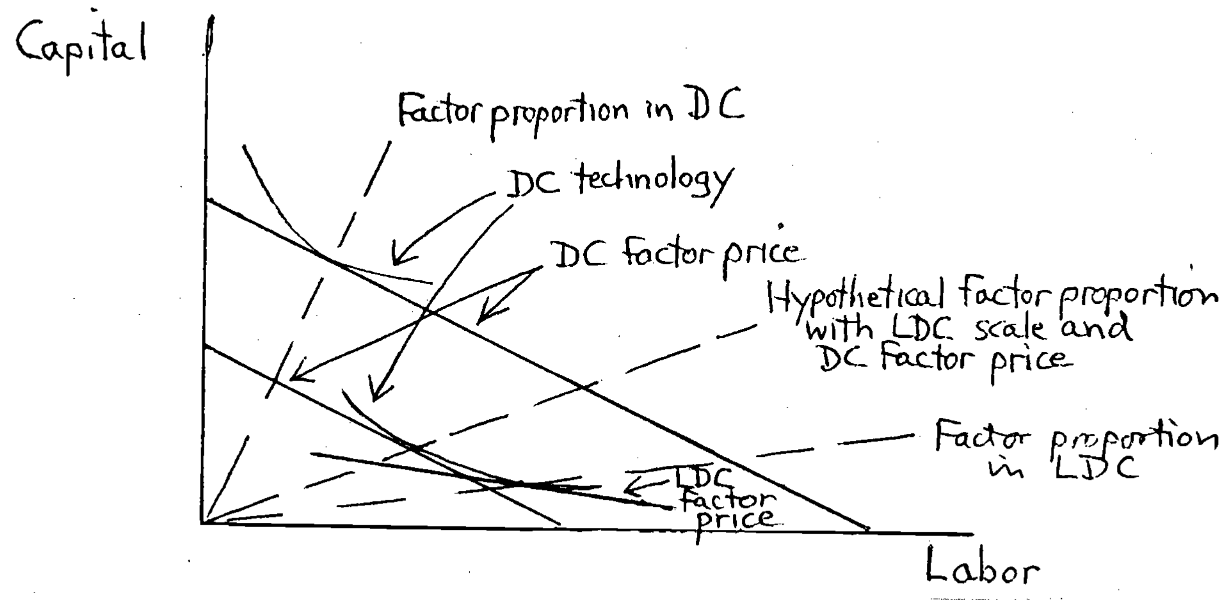

Figure 7

Effect of Scale of Production on Factor Proportions: One Technology, Two Production Levels, Two Factor Prices

A further difficulty arises with production functions fitted to data across countries. Typically no physical output data are available and output is measured by value added. This practice biases the result toward obscuring economies of scale, if they exist. Presumably, plants of uneconomically small size, perhaps in markets too small to sustain plants of optimal size, can survive only if they are afforded high protection or subsidies. The level of protection must be high enough to provide standard levels of wages for the workers and profits sufficient to attract and retain capital. Each worker enters the production function on the right-hand side and his wage on the left, in value added. Each unit of capital is also entered on both sides of the function because the investment (on the right-hand side) will not be made unless the level of protection or subsidy is sufficient to provide a standard return, which enters the equation on the left-hand side.

Within a single economy the presumption is that all producers must sell at the same price, since they are in competition with each other. Any inefficiently small plant with too many workers per unit of output would have the high wage bill included in its value added but, since it is selling in competition with, and at the same price as, efficient plants, the inefficiency will be reflected in a low or even negative return on capital, and a low or negative value added, which will truly reflect net output. The same would happen in the case of a plant with too much capital per unit of output. However, among different countries, prices need not be the same if there are trade barriers and plants in one country do not compete freely with those in another. The value added by inefficient plants is inflated in segregated, protected markets. The results in studies across countries are thus biased toward proportionality between inputs and outputs: that is, constant returns to scale.[3] This analysis assumes, of course, that the degree of protection is that needed for survival by inefficient plants rather than that achieved by politically powerful firms or industries seeking high profits.

---

[3] For a mathematical demonstration of this point see Appendix A.

Whatever the degree or type of adaptation by parent companies to host-country costs, there may still be differences between U.S. or other foreign-owned affiliates and host-country firms. These may represent not only industry mix but also differences within industries.

There are a number of reasons to expect that within LDC's, production by DC-based firms will be more capital- or technology-oriented than production by local firms. The technology may reflect a lower cost of capital or a higher cost of host-country labor to the affiliate, as compared to a local firm, or an advantage of the U.S. affiliate stemming from its cheap access to the technology of the parent because technology flows easily within a firm but only with difficulty outside it (Figure 8). On the other hand, the difference may represent a disadvantage of the DC-based firm. It may be using a technology ill-suited to the host-country environment (although well-suited to the company)

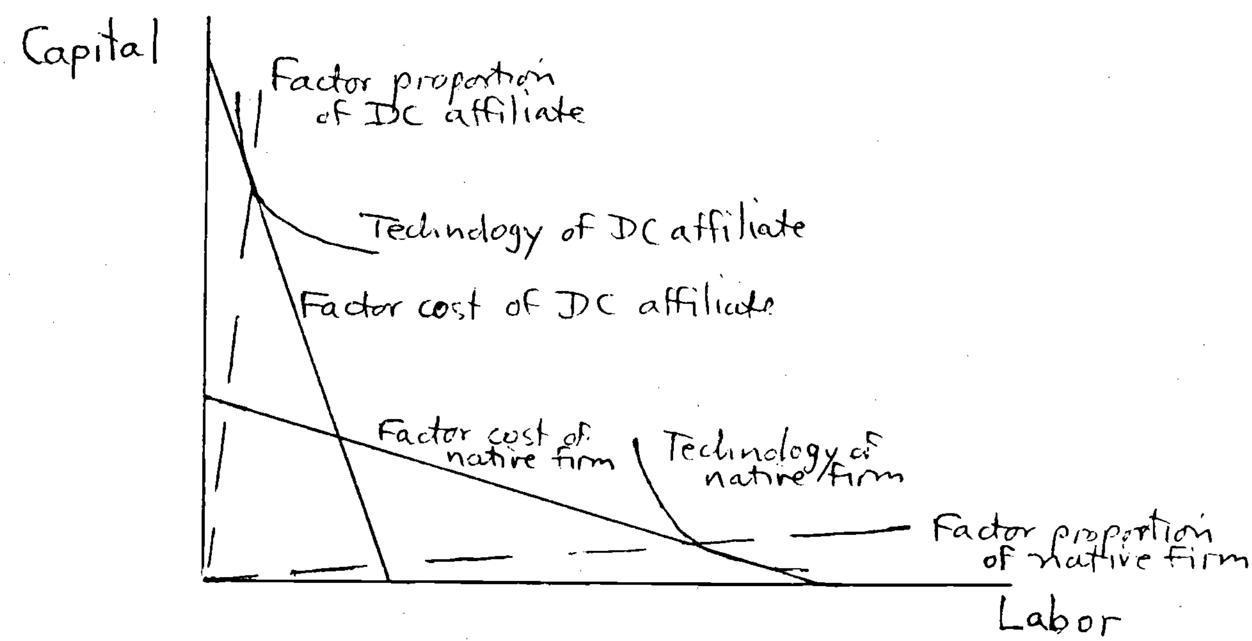

Figure 8

Factor Cost as Determining Technology Choices of DC-Owned and Native Firms because the cost of adapting its customary technology to local conditions is very high (Figure 9).

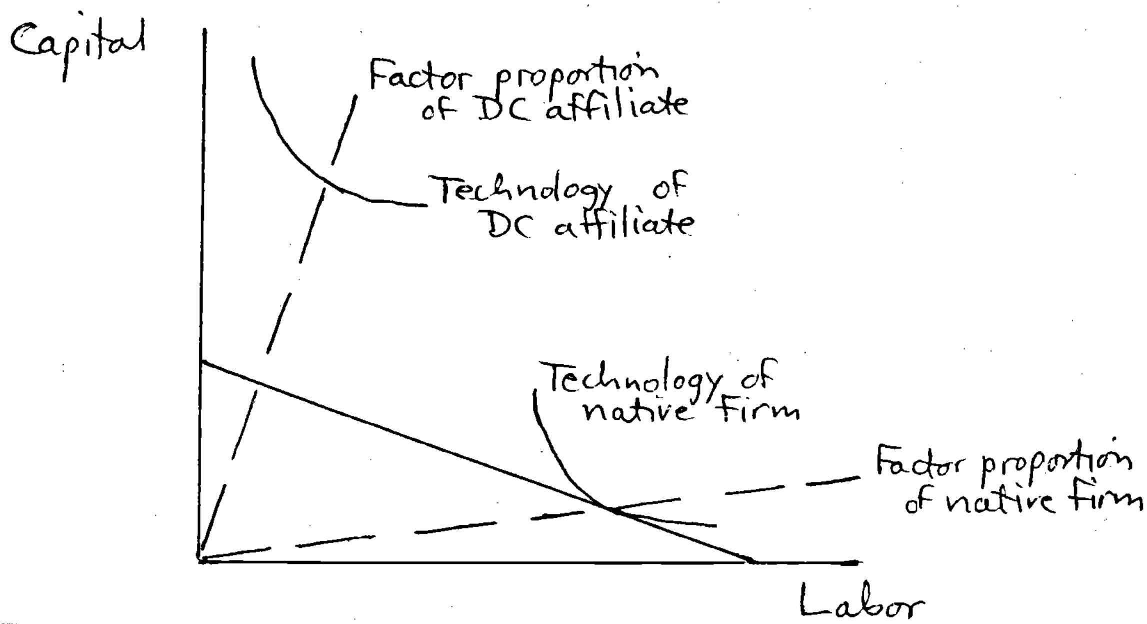

Figure 9

Technology Choice Determined by Cost of Adjustment

Data

The basic data for our analysis came from two sources: surveys of the foreign operations of U.S. firms by the Bureau of Economic Analysis (BEA), formerly the Office of Business Economics (OBE) of the U.S. Department of Commerce and of operations of Swedish firms by the Industriens Utredningsinstitut of Stockholm. The U.S. surveys took place in 1966 (a complete census) and 1970, and the Swedish surveys, believed to have virtually complete coverage, in 1970 and 1974. The U.S. data are described in U.S. Department of Commerce [1972] and [1975], and the 1970 Swedish data in Swedenborg [1973]. The Swedish study for 1974 has not yet been published but the data are similar to those of 1970.

Although the U.S. and Swedish survey questionnaires are quite similar, there are differences which are reflected in the way they are used below. The U.S. data give more detailed balance sheet information, including net and gross book values for property, plant, and equipment. The Swedish data provide more product and industry information for both parents and overseas subsidiaries and also a rough measure of the current gross value of property, plant, and equipment based on fire insurance values. Although the fire insurance valuation presumably does not include revaluations of land, we are inclined to the view that it is better than book value as an estimate of the amount of capital in market values. The U.S. data, on the other hand, characterize each parent and each affiliate only by its single most important industry affiliation and provide only book values of assets.

Factor Proportions of Domestic Industry, Parent Companies, and Foreign Affiliates: Aggregate Data

The basic facts about capital intensity for all manufacturing in parent countries, parent companies, and foreign affiliates are set out in Table 1. In every available comparison, capital intensity in parent country domestic manufacturing as a whole and in parent companies' domestic operations was higher than in foreign affiliates, even those in developed countries. And capital intensities of affiliate operations in developed countries were consistently higher than those of operations in less developed countries. The comparisons clearly indicate that some form of adaptation to differences in labor costs does take place and that the adaptation, or the sum of all the different types of adaptation, was large. Capital intensities of affiliates in less developed countries were typically 40 per cent or more below those of parents or home countries.

As we mentioned earlier, there are many possible reasons for such differences. One possibility is that we are observing only industry selection: the more labor-intensive industries choose to go abroad to benefit from lower labor costs, particularly in less developed countries, but that they produce abroad exactly as at home. One way to test for this possibility is to make comparisons of capital intensity within industries, as in Tables 2 and 3.

TABLE 1

Capital Intensity (Capital per Employee) in Manufacturing
U.S. and Swedish Domestic Industry, Parents, and Foreign Affiliates

Capital Stock Measure		Domestic Industry	Parents	Foreign Affiliates: Total	Foreign Affiliates: Developed Countries	Foreign Affiliates: Less Developed Countries
		Value per Employee				
			Thousands of Dollars			
U.S.						
Total Assets	1966		22.11[a]	16.56	16.99	14.76
	1970		29.29	19.90	20.77	16.16
Net Property, Plant & Equip., Book Value	1966	11.73[b]	8.57[a]	6.56	6.74	5.68
	1970	14.62[c]	11.95	7.65	8.03	6.01
			Thousands of Kronor			
Sweden						
Total Assets	1960				37.9[d]	27.7
	1965				57.8[d]	38.7
	1970	117.65		85.45	91.9[d]	59.0
	1974	176.0				
Net Property, Plant & Equip., Book Value	1970	31.9			25.73	19.43
	1974	40.2			35.09	22.64
Gross Property, Plant & Equip., Fire Ins. Value	1970	107.96			50.81	29.23
	1974	177.54			73.20	43.90

[a] Includes only those parents reporting in 1970.

[b] Gross property plant and equipment for 1967: 1966 not available.

[c] Gross property, plant, and equipment.

[d] Includes Europe, North America, Australia, New Zealand, and South Africa.

Sources: U.S. Department of Commerce [1972], Sweden, Statistiska Centralbyrån [1972], [1972b], [1976a], and 1976b], and Swedenborg [1973].

If all the differences in Table 1 were accounted for by industry selection there would be no differences within industries. If industry selection were unimportant, the differences in Tables 2 and 3 would be as large as thosein Table 1.

It is clear that, even within broad industry groups, home production is most capital-intensive, production in developed-country affiliates next, and production in LDC affiliates least capital-intensive. In Table 2, for the United States, 22 out of 24 comparisons show parent production more capital-intensive than that in developed-country affiliates, 16 out of 16 show developed-country affiliates more capital-intensive than those in LDC's, and 16 out of 16 show parent production more capital-intensive than affiliate production in LDC's. Adaptation, in other words, is visible within industries, at least within industry groups as broad as these. That impression is strengthened by the averages. The average of the industry relatives of affiliate to parent capital intensity show at least as much relation to the type of host country as do the aggregates, and possibly more in the case of LDC's.

The adaptation in capital intensity shown by manufacturing industry as a whole in Table 1, put in index form in the All Manufacturing lines of Table 2, can be divided into two parts. One is the adaptation within industries and the other is adaptation by selection of industries discussed earlier. Adaptation within industries is shown in the individual industry lines of Table 2 and summarized in the Average of Industry Relatives lines. It is calculated by putting each industry line into relative form (parent capital intensity = 100) and averaging across industries with parent employment as weights. If within-industry adaptation were the only type that took place, the All Manufacturing

TABLE 2

Capital Intensity (Capital per Employee) in Manufacturing Industry Groups, U.S. Parents and Foreign Affiliates

(Unit: thousand dollars per employee)

	1970			1966[a]		
		Affiliates in			Affiliates in	
	Parents	Developed Countries	LDC's	Parents	Developed Countries	LDC's
			Total Assets per Employee			
Food Products	28.27	20.17	14.44	21.62	17.42	13.26
Chemicals & Allied Products	35.95	37.77	20.46	29.94	28.27	17.27
Primary & Fabricated Metals	33.71	21.31	-	26.11	21.33	-
Machinery	24.25	18.02	12.08	16.28	13.54	12.26
Transport Equipment	30.01	19.07	-	22.04	17.30	-
Other	29.69	21.26	16.31	23.75	15.99	13.94
			Total Assets per Employee (Parent Ratio=100)			
All Manufacturing	100.0	70.9	55.2	100.0	76.6	66.8
Average of Industry Relatives[b]	100.0	74.8	53.0	100.0	80.4	63.6
			Net Property, Plant, and Equipment per Employee			
Food Products	11.17	7.72	4.18	8.33	6.55	4.68
Chemicals & Allied Products	17.67	17.37	8.28	14.78	13.24	7.33
Primary & Fabricated Metals	18.28	7.52	-	13.04	7.79	-
Machinery	9.86	5.84	3.60	6.38	4.52	3.51
Transport Equipment	8.09	7.78	-	5.75	6.97	-
Other	13.12	8.05	7.24	9.62	6.55	6.15
			Net Property, Plant, and Equipment per Employee (Parent Ratio=100)			
All Manufacturing	100.0	67.2	50.3	100.0	78.6	66.3
Average of Industry Relatives[b]	100.0	72.3	44.1	100.0	81.9	60.5

[a] Includes only those parents reporting in 1970.

[b] Weighted by parent employment in each industry.

Source: U.S. Department of Commerce [1972].

entries and the Average of Industry Relative entries would be identical. If there were, in addition, some selection by choice of industries, in the sense that labor-intensive industries had a larger share of overseas activity than of home-country activity, it would tend to make the All Manufacturing relatives lower than the Averages of Industry Relatives. Such selection does appear to have taken place in the case of affiliates in developed countries. Labor-intensive industries are more important than in the home countries. However, the opposite seems to be true for less developed countries. The industry selection seems to lean toward capital-intensive industries there and offsets, to a small degree, the effect of adaptation within industries. Thus not only does selection of industries play a small role in the total extent of adaptation for manufacturing as a whole, but it even plays an apparently perverse role in LDC's. The major adaptation takes place within these broad industries.

The Swedish data on fire-insurance values in Table 3 point to roughly the same conclusions. By far the largest part of the difference in capital intensity between Sweden and foreign affiliates in developed countries and between affiliates in developed countries and those in LDC's is accounted for by differences within broad industries. Comparing the aggregate ratios with the averages of industry ratios for fire insurance values we find for LDC's that the aggregate is a bit lower, indicating some selection of labor-intensive industries for production in LDC's. However, the effects of that selection were again, as in the United States, minor compared with the use in LDC's of relatively labor-intensive production methods within industries.

TABLE 3

Capital Intensity (Capital per Employee)' in Manufacturing Industry Groups,
Swedish Domestic Industry, Parent Companies, and Foreign Affiliates

(Unit: Thousand kronor per employee)

	1970				1974			
			Affiliates in				Affiliates in	
	Swedish Industry	Parent Companies	Developed Countries	LDC's	Swedish Industry	Parent Companies	Developed Countries	LDC's
	Book Value of Net Property, Plant, and Equipment per Employee							
Food, Drink, & Tobacco	38.08	47.74	34.63		43.64		62.24	
Textiles & Apparel	10.65	11.58	8.74		15.81		6.92	
Wood Manufactures	23.06				34.13			
Pulp, Paper, & Printing	41.54		119.08	46.90	65.22		115.32	167.10
Pulp & Paper		85.85	195.34	-			187.02	
Paper Products & Printing		29.24	39.53	46.90			47.48	167.10
Chemicals & Plastics	57.41	32.95	32.34	15.97	56.98		55.81	17.56
Stone, Clay, & Glass Products	36.41	-	-	-	31.27		-	-
Metal Products	46.23	29.06	32.09	22.82	51.91		35.92	23.81
Machinery	20.14		19.48	21.62	28.52		28.62	23.57
Non-electrical		28.35	20.95	26.38			30.84	21.98
Electrical		19.99	14.48	19.39			20.57	24.70
Transport equipment		43.03	19.09	12.25			64.43	23.16
	Book Value of Net Property, Plant, and Equipment per Employee (Swedish Ratio=100)							
All Manufacturing	100.0		89.8	58.3	100.0		94.1	57.1
Average of industry relatives[e]	100.0		123.2	96.4	100.0		110.8	50.1

(continued)

TABLE 3 (concluded)

	1 9 7 0				1 9 7 4			
			Affiliates in				Affiliates in	
	Swedish Industry	Parent Companies	Developed Countries	LDC's	Swedish Industry	Parent Companies	Developed Countries	LDC's
	Fire Insurance Value of Gross Property, Plant, and Equipment per Employee							
Food, Drink, & Tobacco	108.58	142.36	76.64	-	184.11		120.35	-
Textiles & Apparel	57.81[a]	62.72	12.22	-	85.53		16.53	-
Wood Manufactures	71.15		-	-	129.67		-	-
Pulp, Paper, & Printing	182.24		108.08	71.00	336.52		193.71	110.64
Pulp & Paper	(341.6)[b]	234.22	156.73	-	(630.8)[b]		233.07	-
Paper Products & Printing	(73.2)[b]	117.97	66.03	71.00	(135.2)[b]		137.71	110.64
Chemicals & Plastics	163.99[c]	92.58	94.03	31.91	254.16		170.68	95.12
Stone, Clay, & Glass Products	133.75		-	-	229.36		-	-
Metal Products[d]	(65.7)[b]	117.11	67.07	35.22	97.86[b]		88.34	36.66
	100.30							
Machinery			48.26	27.43	118.28		57.71	35.89
Non-electrical	(82.7)[b]	106.68	54.68	28.60	(123.2)[b]		71.57	17.70
Electrical	(77.6)[b]	78.01	29.79	24.08	(115.6)[b]		40.05	32.36
Transport Equipment	(107.9)[b]	108.62	43.66	22.48	(160.7)[b]		126.78	51.56
	Fire Insurance Value of Gross Property, Plant, and Equipment per Employee (Swedish Ratio=100)							
All Manufacturing	100.0		53.6	26.2	100.0		47.5	24.7
Average of industry relatives[e]	100.0		55.6	32.6	100.0		52.6	31.9

Notes to TABLE 3

[a] Including rubber products.

[b] For 1970, directly from Industriens Utredningsinstitut and for 1974, extrapolations from 1970 using change in census groups.

[c] Excluding rubber products.

[d] Published industry figures include primary metals, excluded from company data. This is a very capital-intensive industry and tends to distort the comparisons. We have therefore used the figure for metal products alone, from the Industriens Utredningsinstitut for 1970 and, for 1974, a rough extrapolation of that figure to 1974 (97.86).

[e] Weighted by industry employment.

Sources: For industries, Sweden, Statistiska Centralbyrån [1972a], [1972b], [1976a], [1976b], except as indicated. For companies, directly from Industriens Utredningsinstitut.

We conclude, then, from these aggregate data that the large differences in capital intensity, especially between LDC's and the DC affiliates of U.S. and Swedish companies and between DC affiliate and parent or home-country capital intensity are not primarily expressions of industry mix, at least among the industries we consider, but reflect mainly differences within industries.

Measures of Labor Cost and Capital Intensity

The theoretical determinant of capital intensity decisions, if scale of production is not a factor, is the relative cost of labor and capital. In examining factor choices within the firm we have assumed that capital costs are identical for the firm in any location, and that ratios of labor cost to capital cost are therefore proportional to labor cost alone. The cost of capital may be considered to consist of two elements, one the opportunity cost to the firm of tying up assets in a particular form, and the other the cost of a physical capital good. Capital costs in the first sense may be taken to be the same for a given firm all over the world, although that will not be the case if a firm is inhibited in transferring profits from a given country or if investments in different countries bear different risks. With respect to physical capital, however, the assumption of equality in all countries is clearly not valid for construction, which is strongly affected by labor cost, although it is not such a bad assumption for equipment, which tends to have a world wide market.[4] Since construction cost and labor cost are positively correlated we exaggerate the differences between countries in relative factor prices and under-estimate elasticities of substitution.

---

[4] Cf. Kravis, Heston, and Summers [1978a], p. 121.

The labor cost we would like to measure is that for pure unskilled labor or for labor of a given quality. Lacking any such cost measure we have used several approximations or proxies, including real GDP per capita, average wage paid by all manufacturing affiliates in a country, average wage, and the latter two deflated by an index of the average quality of labor.

Real GDP per capita is of course not a measure of labor cost. It was used as a proxy under the assumption that the higher the real GDP per capita, the higher the standard of living and the higher the cost of unskilled labor. The estimates are from Kravis, Heston, and Summers [1978b]. Average wages come closer to cost measures but obviously reflect differences in quality as well as differences in price. To remove the effect of quality differences we have devised a rough index of labor quality from various measures calculated by others including Denison [1967], Harbison and Myers [1964], and Krueger [1968], which covers about fifty countries. In using the quality index to deflate money wages for a specific industry, for example, we in effect assume that each company within a country hires workers of average quality and that any deviation of a company's wage or an industry's wage from the average wage represents a higher cost rather than higher quality. Where we use average country wages without distinguishing companies or industries, however, we are making a very different assumption, namely, that all companies and industries in a country face the same labor cost and that any variation represents differences in quality.

Measures of capital intensity raise at least as many problems. We have experimented with assets per worker, book and market values of property, plant, and equipment per worker, value added, and nonwage value added per worker. Assets per worker have the advantage of being comprehensive. If one thinks of inventories, bank accounts, and loans as being production inputs, that comprehensiveness seems desirable. However, for a single company, there is no assurance that the financial assets of a subsidiary are held entirely to assist production in that country. It is quite conceivable that a parent company might arrange to have the subsidiary hold assets for the use of the parent or of other affiliates, and it would then be improper to treat the nonproduction assets as necessarily belonging to the host-country's production function. Similarly, the parent might hold financial assets for the use of all its affiliates, in which case we might be understating the amount of capital involved in a given affiliate's production.

We have, for these reasons, leaned toward fixed assets, or property, plant, and equipment per worker. Most of the data are for net property, plant, and equipment, with all the associated problems of depreciation rates, valuation of assets purchased in the past, etc. However, for Swedish affiliates and their parents and for Swedish domestic firms in each industry we also have data on the valuation for fire insurance of gross property, plant, and equipment.

It would be desirable to have a measure of the flow of capital services instead of the stock of capital, since that would be the appropriate measure of the contribution of capital to production. We do not have adequate measures, however, and proxies which have been suggested, such as value added or nonwage value added per worker[5] do not seem satis-

---

[5] See, for example, Lary [1968].

factory, especially for comparisons within firms. The problem centers on the ability of the firm to manipulate the location of profits, presumably to minimize taxes or to evade other host-country or home-country regulations. The result is that there are large numbers of affiliates with negative or zero value added and others in which value added has been inflated for similar reasons. To the extent they are used, value added per worker is taken to represent total returns to capital per worker, including returns to human capital, following Lary, and nonwage value added is taken to represent returns to nonhuman capital.

We should have liked to investigate differences in skill mix and prices of skilled labor but the data are poor for this purpose. The U.S. survey forms included questions on the breakdown of the labor force and payments by type but the answers were considered unsatisfactory by BEA and were not used. We could not treat differences among countries in average wages as representing skill differences, as one might within a country. The average wage of each country, deflated by average labor quality, is our measure of the cost of standard labor, although it can incorporate skill differences as well. To the extent that it does, the relationship between labor cost and capital intensity is blurred. A possibility that may be worth exploring would be to measure labor cost by average wage for the country as a whole deflated by the average labor quality index and measure skill intensity for a given affiliate or group of affiliates by the ratio of average wage paid to the average national wage.

The Swedish affiliate data did include a usable distinction between production workers and others. We have made some use of the proportion of nonproduction workers as a measure of skill intensity.

Labor Costs and Factor Proportions in Individual Countries and Industries

We begin our analysis of the impact of labor costs on capital intensity with a series of regressions across countries, using data on the characteristics of U.S. and Swedish multinationals' affiliates in different countries.

In the first set of regressions, summarized in Table 4, the data for all U.S.-owned manufacturing affiliates in each country show that capital intensity responds significantly to country differences in wage costs. Equations 5 and 6, which make use of our best measures of wage costs, the average affiliate wage divided by our measure of average labor quality in each country, suggest an elasticity of substitution of between .7 (for fixed capital) and .8 (for all capital). A comparison of equations 1 and 2 with equations 3 and 4 indicates that adding more countries to the 38 covered by our labor quality index would tend to raise the coefficients, their significance, and the $\bar{r}^2$, but would not change the main findings.

Real GDP per capita, which we expected to be a good proxy for labor cost, performed poorly, explaining very little of the variation in capital intensity. To check whether the greater explanatory power of the wage rates might be spurious, stemming from a common price level effect on both labor cost and the capital intensity measure, we ran equations 7 and 8 with price level as the explanatory variable. Price level had no apparent explanatory power and the coefficients were not statistically significant. However, the fact that the coefficients were positive and fairly large does raise the possibility that the elasticity of substitution we calculate may be somewhat exaggerated by spurious price effects.

TABLE 4

Relation of Capital Intensity of Production
to Labor Cost, U.S.-Owned Affiliates, by Country

All Manufacturing, 1966

Eq. No.[a]	Number of Observations[b]	Capital Intensity Measure	Labor Cost Measure	Coefficients: Labor Cost	Coefficients: Constant Term	$\bar{r}^2$
1[c]	66	PPE	Av. Affiliate Wage	0.72 (4.73)	2.97 (2.55)	.25
2[c]	66	Assets	"	0.68 (5.55)	4.28 (4.53)	.31
3	38	PPE	"	0.60 (2.80)	3.96 (2.38)	.16
4	38	Assets	"	0.62 (3.26)	4.76 (3.21)	.21
5	38	PPE	Av. Affiliate Wage / Av. Quality	0.73 (3.10)	6.29 (8.31)	.19
6	38	Assets	"	0.79 (3.84)	7.07 (10.73)	.27
7	38	PPE	Price Level	.26 (.76)	7.57 (5.49)	-.01
8	38	Assets	"	.31 (1.01)	8.32 (6.62)	.00

PPE = Gross property, plant, and equipment per worker, in $ thousand.
Assets = Total assets per worker, in $ thousand.
Average Affiliate Wage = Average wage in U.S. manufacturing affiliates.
Average Quality = Index of average quality of the labor force.
Price Level = Money GDP, translated into dollars by exchange rate, divided by real GDP.

[a]Each equation is in double-log form, with capital intensity as the dependent variable and labor cost as the independent variable.

[b]Each observation is for all affiliates of U.S. manufacturing companies in a country.

[c]Equations 1 and 2 are based on all observations for which average affiliate wage is available. The other equations are confined to countries for which the labor quality measure could be constructed.

The Swedish data of Table 5 again show strong effects of labor cost on capital intensity. The coefficients for average wage and quality-adjusted average wage range from .75 to .87, somewhat above those in the U.S. equations. What is different about the Swedish results is that both price level and real GDP are related to capital intensity. The high price level coefficient hints at some exaggeration of the calculated substitution elasticities but the considerable explanatory power of real GDP, the labor cost proxy most clearly cleansed of price effects, shows that labor cost is an influential factor.

If we accept the results of Tables 4 and 5 as indicating significant response to labor cost, we still would wish to know whether the response involved only the choice of industries for investment (labor-intensive industries in low-wage countries) or choices among companies or production methods within industries. We can get some notion of the answer to this question from Tables 6 and 7 which show the same relationships within broad industry groups for both U.S. and Swedish affiliates.

The U.S. equations for aggregate manufacturing (Table 4) and for pooled individual industries (Table 6) are quite similar, except that the latter imply lower elasticities of substitution, .50-.55 instead of .6-.7. In other words, the substitution between labor and capital in the manufacturing aggregate owes a little to the choice of industries but mostly takes place within the broad industry groupings found in the table. There is some tendency for labor intensive industries to be more heavily represented in lower income countries but it accounts for only a small part of the apparent substitution of labor for capital there. We can judge from equation 2 that the elasticity of substitution estimated in equation 3, limited to

TABLE 5

Relation of Capital Intensity of Production (Fire-Insurance Value of Property, Plant, & Equipment per Worker)[a] to Labor Cost: Swedish-Owned Affiliates, by Country

All Manufacturing

Eq. No.[b]	Number of Observations	Year	Labor Cost Measure or Proxy	Coefficients: Labor Cost	Coefficients: Constant Term	$\bar{r}^2$
1	27	1970	Av. Affiliate Wage[c]	0.75 (3.29)	1.16 (1.41)	.27
2	25	1974	"	0.80 (2.53)	1.31 (1.12)	.18
3	27	1970	Av. Wage[c] / Av. Quality	0.84 (3.22)	4.69 (6.71)	.27
4	25	1974	"	0.87 (2.30)	5.05 (13.82)	.15
5	28	1970	Real GDP	0.46 (3.71)	2.23 (4.98)	.32
6	26	1974	"	0.49 (3.07)	2.40 (3.94)	.25
7	28	1970	Price Level	0.89 (2.92)	0.18 (0.14)	.22
8	26	1974	"	0.98 (2.87)	0.14 (0.10)	.22

For definitions of labor cost measures see Table 4.

[a]Capital intensity for each industry is measured relative to capital intensity for the same industry in Sweden to reduce inter-industry effects.

[b]Each equation is in double-log form, with capital intensity as the dependent variable and labor cost as the independent variable.

[c]Average wages in U.S. affiliates.

TABLE 6

Relation of Capital Intensity of Production to Labor Cost,
U.S. Affiliates Aggregated by Country

5 Industries separately and pooled
1966

Eq. No.[a]	Industry	Number of Observations	Capital Intensity Measure	Labor Cost Measure[b]	Coefficients: Labor Cost	Coefficients: Constant Term	$\bar{r}^2$
1	All Mfg., Pooled	179	PPE[c]	Av. Wage	0.50 (4.97)	-5.28 (6.82)	.12
2		128	"[c]	" "	0.51 (4.30)	-5.32 (5.76)	.12
3		128	"[c]	Av. Wage / Av. Quality	0.55 (4.18)	-3.12 (7.36)	.11
4	Food Mfg.	45	"	Av. Wage	0.40 (3.66)	5.33 (6.48)	.22
5		31	"	Av. Wage / Av. Quality	0.56 (4.35)	6.68 (16.70)	.37
6		45	Assets	Av. Wage	0.53 (5.17)	5.21 (6.70)	.37
7		31	"	Av. Wage / Av. Quality	0.61 (5.57)	7.45 (21.78)	.50
8	Chemicals	52	PPE	Av. Wage	1.07 (4.70)	0.26 (0.14)	.29
9		33	"	Av. Wage / Av. Quality	1.20 (3.60)	4.80 (4.31)	.27
10		52	Assets	Av. Wage	0.73 (5.02)	4.06 (3.56)	.32
11		33	"	Av. Wage / Av. Quality	0.78 (3.25)	7.24 (9.01)	.23
12	Metals	29	PPE	Av. Wage	0.54 (1.91)	4.45 (1.99)	.09
13		23	"	Av. Wage / Av. Quality	0.81 (1.96)	5.97 (4.34)	.11

(continued)

TABLE 6 (concluded)

Eq. No.[a]	Industry	Number of Observa- tions	Capital Intensity Measure	Labor Cost Measure[b]	Coefficients: Labor Cost	Coefficients: Constant Term	$\bar{r}^2$
14	Metals	29	Assets	Av. Wage	0.55 (2.73)	5.40 (3.43)	.19
15		23	"	Av. Wage / Av. Quality	0.66 (2.20)	7.49 (7.50)	.15
16	Machinery	38	PPE	Av. Wage	0.49 (3.80)	4.22 (4.27)	.27
17		28	"	Av. Wage / Av. Quality	0.51 (2.82)	6.42 (11.18)	.20
18		38	Assets	Av. Wage	0.56 (5.65)	5.02 (6.64)	.46
19		28	"	Av. Wage / Av. Quality	0.62 (4.42)	7.40 (16.71)	.41
20	Transp. Equip.	15	PPE	Av. Wage	0.44 (1.12)	4.71 (1.51)	.02
21		13	"	Av. Wage / Av. Quality	0.64 (1.33)	6.12 (3.82)	.06
22		15	Assets	Av. Wage	0.30 (1.20)	7.10 (3.57)	.03
23		13	"	Av. Wage / Av. Quality	0.40 (1.32)	8.15 (7.91)	.06

[a]Each equation is in double log form with capital intensity as the dependent variable and labor cost as the independent variable.

[b]Average wage paid by all U.S.-owned affiliates in an industry in a country.

[c]In pooled equations the capital intensity (gross property, plant, and equipment per worker) of U.S. affiliates is taken as a per cent of the capital intensity in the corresponding U.S. industry.

128 observations because of the lack of complete coverage in the labor quality variable, is not higher than that of equation 1 because of differences in country coverage. The coefficient for average wage among the countries included in the quality data is almost identical to that calculated from data for all countries.

The equations for individual U.S. industries almost all show significant labor cost coefficients, implying substitution of labor for capital in low-labor-cost countries. The exception was transport equipment, for which the number of observations was very small. The largest coefficient, suggesting an elasticity of substitution above "1" was for the chemicals industry.

A similar analysis of Swedish affiliates is made in Table 7. Since we had no wage data by country for these affiliates the elasticities were estimated using average wages paid in each country by U.S. affiliates: the same wage variable as in Tables 4 and 5. Both 1970 and 1974 equations indicated strong response to labor costs, as measured by average wages or by quality-deflated average wages. However, both real GDP and price level were also related to capital intensity and, in fact, explained it better than the presumably appropriate wage variable did.

Although there were not enough observations to calculate an equation for each industry among Swedish affiliates, there did seem to be some industry differences large enough to affect the elasticity measure. When we distinguished two industries, which seemed to be outliers, Paper Products & Printing and Metal Products, from the others, we found them to have somewhat higher elasticities and the explanatory power of the equation increased greatly. In any case, the Swedish affiliates appeared to respond to labor costs as the U.S. affiliates did, and perhaps to a greater degree, with elasticities of substitution mainly over .7.

TABLE 7

Relation of Capital Intensity of Production (Fire-Insurance Value of Property, Plant and Equipment per Worker[a]) to Labor Cost Swedish Affiliates Aggregated by Country within Industry

Manufacturing Industries, Pooled, 1970 and 1974

				Coefficients				
Eq. No.	No. of Obs.	Year	Labor Cost Measure	Labor Cost or Proxy	Labor Cost for 2 Ind.[b]	Constant	Dummy Variable for 2 Ind.[c]	$\bar{R}^2$
1	104	1970	Av. Wage[d]	0.78 (4.08)		-3.65 (5.15)		.13
2	96	1974	" "	0.69 (3.21)		-3.34 (4.12)		.09
3	104	1970	" "	0.70 (3.51)	0.63 (0.16)	-3.53 (4.79)	0.89 (0.53)	.25
4	96	1974	" "	0.71 (3.05)	0.79 (0.19)	-3.58 (4.07)	0.36 (0.22)	.25
5	104	1970	Av. Wage[d]/Qual.	0.83 (3.69)		-0.01 (.05)		.11
6	96	1974	" " "	0.69 (2.67)		-0.15 (0.65)		.06
7	104	1970	" " "	0.75 (3.19)	0.68 (0.13)	-0.25 (1.06)	0.57 (1.19)	.23
8	96	1974	" " "	0.73 (2.57)	0.83 (0.19)	-.29 (1.15)	0.75 (1.59)	.22
9	108	1970	Real GDP	0.50 (4.85)		-2.67 (6.71)		.17
10	100	1974	" "	0.51 (4.40)		-2.73 (6.00)		.16
11	108	1970	" "	0.47 (4.39)	0.36 (0.48)	-2.73 (6.64)	1.07 (1.13)	.29
12	100	1974	" "	0.51 (4.10)	0.53 (0.09)	-2.89 (5.93)	0.56 (0.62)	.31
13	108	1970	Price Level	1.03 (4.59)		-5.13 (5.39)		.16
14	100	1974	" "	1.00 (4.35)		-4.99 (5.10)		.15
15	108	1970	" "	0.89 (3.81)	0.96 (0.12)	-4.72 (4.76)	0.36 (0.16)	.27
16	100	1974	" "	0.89 (3.72)	1.22 (0.69)	-4.69 (4.60)	0.81 (0.39)	.30

Notes to TABLE 7

[a]Capital intensity for each industry is measured relative to that of the same industry in Sweden to eliminate industry effects.

[b]The coefficient reproduced below is the sum of the labor cost coefficient in the preceding column and the coefficient of the product of labor cost and the dummy variable for the paper products and metal products industries. Thus, if we write the fitted equation as

$$\ln\left(\frac{K}{L}\right) = a + b \ln D + c \ln LC + d \ln LC \cdot D$$

where $\frac{K}{L}$ is the capital/labor ratio, ln D is the dummy variable for the two industries, and LC is the labor cost measure, the coefficient shown here is c + d. The t-ratio, however, is for the coefficient d.

[c]Coefficient and t-ratio for b in the equation described in footnote b.

[d]Average wage in manufacturing affiliates of U.S. companies.

Labor Costs and Factor Proportions Within Firms

The degree of adaptation we have found to exist within industries might still be a matter of selection, either among sub-industries or among companies within each industry, with each company producing in the same way at home and abroad and in each foreign location. We cannot work with much finer industry classifications than those of Table 6 for lack of data or of sufficient numbers of observations but we can, for both the United States and Sweden, use information for individual companies and their affiliates to look for adaptation within companies. The within-company adaptation might be within a given technology (Figure 1 in the Introduction), between technologies (Figure 2), some combination of these (Figure 3), or some selection of processes for LDC production (Figure 6). In addition, the capital/labor ratio may reflect the effects of scale economies or diseconomies within the firm (Figure 7).

A sampling of U.S. results for all industries pooled in 1966 and 1970 is given in Table 8. Since we are using individual affiliates as the units of observation here we can include not only labor cost in the host country but also scale of operations for the affiliate itself as explanatory variables.

The data for 1966 have some advantages and some drawbacks compared with those from the 1970 survey. The main advantage is that they are from a complete census of foreign direct investment, and the number of observations is therefore much greater. Secondly, the 1966 questionnaire was much more detailed than the later one, a fact that permits us to measure more and different variables. On the other hand, the 1966 census does not include as much parent data as in 1970, or less were tabulated than in 1970. Therefore, the capital intensity variables for 1966 could not be calculated relative to those of parents because we lack parent data. The result is that some selection of parents may be mixed in with the adaptation by individual companies.

TABLE 8

Relation of Capital Intensity of Production to Labor Cost:
Individual U.S. Affiliates

All Manufacturing Industries, Pooled, 1966 and 1970

Eq. No.[a]	Year	No. of Obs. (Affiliates)	Capital Intensity Measure	Labor Cost Measure	Labor Cost or Proxy	Scale	Constant	$\bar{R}^2$
1	1966	4,502	Gross PPE[b]	Av. Affiliate Wage	0.44 (14.29)	0.13 (11.54)	8.88 (98.51)	.08
2	1966	4,336	" "	Av. Affiliate Wage / Av. Quality	0.47 (13.18)	0.14 (12.27)	-9.73 (101.40)	.08
3	1966	4,336	" "	Av. Country Wage / Av. Quality	0.34 (7.96)	0.15 (13.06)	-9.62 (96.18)	.06
4	1966	4,502	" "	Real GDP	0.17 (6.47)	0.14 (12.79)	-9.79 (46.67)	.05
5	1970	2,305	Net PPE[c]	Av. Affiliate Wage	0.45 (9.89)	0.08 (4.53)	-2.18 (14.30)	.06
6	1970	2,256	" "	Av. Affiliate Wage / Av. Quality	0.45 (8.98)	0.09 (4.86)	-2.23 (14.20)	.06
7	1970	2,213	" "	Av. Country Wage / Av. Quality	0.62 (9.20)	0.09 (5.12)	-2.55 (15.15)	.06
8	1970	2,305	" "	Real GDP	0.30 (7.94)	0.09 (5.27)	-4.04 (13.28)	.05
9	1970	2,315	Assets[c]	Av. Affiliate Wage	0.60 (20.05)	-0.02 (1.95)	-1.11 (11.28)	.15
10	1970	2,266	"	Av. Affiliate Wage / Av. Quality	0.60 (18.38)	-0.02 (1.39)	-1.17 (11.47)	.13
11	1970	2,223	"	Av. Country Wage / Av. Quality	0.59 (13.08)	0.00 (0.27)	-1.37 (12.12)	.07
12	1970	2,315	"	Real GDP	0.33 (12.44)	0.00 (0.20)	-3.04 (14.70)	.07

[a]Each equation is in double log form with capital intensity as the dependent variable and labor cost as the independent variable.

[b]Affiliate relative to U.S. industry. [c]Affiliate relative to parent.

Scale = Net sales of affiliate (total sales less imports from the U.S.)
Gross PPE = Gross property, plant, and equipment per worker.
Net PPE = Net property, plant, and equipment per worker.
Assets = Assets per worker.

The labor cost coefficients in equations 2 and 3 are close to, but a little smaller than, those of Table 6 where we used country aggregates of affiliates. Most of the response to labor cost within industries takes place within individual companies but there is also a tendency for firms with low capital intensity to operate in low wage countries, reinforcing the effects of intra-firm adaptation. Thus, we have evidence of adaptation by the definitions of Figure 5 and of Figure 1 or Figure 6 of the Introduction.

The scale variable proves to be highly significant and in the expected direction for capital intensity as measured by physical plant and equipment. That is, larger scale is associated with more capital-intensive methods of production. But this was not true where capital intensity was measured by total assets per worker. By that measure, larger size was associated with lower capital intensity, although the effect was not strong when the quality-adjusted wage was used as the labor cost measure.

The labor cost measure used here is different for each affiliate. It is the affiliate's average wage per worker deflated by the average labor quality of the country in which the affiliate is located. Use of the individual firm average wage as a labor cost measure implies that, within a country, higher wages represent higher cost for standard labor rather than higher labor quality. If this is not the case (if internal labor markets are competitive, for example) labor cost might be better measured by average manufacturing affiliate wage for the country as a whole. Equations 3, 7, and 11 of Table 8 use this labor cost measure but the results are not consistently higher or lower labor cost coefficients than those of equations 2, 6, and 10.

The pooling of all industries implies that labor cost and scale effects are identical among all of them, an assumption that we have no great confidence in. Separate equations for the various manufacturing groups in 1970 are given in Tables 9 and 10, the former using property, plant, and equipment as the capital measure, to give physical capital intensity, and the latter using assets per worker, or total capital intensity.

Physical capital intensity is clearly responsive to labor cost differences. The variable is significant in 11 out of 14 equations, not counting groups such as chemicals for which we also have subgroup equations, and the average elasticity of substitution is about .60, very close to the estimate from the country aggregates in Table 6.

Scale, which appeared important in the pooled data, rarely appears significant in the individual industry equations, although it is positive, as expected, where it is significant. The implication is that we were observing an inter-industry effect in the pooled data rather than a true effect of scale on capital intensity within industries. That possibility is suggested also by the fact that two of the three significant scale effects in Table 9 are for combinations of industries: other chemicals, and other non-electrical machinery.

Somewhat surprisingly, in view of our doubts expressed earlier about assets as a capital measure for individual affiliates, we are better able to explain variation in total capital per worker than in physical capital per worker. The levels of the $\bar{R}^2$ in Table 10 are substantially above those in Table 9 and the average estimated elasticity of substitution among the significant coefficients is also somewhat higher, at almost .70. The scale variable,

TABLE 9

Relation of Net Property, Plant, and Equipment per Worker[a] to Labor Cost: Individual U.S. Affiliates, by Industy, 1970

Eq. No.[b]	Industry	No. of Obs. (Affiliates)	Coefficients: Labor Cost[c]	Scale[d]	Constant Term	$\bar{R}^2$
1	Food Processing	233	0.45 (3.39)	0.10 (2.17)	-2.26 (5.43)	.08
2	Paper & Allied Products	101	0.44 (2.14)	0.09 (1.18)	-1.96 (2.92)	.06
3	Chemicals	613	0.55 (5.28)	0.15 (4.05)	-3.12 (9.73)	.09
4	**Drugs**	191	0.41 (2.53)	0.10 (1.30)	-2.73 (4.63)	.04
5	**Other chemicals**	422	0.58 (4.32)	0.15 (3.33)	-2.97 (7.68)	.08
6	Rubber & Plastics	41	0.19 (0.64)	0.03 (0.26)	-0.93 (1.03)	.00
7	Primary & Fabricated Metals	189	0.44 (2.85)	-0.06 (0.89)	-1.02 (1.89)	.03
8	Non-electrical Machinery	295	0.52 (4.34)	0.12 (2.79)	-2.56 (6.83)	.10
9	**Computers**	52	1.04 (5.48)	0.02 (0.24)	-2.25 (3.72)	.43
10	**Other non-elec. mach.**	243	0.32 (2.18)	0.12 (2.37)	-2.35 (4.95)	.04
11	Electrical Machinery	262	0.54 (3.81)	-0.05 (0.96)	-1.35 (2.98)	.05
12	**Radio, TV, & electronics**	109	0.47 (2.59)	-0.03 (0.41)	-1.73 (2.46)	.04
13	**Household electrical equip.**	37	1.28 (3.26)	-0.11 (0.83)	-1.46 (1.24)	.19
14	**Other electrical mach.**	116	0.33 (1.30)	-0.06 (0.77)	-0.84 (1.26)	.00
15	Transport Equipment	132	0.54 (2.79)	-0.01 (0.20)	-1.14 (2.63)	.04
16	Motor Vehicles	122	0.59 (2.85)	-0.01 (0.27)	-1.17 (2.67)	.05
17	Other Transport Equip.	10	-0.43 (0.27)	0.04 (0.17)	0.16 (0.06)	.00
18	Other Manufacturing	390	0.38 (2.50)	0.08 (1.41)	-1.97 (3.73)	.02

Notes to TABLE 9

[a]Affiliate net property, plant, and equipment per worker relative to the same measure for the parent company.

[b]Equation is in form: $\ln\left(\frac{K}{L}\right) = a + b \ln LC + c \ln NS$.

[c]Average wage per worker in each affiliate, deflated by average labor quality in the country in which the affiliate is located.

[d]Net sales of an affiliate (total sales less imports from the United States).

TABLE 10

Relation of Assets per Worker[a] to Labor Cost
Individual U.S. Affiliates, by Industry, 1970

Eq. No.[b]	Industry	No. of Obs. (Affiliates)	Coefficients: Labor Cost[c]	Coefficients: Scale[d]	Coefficients: Constant Term	$\bar{R}^2$
1	Food Processing	237	0.91	-0.10	-0.82	.22
			(8.17)	(2.51)	(2.32)	
2	Paper & Allied Prod.	101	0.40	-0.02	-0.74	.06
			(2.93)	(0.32)	(1.66)	
3	Chemicals	616	0.64	0.02	-1.65	.12
			(8.86)	(0.91)	(7.57)	
4	Drugs	192	0.37	0.08	-1.85	.08
			(3.56)	(1.68)	(4.92)	
5	Other chemicals	424	0.76	-0.00	-1.54	.14
			(8.04)	(0.14)	(5.70)	
6	Rubber & Plastics	41	0.27	-0.01	-0.80	.00
			(1.31)	(0.13)	(1.28)	
7	Primary & Fabricated Metals	190	0.59	-0.07	-0.67	.11
			(5.10)	(1.46)	(1.66)	
8	Non-electrical Machinery	297	0.60	0.01	-1.30	.18
			(7.77)	(0.39)	(5.47)	
9	Computers & office equip.	52	0.78	-0.07	-0.86	.57
			(8.16)	(2.00)	(2.80)	
10	Other Non-electrical mach.	245	0.56	0.04	-1.49	.12
			(5.71)	(1.17)	(4.78)	
11	Electrical Machinery	262	0.82	-0.11	-0.57	.26
			(9.51)	(3.55)	2.08	
12	Radio, TV, & electronics	109	0.90	-0.17	-0.36	.36
			(7.86)	(3.33)	(0.82)	
13	Household appliances	37	1.00	-0.08	-0.78	.36
			(4.74)	(1.19)	(1.24)	
14	Other electrical mach.	116	0.58	-0.08	-0.40	.11
			(3.94)	(1.91)	(1.03)	
15	Transportation Equipment	132	0.29	0.02	-0.96	.03
			(2.00)	(0.50)	(2.95)	
16	Motor vehicles	122	0.30	0.02	-1.00	.03
			(1.88)	(0.63)	(2.93)	
17	Other transport. equip.	10	-0.19	0.01	0.08	.00
			(0.24)	(0.07)	(0.05)	
18	Other Manufacturing	390	0.49	-0.02	-0.99	.08
			(5.98)	(0.62)	(3.49)	

Notes to TABLE 10

[a]Affiliate total assets per worker relative to the same measure for the parent company.

[b]Equation is in form: $\ln\left(\frac{K}{N}\right) = a + b \ln LC + c \ln NS$.

[c]Average wage per worker in each affiliate, deflated by average labor quality in the country in which the affiliate is located.

[d]Net sales of an affiliate (total sales less imports from the United States).

however, is negative where it is significant. Taken in conjunction with the positive scale coefficients in equations in which physical assets alone were the dependent variable, the negative coefficients seem to imply that larger affiliates economize on non-physical assets per worker.

Some equations based on the 1966 data appear in Tables 11 and 12. They differ from the 1970 equations in several respects. As mentioned earlier, affiliate capital intensity is not calculated relative to that of the parent, and we have omitted the equations for net property, plant and equipment per worker because they are similar to those for gross P.P.&E. but show slightly lower elasticities and $\bar{R}^2$s.

The impression of strong response of physical capital intensity to labor costs from the 1966 data is quite similar to that from the 1970 survey. However, there are many more significant scale coefficients, all positive. The main reason seems to be the use of gross rather than net physical assets, since the equations for net property, plant, and equipment per worker in 1966 do not show such strong scale effects. The 1970 equations in Table 8 also showed larger scale effects when gross, rather than net, property, plant, and equipment was used in the capital intensity measure.

As in the 1970 data, the equations using assets per worker (Table 12) give the highest estimates of the elasticity of substitution and the highest levels of $\bar{R}^2$, the former averaging about .70. Also, there is again a strong, although not universal, negative scale effect. The larger the affiliate the lower the total assets per worker even though some of the same industries' equations showed that the larger the affiliate, the higher the gross property, plant, and equipment per worker.

TABLE 11

Relation of Gross Property, Plant, and Equipment per Worker[a] to Labor Cost: Individual U.S. Affiliates, by Industry, 1966

Eq. No.[b]	Industry	No. of Obs. (Affiliates)	Coefficients: Labor Cost[c]	Coefficients: Scale[d]	Coefficients: Constant Term	$\bar{R}^2$
1	Food Processing	540	0.53 (6.14)	0.06 (2.08)	0.86 (3.50)	.08
2	Paper & Allied Prod.	200	0.70 (4.30)	0.06 (1.31)	1.04 2.70	.10
3	Chemicals	1,349	0.67 (9.68)	0.21 (8.84)	-0.56 (2.89)	.12
4	Drugs	400	0.29 (2.69)	0.26 (6.10)	-0.96 (2.78)	.10
5	Other chemicals	949	0.75 (8.85)	0.19 (7.04)	-0.35 (1.55)	.13
6	Rubber & Plastics	143	0.50 (2.87)	0.13 (2.66)	0.38 (0.90)	.10
7	Primary & Fabricated Metals	565	0.45 (5.11)	0.09 (3.27)	0.73 (3.12)	.07
8	Non-electrical Machinery	797	0.39 (5.83)	0.11 (4.45)	0.26 (1.32)	.07
9	Computers & office mach.	105	0.70 (5.42)	0.32 (6.05)	-2.25 (5.10)	.45
10	Other non-electrical mach.	692	0.25 (3.33)	0.07 (2.71)	0.75 (3.48)	.03
11	Electrical Machinery	484	0.57 (7.73)	0.02 (0.84)	0.51 (2.30)	.11
12	Radio, TV, & electronics	185	0.70 (6.26)	0.02 (0.54)	0.14 (0.46)	.17
13	Household appliances	87	0.41 (2.48)	0.04 (0.65)	0.73 (1.55)	.06
14	Other electrical mach.	212	0.47 (4.05)	0.03 (0.64)	0.72 (1.98)	.07
15	Transport Equipment	258	0.28 (2.06)	0.05 (1.57)	1.07 (4.30)	.03
16	Motor Vehicles	213	0.22 (1.62)	0.06 (2.13)	1.01 (4.23)	.05
17	Other transport equip.	45	0.65 (1.36)	-0.08 (0.66)	1.51 (1.50)	.00
18	Other Manufacturing	1,126	0.47 (6.61)	0.03 (1.12)	0.73 (3.62)	.04

Notes to TABLE 11

[a]Affiliate gross property, plant, and equipment per worker.

[b]Equation is in form: $\ln\left(\frac{K}{L}\right) = a + b \ln LC + c \ln NS.$

[c]Average wage per worker in each affiliate, deflated by average labor quality in the country in which the affiliate is located.

[d]Net sales of affiliate (total sales less imports from the United States).

TABLE 12

Relation of Assets per Worker[a] to Labor Cost:
Individual U.S. Affiliates, by Industry, 1966

Eq. No.[b]	Industry	No. of Obs. (Affiliates)	Coefficients: Labor Cost[c]	Coefficients: Scale[d]	Coefficients: Constant Term	$\bar{R}^2$
1	Food Processing	541	0.85 (12.96)	-0.06 (2.72)	2.34 (12.54)	.24
2	Paper & Allied Products	202	0.71 (5.64)	-0.06 (1.52)	2.47 (8.22)	.13
3	Chemicals	1,356	0.78 (17.48)	0.01 (0.64)	1.90 (15.21)	.18
4	Drugs	402	0.58 (9.28)	0.03 (1.01)	1.76 (8.73)	.18
5	Other chemicals	954	0.82 (14.43)	0.00 (0.22)	2.01 (13.30)	.18
6	Rubber & Plastics	143	0.68 (6.15)	-0.04 (1.21)	2.24 (8.44)	.20
7	Primary & Fabricated Metals	568	0.62 (9.28)	-0.04 (2.04)	2.40 (13.42)	.13
8	Non-electrical Machinery	802	0.69 (14.79)	-0.02 (1.37)	2.08 (15.49)	.21
9	Computers & office mach.	105	0.78 (9.61)	0.05 (1.38)	1.02 (3.69)	.50
10	Other non-elect. mach.	697	0.63 (11.99)	-0.02 (1.10)	2.18 (14.51)	.17
11	Electrical Machinery	486	0.85 (15.61)	-0.09 (4.66)	2.25 (13.97)	.34
12	Radio, TV, & electronics	187	0.92 (11.94)	-0.06 (2.27)	1.79 (8.23)	.43
13	Household appliances	87	0.65 (5.16)	-0.17 (4.00)	3.26 (9.06)	.28
14	Other electrical mach.	212	0.83 (9.33)	-0.10 (2.78)	2.39 (8.53)	.29
15	Transport Equipment	258	0.67 (6.24)	-0.04 (1.53)	2.19 (11.07)	.13
16	Motor vehicles	213	0.60 (5.48)	-0.02 (0.76)	2.12 (10.98)	.13
17	Other transport equip.	45	1.04 (2.82)	-0.02 (1.80)	2.71 (3.51)	.14
18	Other Manufacturing	1,137	0.81 (16.93)	-0.09 (5.05)	2.30 (17.00)	.21

Notes to TABLE 12

[a]Affiliate total assets per worker.

[b]Equation is in form: $\ln\left(\frac{K}{L}\right) = a + b \ln LC + c \ln NS$.

[c]Average wage per worker in each affiliate, deflated by average labor quality in the country in which the affiliate is located.

[d]Net sales of affiliate (total sales less imports from the United States).

The negative scale coefficients in the equations using assets per worker as the measure of capital intensity are a surprise. There is virtually no relationship between size of affiliate and assets per worker in simple regressions within industries and the few significant coefficients are split between positive and negative ones. However, there is a strong relationship between affiliate size and gross property, plant, and equipment per worker, and all the statistically significant coefficients are positive. These results suggest that indivisibilities in machinery and equipment are responsible for the relationship and that the effect of these is offset in other types of assets.

The data for Swedish firms and their foreign affiliates differ from the U.S. data in several respects. One of the chief advantages of the Swedish data is that they give production, by industry, for each parent and affiliate. We can thus distinguish industry-mix choices even within the firm from choices of factor proportions within an industry in a way that is impossible with the U.S. data in which each parent and affiliate is characterized by only one industry. We do this by calculating, for each parent and affiliate, capital intensities at Swedish industry coefficients. Any difference between the capital intensities of parents and affiliates at Swedish industry coefficients then represents a choice of industry mix, while the difference between the actual capital intensity of an affiliate and its calculated capital intensity at Swedish industry coefficients represents a choice of production methods within industry. Thus we can calculate the affiliate's inputs at Swedish coefficients as

$$AK^{sw} = \sum_{i=1}^{m} Aq_i \frac{K_i^{sw}}{q_i^{sw}}$$

and

$$AL^{sw} = \sum_{i=1}^{m} Aq_i \frac{L_i^{sw}}{q_i^{sw}}$$

where AK^{sw} and AL^{sw} are affiliate capital and labor inputs at Swedish industry coefficients, Aq_i is the affiliate's production in industry i, K_i^{sw} is capital input and L_i^{sw} is labor input in the domestic Swedish industry i, and q_i^{sw} is output in Swedish industry i. We can similarly calculate parent capital and labor inputs at Swedish industry ratios, PK^{sw} and PL^{sw}, and we can compare all of these with actual affiliate and parent inputs, AK, AL, PK, and PL.

Another advantage of these data is that both numbers and payroll are given separately for wage and salaried workers, enabling us to calculate average earnings for each. The wage per wage worker, while not standardized for quality, may be a little less subject to wide differences in mix than the average wage in the U.S. figures, which lump wage and salaried workers together.

This possibility of breaking down the Swedish parents and affiliates by industry is particularly important for our purposes because the number of Swedish affiliates in any one industry is small, and we were therefore unable to run separate equations for individual industries. All the equations reported on below are, therefore, pooled over all industries.

Affiliate industry mix was not explained well in any equations and in fact, two measures of wage cost gave effects with opposite signs. When we measured wages by money GDP per capita deflated by average quality we found that higher wage levels were associated with less capital-intensive industries, but when we measured wages by average affiliate wage deflated by average country labor quality, as in the equations for U.S. affiliates, we found, as expected, that high wages were associated with more capital-intensive industries. However, in neither case did we explain more than a very small fraction of the industry mix variation.

When we tried to explain the adaptation of capital intensities within industries, the variable that seemed most effective was the ratio of real GDP per capita to the average labor quality, a kind of labor productivity ratio with the labor input adjusted for quality. The variable may be a proxy for capital input per unit of standard labor input, in which case we would be using something like the same variable on both sides of the equation and the results would be meaningless. The equations were:

$$\ln \frac{AK}{AL} \Big/ \frac{AK^{SW}}{AL^{SW}} = -2.90 + .744 \ln \frac{\text{Real GDP per Capita}}{\text{Av. Quality of Labor}} \qquad \bar{R}^2 = .43 \tag{1}$$

and

$$\ln \frac{AK/AL}{AK^{SW}/AL^{SW}} \Big/ \frac{PK/PL}{PK^{SW}/PL^{SW}} = -2.93 + .713 \ln \frac{\text{Real GDP per Capita}}{\text{Av. Quality of Labor}} \tag{2}$$

$$\bar{R}^2 = .38$$

When we used average wage deflated by average labor quality as the explanatory variable, our usual wage measure, the coefficients were negative and the degree of explanation much poorer, as in the following:

$$\ln \frac{AK}{AL} \Big/ \frac{AK^{SW}}{AL^{SW}} = -1.16 - .442 \ln \frac{\text{Av. Wage}}{\text{Av. Quality}} \qquad \bar{R}^2 = .19 \tag{3}$$

The results using real GDP per capita as a proxy for wage costs, on the other hand, were more along the expected lines. No logarithmic equation was run, but the arithmetic forms indicated the existence of substitution

$$\frac{AK}{AL} \Big/ \frac{AK^{sw}}{AL^{sw}} = .30 + .12 \text{ Real GDP per Capita} \qquad \bar{R}^2 = .25 \tag{4}$$

$$\frac{AK/AL}{AK^{sw}/AL^{sw}} \Big/ \frac{PK/PL}{PK^{sw}/PL^{sw}} = .32 + .08 \text{ Real GDP per Capita} \qquad \bar{R}^2 = .10 \tag{5}$$

We must describe these results as quite inconclusive as to the existence of factor substitution within Swedish firms.

Since most of the equations for Swedish data were run only in arithmetic form, they do not yield elasticities of substitution directly and, to judge from our experience with the U.S. affiliate data, the degree of association between labor cost and capital intensity is probably understated. However, the direction of the relationships found is of some interest for confirming, contradicting or supplementing, the results of the U.S. analysis. We can summarize the results from equations on Swedish affiliate data briefly as follows:

1. Affiliates in industries of low capital intensity relative to parents tended to be in higher income countries -- Non-adaptation.
2. Parents in industries with high capital intensity tended to have affiliates in high-income countries -- Adaptation.
3. Affiliates in industries of high skill intensity relative to parents tended to be in high-skill countries -- Adaptation.
4. Affiliates, individually and in the aggregate, produce with higher capital intensity relative to parents or Swedish industry in high-income and high-wage countries -- Adaptation.

5. Affiliates use higher skill ratios relative to parents or Swedish industry in countries whose salaried work is relatively cheap -- Adaptation.

In all these calculations we have looked at relations among affiliates. We can also use the affiliate data to compare affiliates in general with their parents and with Swedish industry, taking advantage of the information on industry composition instead of relying on the single-industry designations as in the earlier comparisons of aggregates. For example, the average ratios of affiliate/parent industry capital intensities and skill intensities at Swedish industry coefficients were:

$$\frac{aK^{sw}}{aL^{sw}} \Big/ \frac{PK^{sw}}{PL^{sw}} = 1.06$$

$$\frac{aLS^{sw}}{aL^{sw}} \Big/ \frac{PLS^{sw}}{PL^{sw}} = 1.01$$

where aLS^{sw} is the number of salaried workers an affiliate would have if it used the Swedish industry ratio of salaried workers to output. The affiliate industry mix was more capital intensive than Swedish output in general and very slightly more skill-intensive. Thus there is no evidence here of adaptation to lower labor costs outside Sweden in the form of selection of industries.

However, the actual capital intensities of the affiliates were substantially below the Swedish and parent levels for the same industries.

$$\text{Average} \quad \frac{aK}{aL} \Big/ \frac{aK^{sw}}{aL^{sw}} = .81$$

$$\text{Average} \quad \frac{\frac{aK}{aL} \Big/ \frac{aK^{sw}}{aL^{sw}}}{\frac{PK}{PL} \Big/ \frac{PK^{sw}}{PL^{sw}}} = .79$$

That is, when we compare the actual average capital intensity in Swedish affiliates $\left(\frac{aK}{aL}\right)$ with what it would have been if they had, in each industry, used the same ratio of capital to labor as in Swedish industry $\left(\frac{aK^{sw}}{aL^{sw}}\right)$, the actual capital intensity was 19 per cent lower. The actual parent capital intensities, on the other hand, were slightly above those of the corresponding Swedish industries. The affiliate capital intensities therefore represented even a little more than the 19 per cent adaptation relative to the parent capital intensities.

On the whole, then, the Swedish data suggest considerable adaptation within industries between the very high labor costs in Sweden and the lower labor costs in host countries, and between developed and less-developed host countries. The evidence on adaptation within firms was mixed, but it did predominantly point to some degree of adaptation to differences in labor cost.

Adaptation as Factor Substitution and Technology Choice

The tests of individual firm adaptation up to this point have attempted to determine whether there was any effect of differences in labor costs on factor proportions. Here we look at adaptation as the product of two decisions the parent company makes about affiliate production methods. One is the choice of technology, which might be the choice of machinery or plant design, or even of product mix, and is represented by a family of isoquants belonging to a production function. The other is the way in which the affiliate operates within the chosen technology, which might include decisions regarding multi-shift operation or ancillary services, and is represented by the choice of a location on the isoquant defining the technology.

This conceptualization is broad enough to include all the variables that influence the choice of factor proportions. Factor prices will determine the factor substitution effect, i.e., the choice of location on the isoquant. The choice of technology can be thought of as an ex-ante decision determined not only by technological considerations but by economic variables as well. Some of these variables are the product-mix, the availability of skilled labor force and the scale of production.[6]

---

[6] See Roldan [1978], pp. 40-58.

Across countries these variables are assumed to be correlated with the level of development of the country. The factor intensity technology parameter of a production function is specified as a function of the per capita income of the country in which the affiliate is located. The elasticity of substitution parameter and the factor price ratio determine the magnitude of the factor substitution effect.

This section, then, explains the difference in capital-labor ratios[7]

---

[7] Capital is measured here as Net Property, Plant and Equipment.

between affiliates operating in DC's and LDC's, i.e., the adaptation, as the product of a factor substitution effect and a choice of technology effect.

Assuming a Cobb-Douglas production function,[8]

$$V = A K^{a} L^{b} \tag{6}$$

[8] Similar analysis can be made in terms of a CES production function. Results corresponding to that case are shown below.

where V is value added, K denotes capital stock and L employment, the parameter A is the efficiency parameter and a and b represent the output elasticity parameters of capital and labor, respectively. Let w and r be the wage rate and the rental cost of capital per unit of capital.

Applying the cost minimizing conditions

$$\frac{\partial V/\partial K}{\partial V/\partial L} = \frac{r}{w}$$

to expression (6), we obtain

$$k = \frac{K}{L} = \frac{a}{b} \cdot \frac{w}{r} \tag{7}$$

The ratio a/b is the factor intensity parameter of the technology (position of the isoquant) since given a factor price ratio w/r, the larger the ratio a/b is, the larger k will be. We assume further that the ratio a/b is a function of the host country income per capita Y. In particular,

$$\frac{a}{b} = \alpha Y^{\beta} \tag{8}$$

Introducing expression (8) into (7), we get the regression equation:

$$\ln \frac{wL}{rK} = c + d \ln Y + u \tag{9}$$

where u is the error term. The parameters $c = \ln (1/\alpha)$ and $d = -\beta$ are estimated by ordinary least-squares.

The resulting expression for the predicted capital/labor ratio k in terms of the estimated parameters is [EXP (-c) being e^{-c}]

$$\hat{k} = \text{EXP}\ (-c) \cdot Y^{-d} \cdot \frac{w}{r} \tag{10}$$

As the factor intensity parameter varies from country to country according to Y, we can calculate a predicted average capital labor ratio for affiliates operating in DC's and LDC's by substituting in expression (10) the proper averages for the income and factor price variables. Y_D and Y_L are calculated as the average per capita income for the DC's and LDC's respectively; $(w/r)_D$ and $(w/r)_L$ are calculated as the average factor price ratio for affiliates operating in DC's and LDC's respectively.

The relative capital intensity that measures the adaptations between DC's and LDC's affiliates is given by the expression

$$\frac{\hat{k}_D}{\hat{k}_L} = \frac{Y_D^{-d}}{Y_L^{-d}} \cdot \frac{\left(\frac{w}{r}\right)_D}{\left(\frac{w}{r}\right)_L} = T \times S \tag{11}$$

The first term,

$$\left(\frac{Y_D^{-d}}{Y_L^{-d}}\right)$$

that we will call T from here on, gives a measure of the extent and direction of the technology selection effect. $T < 1$ implies that affiliates operating in DC's will tend to use a technology that is, at every factor price ratio, less capital intensive than the one used in LDC's; and vice versa if $T > 1$.

Since Y_D and Y_L are such that $Y_D > Y_L$, the selection of technology effect T will be larger or smaller than 1 depending on the sign of the regression coefficient d. In other words $T \lesseqgtr 1$ if $d \lesseqgtr 0$. Thus, the empirical estimation of the coefficient d in equation (9) will be of extreme importance. In particular, the possibility of biases in the estimation procedure should be kept in mind, although our own analysis does not suggest any source of potential bias.

The substitution effect--denominated S--is measured by the expression

$$\frac{\left(\frac{w}{r}\right)_D}{\left(\frac{w}{r}\right)_L}$$

If $T = 1$, i.e., if the regression coefficient d is not different from zero in the regression of equation (9), it would indicate that affiliates in DC's and LDC's operate with the same technology (on the same isoquant) and that differences in capital labor ratios between them can be explained by differences in factor price ratios. The expression $\hat{k}_D/\hat{k}_L$ will be given simply by

$$\frac{\hat{k}_D}{\hat{k}_L} = \frac{\left(\frac{w}{r}\right)_D}{\left(\frac{w}{r}\right)_L} \qquad (12)$$

The results for the predicted relative capital-labor ratios and their component technology selection (T) and factor substitution (S) effects are presented in Tables 13 through 16.

The main result is the opposite direction in which the technology selection and the factor substitution effects work in all industries. T is always less than one, meaning that the technology used by the LDC affiliates is more capital intensive than the one used by developed country affiliates. The situation can be represented graphically in Figure 10, a version of Figure 3 where the isoquant representing the LDC's affiliates technology is to the right of the one for DC affiliates. The selection of technology effect could be represented by the distance ab. However, the factor substitution effect from the relatively lower labor costs in LDC's will operate in the direction of using relatively more labor than capital. This effect can be represented by the shift from b to c in the isoquant for LDC affiliates, and it can be strong enough to make the capital labor ratios in use in some industries significantly higher for DC's than for LDC's affiliates.

Figure 10 has to be interpreted carefully since it is only a two-dimensional representation of our empirical results. Failure to understand that would lead one to conclude that country L would be better off--given its factor price relationship $(w/r)_L$--operating somewhere on the isoquant of the DC's, instead of in the isoquant for LDC's as the graph shows. That situation cannot materialize because both the isoquants and factor price relationships of DC's and LDC's are associated with different values of variables affecting the choice of technology.

TABLE 13

Capital Intensity Comparisons, Technology Selection, and Factor Substitution: Developed Country vs. LDC Affiliates of U.S. Firms

Cobb-Douglas Specification, 1966 Sample

Industry	Actual	Predicted			
		With Technology Selection Effect ($T \neq 1$)			No Technology Selection Effect ($T=1$)
	k_D/k_L	k_D/k_L	T	S	k_D/k_L
1. Food Products	1.29	1.37	0.74	1.83	1.83
2. Bakery Products	1.23	--	--	--	1.85
3. **Taxtiles and Apparal**	0.81	1.23	0.78	1.58	1.58
4. Paper and Pulp	0.93	1.36	0.70	1.94	1.94
5. All Chemicals	1.59	--	--	--	1.64
6. Industrial Chemicals	1.67	--	--	--	1.82
7. Drugs	1.27	--	--	--	1.26
8. All Chemicals <u>less</u> Drugs	1.62	1.29	0.75	1.71	1.71
9. Stone, Clay, Glass and Non-Met. Products	1.00	1.68	0.79	2.12	2.12
10. Fabricated Metals	1.15	1.38	0.71	1.96	1.96
11. **Farm, Mining, & Industrial** Equipment (FMI)	1.47	1.51	0.75	2.00	2.00
12. Industrial Equipment	1.47	--	--	--	2.00
13. **Non-Electrical Machinery** <u>**less**</u> FMI	1.11	1.29	0.71	1.80	1.80
14. Electrical Machinery	1.41	1.69	0.66	2.55	2.55
15. Radio, TV and Electronics	1.37	1.66	0.67	2.47	2.47
16. **Electrical Machinery** <u>**less**</u> **Radio, TV, & Elect.**	1.51	1.53	0.57	2.68	**2.68**
17. **Transportation Equipment**	1.13	1.30	0.56	2.30	2.30

(--) Technology selection effect not significantly different from 1.

k_D and k_L = Capital/Labor ratios in developed and LDC affiliates.

T = Technology effect.

S = Factor substitution effect.

TABLE 14

Capital Intensity Comparisons, Technology Selection, and Factor Substitution: Developed Country vs. LDC Affiliates of U.S. Firms

Cobb-Douglas Specification, 1970 Sample

Industry	Actual	Predicted			
		With Technology Selection Effect ($T \neq 1$)			No Technology Selection Effect ($T=1$)
	k_D/k_L	k_D/k_L	T	S	k_D/k_L
1. Food Products	1.62	1.46	0.72	2.00	2.00
2. Bakery Products	1.62	1.91	0.64	2.96	2.96
3. Textiles and Apparel	1.93	--	--	--	1.59
4. Paper and Pulp	0.85	1.05	0.62	1.68	1.68
5. All Chemicals	2.52	--	--	--	2.30
6. Industrial Chemicals	3.65	--	--	--	2.96
7. Drugs	1.81	--	--	--	1.59
8. All Chemicals less Drugs	2.44	2.05	0.79	2.57	2.57
9. Stone, Clay, Glass, and Non-Met. Products	1.08	0.97	0.59	1.64	1.64
10. Fabricated Metals	1.27	--	--	--	1.12
11. **Farm, Mining, and Industrial Equipment (FMI)**	0.67	0.74	0.72	1.03	1.03
12. **Industrial Equipment**	0.75	0.77	0.72	1.06	1.06
13. Non-Electrical Machinery less FMI	1.10	--	--	--	1.55
14. Electrical Machinery	1.21	1.02	0.57	1.76	1.76
15. Radio, TV and Electronics	0.97	1.03	0.67	1.53	1.53
16. **Electrical Machinery less Radio, TV, & Elect.**	1.36	1.05	0.54	1.92	1.92
17. **Transportation Equipment**	1.52	1.15	0.58	1.97	1.97

(--) Technology selection effect not significantly different from 1.

k_D and k_L = Capital/Labor ratios in developed and LDC affiliates.

T = Technology effect.

S = Factor substitution effect.

TABLE 15

Capital Intensity Comparisons, Technology Selection, and Factor Substitution: Developed Country vs. LDC Affiliates of U.S. Firms

CES Specification, 1966 Sample

	Actual	Predicted			
		With Technology Selection Effect ($T \neq 1$)			No Technology Selection Effect ($T=1$)
Industry	k_D/k_L	k_D/k_L	T	S	k_D/k_L
1. Food Products	1.29	1.38	0.92	1.50	1.49
2. Bakery Products	1.23	--	--	--	1.47
3. Textiles and Apparel	0.81	1.15	0.82	1.40	1.39
4. Paper and Pulp	0.93	1.19	0.78	1.52	1.47
5. All Chemicals	1.59	--	--	--	1.46
6. Industrial Chemicals	1.67	--	--	--	1.61
7. Drugs	1.27	--	--	--	1.15
8. All Chemicals less Drugs	1.62	1.31	0.84	1.56	1.54
9. Stone, Clay, Glass and Non-Met. Products	1.00	--	--	--	1.59
10. Fabricated Metals	1.15	1.30	0.87	1.48	1.45
11. Farm, Mining, and Industrial Equipment (FMI)	1.47	--	--	--	1.46
12. Industrial Equipment	1.47	--	--	--	1.48
13. Non-Electrical Machinery less FMI	1.11	1.25	0.82	1.51	1.50
14. Electrical Machinery	1.41	1.44	0.82	1.75	1.68
15. Radio, TV, and Electronics	1.37	--	--	--	1.58
16. Electrical Machinery less Radio, TV, & Elect.	1.51	1.36	0.76	1.79	1.70
17. Transportation Equipment	1.13	1.18	0.78	1.51	1.42

(--) Technology selection effect not significantly different from 1.

k_D and k_L = Capital/Labor ratios in developed and LDC affiliates.

T = Technology effect.

S = Factor substitution effect.

TABLE 16

Capital Intensity Comparisons, Technology Selection, and Factor Substitution:
Developed Country vs. LDC Affiliates of U.S. Firms
CES Specification, 1970 Sample

Industry	Actual	Predicted			
		With Technology Selection Effect ($T \neq 1$)			No Technology Selection Effect ($T=1$)
	k_D/k_L	k_D/k_L	T	S	k_D/k_L
1. Food Products	1.62	1.37	0.86	1.59	1.55
2. Bakery Products	1.62	--	--	--	1.85
3. Textiles and Apparel	1.93	--	--	--	1.49
4. Paper and Pulp	0.85	1.05	0.72	1.44	1.39
5. All Chemicals	2.52	--	--	--	1.82
6. Industrial Chemicals	3.65	--	--	--	2.34
7. Drugs	1.81	--	--	--	1.31
8. All Chemicals <u>less</u> Drugs	2.44	--	--	--	2.01
9. Stone, Clay, Glass and Non-Met. Products	1.08	1.03	0.73	1.41	1.36
10. Fabricated Metals	1.27	--	--	--	1.07
11. Farm, Mining, and Industrial Equipment (FMI)	0.67	0.83	0.81	1.02	1.01
12. Industrial Equipment	0.75	--	--	--	2.34
13. Non-Electrical Machinery <u>less</u> FMI	1.10	--	--	--	1.37
14. Electrical Machinery	1.21	1.02	0.66	1.53	1.48
15. Radio, TV, and Electronics	0.97	--	--	--	1.35
16. Electrical Machinery <u>less</u> Radio, TV, & Elect.	1.36	1.01	0.62	1.63	1.56
17. Transportation Equipment	1.52	--	--	--	1.39

(--) Technology selection effect not significantly different from 1.
k_D and k_L = Capital/Labor ratios in developed and LDC affiliates.
T = Technology effect.
S = Factor substitution effect.

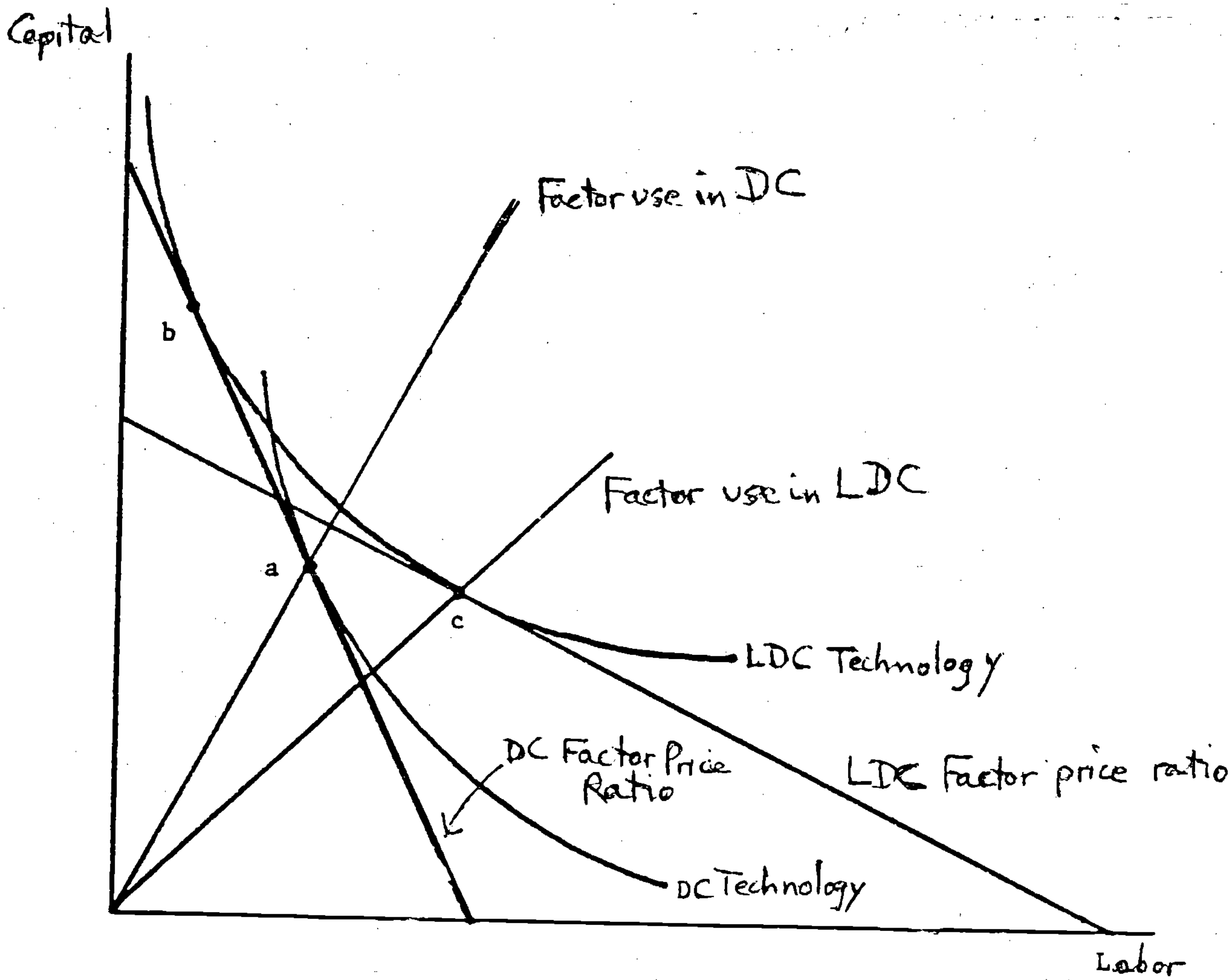

Figure 10

Representation of Empirical Results of Affiliates' Factor Substitution and Technology Selection Effects

The Chemical industry and its subsections, Drugs and Industrial Chemicals, are among the ones with higher capital labor ratios for DC affiliates. Since there is no selection of technology effect in these cases, the factor substitution effect alone explains the differences found.

The result that multinational firms use comparatively capital-intensive technology in less developed countries is a surprise. If the apparent choice of capital-intensive technology is genuine, it may be that the multinational firms are selecting technologies that reduce the need for skilled labor, scarce and expensive in LDC's, but can use large amounts of unskilled labor where it is cheap. This choice of capital-intensive technology may apply to the production process itself, but the affiliate may find it profitable to use unskilled labor extensively in ancillary activities. There has also been a good deal of evidence that exchange-control regimes in some LDC's have encouraged overinvestment in capital[9] although it is not clear that such overinvestment would show up

---

[9] See Bhagwati [1978], Chapter 5.

---

as choice of technology rather than factor use within a technology.

We should point out that the estimates of production functions here are made from data that are far from ideal, and the results may at least reflect the compromises made necessary by data inadequacies rather than the realities of technological choice. One problem is that our measures of technology and factor use are identical--both being capital stock per worker. That fact alone causes difficulties in making the distinction we are aiming at. Furthermore, the industries we deal with are very broad and it is likely that the nature of the activity differs substantially from country to country. The return to capital is calculated as the ratio of nonwage value added to the stock of capital and therefore suffers from all the defects of the value added including that mentioned in Appendix A and also the many vagaries of corporate accounting methods aimed at minimizing the tax burden. The estimates of labor cost, presumably far more reliable than the figures on returns to capital, are subject to the problem of our inability to distinguish among types of labor and therefore to distinguish those differences in payroll per worker that represent differences in quality from those that represent differences in the price of labor of some standard quality.

Choice of Factor Intensities by Multinationals and Host-Country Firms

Even if there is considerable adaptation among affiliates to differences in labor cost, U.S.-owned or other foreign-owned affiliates might fall short of the labor intensity of local firms. The affiliates might enjoy lower costs of capital than native firms through their parents' access to capital markets, particularly developed country capital markets. They might face a need to pay higher wages than native firms because of host-country government or union rules. Even if factor prices were identical to those paid by native firms, the foreign affiliate may select a more capital-intensive technology than a native firm because the foreign parent may be familiar with such technology from its home environment and find the costs of adapting the technology uneconomically high. In this section we attempt to measure the differences in capital intensities between U.S. affiliates and host-country firms.

Since our source of U.S. data for the previous section did not cover host-country firms other than affiliates, other sources had to be used. These did not provide data on individual firms, but only on aggregates by industry within each country, and the affiliate data were therefore aggregated to the same level for comparison. Country data were derived from the Growth of World Industry reports of the United Nations and from other sources.[10] The fact that each country's report has its peculiarities with respect to definitions, coverage, etc. may introduce some biases in our analysis.

[10] See Roldan [1978], Appendix I, Sections 2 and 3.

We make our comparisons between affiliates and host-country firms. The alternative would have been to compare affiliates with the domestic sector of the industry, defined as host country data minus affiliate data. We felt, however, that the first alternative would avoid the mixing of information obtained from different sources. Most of the variables used in the analysis are ratios of original categories of information (for example, the wage rate is calculated in our study as a ratio of payroll to employment, both of which are obtained from the same original country source) and a number of measurement errors are more likely to cancel out if the information comes from a common source. Thus, the conclusions of this section will deal basically with differences in factor intensities between affiliates and host-country firms instead of domestic firms, although inferences with respect to the last ones can be easily made.

Information on capital stock by host-country and industry is not available, precluding a direct comparison of capital-labor ratios between host-country firms and U.S. affiliates. The method followed here involves obtaining estimates for these capital-labor ratios by means of a production function approach. The available data allow the calculation of the price response (elasticity of substitution) and the factor intensity parameter of the technology. These two parameters, given the knowledge of the factor prices paid by affiliates and host-country firms, will be enough to calculate estimates of the factor intensities. This indirect method, however, does not solve all the problems. In particular, the exclusion of the rental cost of capital from the regressions, because of the lack of host-country data, introduces some estimate biases that need to be considered to assess the nature of the results obtained.

The regression model used in the following analysis is limited to the CES production function to allow for the possibility that elasticities of substitution could be different between affiliates and host-country firms.

Let us assume a CES production function,

$$V = A\ (sK^{-p} + (1-s)\ L^{-p})^{-v/p} \qquad (13)$$

where $\underline{V}$ is value added, $\underline{K}$ denotes capital stock and $\underline{L}$ employment. The parameters $\underline{A}$, $\underline{s}$, $\underline{p}$, and $\underline{v}$ correspond to the efficiency, factor intensity, substitution and scale parameters, respectively. Let $\underline{w}$ and $\underline{r}$ be the wage rate and the rental cost per unit of capital respectively.

Applying cost minimization conditions to expression (13) we obtain,

$$\frac{K}{L} = \left(\frac{s}{1-s}\right)^{\frac{1}{1+p}} \left(\frac{w}{r}\right)^{\frac{1}{1+p}} \tag{14}$$

In the process, the scale parameter has dropped out, meaning that condition (14) is independent of the degree of returns to scale. From (14) it is clear how s is the capital intensity parameter: given a factor price ratio and the value for the elasticity of substitution $\frac{1}{1+p}$ (denominated as σ **hereafter**), the larger s is, the larger K/L will be. **The factor intensity of the technology described by the CES production function is given by the expression**

$$\left[\frac{s}{1-s}\right]^{\sigma} \tag{15}$$

showing that it also depends on the particular value of the elasticity of substitution.

The technological parameters in (14) can be empirically estimated from the formulation

$$\ln \frac{rK}{L} = \sigma \ln \frac{s}{1-s} + \sigma \ln w + \mu \tag{16}$$

that is derived from the cost minimization conditions given by expression (14).

The rental cost of capital r should have entered equation (16) as the denominator in the term for labor cost, but it has been omitted because we lack data for host countries. This omission will introduce a negative bias in the estimator of the elasticity of substitution if the true value of σ is less than one and the coefficient in the regression of ln r on ln w is negative.[11]

[11] See Roldan [1978], Appendix II.

The relative difference in the capital labor ratios between affiliates and host country firms, assuming that the rental cost of capital is similar for both of them, will be given by the expression:

$$\frac{k_a}{k_c} = \frac{\left(\frac{s}{1-s}\right)_a^{\sigma_a}}{\left(\frac{s}{1-s}\right)_a^{\sigma_a}} \cdot \frac{w_a^{\sigma_a}}{w_b^{\sigma_b}} \tag{17}$$

where the subindexes a and c denote affiliate and host country firms, and the technological parameters are estimates obtained from regression analysis.

The difference in capital labor ratios k_a/k_c can be interpreted as the product of two effects: the technology choice effect, T, given by the expression:

$$T = \frac{\left(\frac{s}{1-s}\right)_a^{\sigma_a}}{\left(\frac{s}{1-s}\right)_c^{\sigma_c}} \tag{18}$$

and by a factor substitution effect, S, given by the expression:

$$S = \frac{\left(\frac{w}{r}\right)_a^{\sigma_a}}{\left(\frac{w}{r}\right)_c^{\sigma_c}} \tag{19}$$

Imposing profit maximizing conditions on a CES production function and assuming constant returns to scale we obtain an alternative equation to estimate the elasticity of substitution:

$$\ln \frac{V}{L} = \text{constant} + \sigma \ln w \qquad (20)$$

The variable for product price that should have entered as a divisor in the term for labor costs has been omitted because we lack information. The bias introduced by this omission will be positive if prices and wages are positively correlated across countries.

The empirical analysis has been conducted for the industries and years for which a relatively large number of matching observations could be obtained from country sources and the U.S. Department of Commerce surveys of direct investment abroad (see Table 17).

The results for the estimation of the elasticities of substitution for affiliates and host-country firms are presented in Table 17, along with results of the Chow test to determine whether the functions differ between country and affiliate data. In eight out of the ten equations the point estimates for the elasticity of substitution are higher for the affiliate data than for country data. This result could be taken as supporting the thesis that multinational firms have more flexibility in the choice of techniques of production than their domestic counterparts. However, the Chow test in Table 17 shows that only for Food Products 1966 is it possible to reject the hypothesis that the affiliate and the country regression have similar parameters. This should be interpreted cautiously because it refers to the joint action of all the parameters involved in the regression, and it is possible that each parameter could be different for the two regressions, but their combined effects are not statistically different.

TABLE 17

Regressions Estimating Elasticities of Substitution in Affiliates (A) and Host-Country Firms (C)
$\ln V/L = \text{constant} + \sigma \ln w$

Industry	Sample	Constant	σ	$\bar{R}^2$	F	No. obs.	Chow test
Food Products 1966	A	-1.285	0.695	.830	103.48	22	13.36**
		(3.06)	(10.17)				
	C	-1.494	0.602	.724	56.07	22	
		(2.85)	(7.48)				
Beverages 1966	A	1.684	1.082	.658	31.77	17	2.63
		(1.53)	(5.63)				
	C	-1.426	0.566	.579	22.99	17	
		(1.92)	(4.79)				
All Chemicals 1966	A	-1.613	0.595	.317	11.19	23	3.57*
		(1.55)	(3.34)				
	C	-0.951	0.670	.789	83.46	23	
		(2.11)	(9.13)				
Electrical Machinery 1966	A	-2.144	0.563	.564	25.54	20	3.57*
		(3.14)	(5.04)				
	C	-1.957	0.562	.759	60.86	20	
		(4.30)	(7.80)				
Food Products 1970	A	-2.880	0.412	.194	7.26	27	4.37*
		(3.14)	(2.69)				
	C	-1.268	0.630	.663	52.24	27	
		(2.25)	(7.22)				
Paper 1970	A	-0.140	0.842	.505	22.40	22	1.88
		(0.13)	(4.73)				
	C	-1.962	0.509	.660	41.78	22	
		(4.27)	(6.46)				

(concluded)

TABLE 17 (concluded)

Industry	Sample	Constant	σ	$\bar{R}^2$	F	No. obs.	Chow test
All Chemicals 1970	A	-0.600	0.748	.294	11.01	25	0.83
		(0.47)	(3.31)				
	C	-0.761	0.694	.858	145.88	25	
		(2.22)	(12.07)				
Other Chemicals 1970	A	-0.268	0.830	.584	24.83	18	4.60*
		(0.28)	(4.98)				
	C	-1.479	0.564	.581	24.58	18	
		(2.11)	(4.95)				
Electrical Machinery 1970	A	-0.962	0.754	.721	63.03	25	3.98*
		(1.71)	(7.93)				
	C	-1.670	0.595	.477	22.87	25	
		(2.15)	(4.78)				
Non-Electrical Machinery 1970	A	0.362	0.948	.770	57.92	18	0.70
		(0.52)	(7.61)				
	C	-0.388	0.831	.853	99.42	18	
		(0.77)	(9.97)				

**Chow test significant at a 99% level.

*Chow test significant at a 95% level.

Table 18 presents for some industries estimates of the elasticity of substitution obtained with specification (16). These estimates differ as expected from the ones obtained with equation (20) because of the different biases they are subject to.

Tables 17 and 18 suggest that, a) estimates for equation (16) are lower than those for equation (20) for the same industries and, b) that elasticities of substitution estimated from affiliate data are higher than those from country data.

The direction of the biases will be determined by the correlation between ln w and ln r for equation (16) and ln w and ln p for equation (20). Rental cost of capital figures are not available for country data, nor product prices for either data set, but for affiliates we found that the rental cost of capital was not statistically different between developed and less developed countries, while wages differed between them.

The assumption that rental cost of capital is constant for affiliates, with wages varying across countries, implies that product prices must vary as wages do. In other words we can assume that prices and wages are positively correlated for the affiliate, while wages and rental cost are not correlated at all. Thus the affiliate elasticity estimates given by equation (16) would be unbiased while the ones given by equation (20) would be biased upwards.

As for the country firms, the very limited information given by Minhas [1963] on rates of returns for various industries in U.S., Canada, U.K., Japan and India suggests that in Japan and India, rates of return were larger or at least equal to those in the U.S., Canada and U.K., with the exception of the Non-Electrical Machinery Industry. This is obviously

TABLE 18

Regression Equations to Estimate Elasticity of Substitution and Factor Intensity for Affiliates (A), Host-Country Firms (C) and All Data Pooled (P)

$$\ln rK/L = \sigma \ln (s/1-s) + \sigma \ln w$$

Industry	Sample	$\sigma \ln s/(1-s)$	σ	$\overline{R}^2$	F	No. obs.	Chow test
Food Products 1966	A	-3.895	0.412	.267	8.66	22	
		(4.52)	(2.94)				
	C	-3.435	0.377	.298	9.91	22	
		(4.41)	(3.14)				
	P	-4.505	0.260	.090	5.23	44	16.34**
		(6.25)	(2.28)				
Beverages 1966	A	1.405	1.109	.486	16.13	17	
		(0.88)	(4.01)				
	C	-3.149	0.354	.098	2.74	17	
		(2.34)	(1.65)				
	P	-0.663	0.750	.360	19.59	34	2.35
		(0.65)	(4.42)				
All Chemicals 1970	A	-2.783	0.488	.035	1.86	25	
		(1.39)	(1.36)				
	C	-2.243	0.522	.580	34.17	25	
		(4.21)	(5.84)				
	P	-2.960	0.428	.133	8.53	50	1.79
		(3.50)	(2.92)				

(continued)

TABLE 18 (concluded)

Industry	Sample	ln s/(1-2)		$\bar{R}^2$	F	No. obs.	Chow test
Other Chemicals 1970	A	-1.960	0.670	.152	4.04	18	
		(1.04)	(2.01)				
	C	-3.084	0.369	.241	6.39	18	
		(3.43)	(2.52)				
	P	-3.967	0.266	.050	2.84	36	5.32*
		(4.26)	(1.68)				
Non-Electrical Machinery 1970	A	-0.301	0.978	.488	17.19	18	
		(0.22)	(4.14)				
	C	-2.305	0.654	.474	16.31	18	
		(2.36)	(4.03)				
	P	-1.310	0.809	.514	38.07	36	0.97
		(1.72)	(6.17)				

**Chow test significant at a 99% level.

*Chow test significant at a 95% level.

not hard evidence, but in absence of other alternatives, we can interpret it as suggesting that lower wages across countries are accompanied by higher rates of return. In other words, the correlation between r and w is negative, implying a downward bias in the equation (16) elasticity estimate for the country data. How prices are correlated with wages in a cross-country sample is not clear from the above since higher costs of capital are offset by lower wages. An hypothesis is that at the country level, prices are correlated with wages. A country with higher wages presumably has a higher standard of living and an output composition for a given industry with a larger share of more sophisticated and expensive goods. This hypothesis implies that the elasticity of substitution estimates from equation (20) for country data will be upwardly biased, as the estimates for the affiliate data are. Although we lack information on the extent of these biases the fact that they work in the same direction for equation (20) reinforces the presumption that the elasticities of substitution for host-country firms and affiliates do not differ.

Differences in capital-labor ratios. There are at least two alternative ways to proceed to the calculation of capital-labor ratios starting from specification (16). The first is to run separate regressions for affiliate and country data. A Chow test would indicate whether the regressions are significantly different or not. If the regressions are shown to be statistically different, we can proceed to introduce the point estimates of the parameters for affiliates and country data in expression (17) to calculate k_a/k_c and the technology (T) and substitution (S) effects. If the parameters for the affiliates and host-country firms are similar, the ratio k_a/k_c will correspond to the substitution effect S given in expression (19), with $\sigma_a = \sigma_c$. The common value for σ can be taken from the estimate of the pooled affiliate and host-country regression.

The results for these calculations are given in Tables 18 and 19. The poor fit of equation (16) shows in that estimates were obtained only for five industries. The Chow test in Table 18 shows that for two cases the functions are statistically different. For these two industries, Table 19 shows the choice of technology effect T smaller than 1, meaning that affiliates use a more labor-intensive technology than host-country firms. However, the factor substitution effect S is larger than 1 for two reasons. First, the value of the point estimates for the elasticity of substitution appears to be higher for affiliates than for host-country firms (0.41 versus 0.37 for Food Products and 0.67 versus 0.37 for Other Chemicals). Second, affiliates face higher wages on average: \$3,260 for affiliates versus \$2,031 for host-country firms in the Food industry, and \$4,723 versus \$3,330 in the Other Chemicals industry (Table 20). As Table 19 shows, this brings k_a/k_c close to 1 for the Food Products industry. Thus the equation predicts that on the average, affiliates will use techniques characterized by the same capital labor ratio as host-country firms. In three other industries shown in Table 19, for which the Chow test shows the functions do not differ significantly between affiliates and host countries, the substitution effect S, and hence k_a/k_c, is larger than 1, reflecting the fact that affiliates pay higher wages on average than host-country firms.

TABLE 19

Affiliates (A) and Host Countries (C) Estimated Relative Capital-Labor Ratios, Technology (T) and Substitution Effects, from Equation

$$\ln rK/L = \sigma \ln (s/1-s) + \sigma \ln w$$

Industry	k_a/k_c	T	S
Food Products 1966	0.99	0.63	1.59
Beverages 1966	1.33	1.00[a]	1.33
All Chemicals 1970	1.20	1.00[a]	1.20
Other Chemicals 1970	7.55	0.52	14.52
Non-Electrical Machinery 1970	1.31	1.00[a]	1.31

[a] Chow test shows production functions not significantly different.

TABLE 20

Labor Costs Averages for Affiliates and Host-Country Firms

(U.S. $ thousands)

Industry	Affiliates	Host Countries
Food Products 1966	3,260	2,031
Beverages 1966	3,494	2,377
All Chemicals 1966	4,115	3,251
Electrical Machinery 1966	3,776	2,228
Food Products 1970	3,985	2,356
Paper 1970	6,210	3,920
All Chemicals 1970	5,313	3,446
Other Chemicals 1970	4,723	3,330
Electrical Machinery 1970	4,196	2,845
Non-Electrical Machinery 1970	5,589	4,006

Source: Roldan [1978], Appendix II.

The second alternative way of calculating the k_a/k_c ratios is to assume from the start that the elasticities of substitution of affiliates and host country firms are similar. This similarity has been suggested above, in the section analyzing this parameter. This assumption is equivalent to assuming that the only difference between the affiliate and host country production function can arise from the factor intensity parameter. We can proceed to test the difference between the two production functions by introducing a dummy variable in the pooled regression of affiliates and host countries. The cost minimizing expression for the capital labor ratio (14), becomes:

$$\frac{K}{L} = \left[\frac{s}{1-s} \cdot EXP^{\alpha D}\right]^{\sigma} \left[\frac{w}{r}\right]^{\sigma} \qquad (14')$$

and the regression equation (16),

$$\ln \frac{rK}{L} = \sigma \ln \frac{s}{1-s} + \beta D + \sigma \ln w \qquad (16')$$

where D is a dummy variable taking the value 1 for affiliate' observations and 0 for country observations. The coefficient for the dummy variable β, equals α times σ. The expression for k_a/k_c will become,

$$\frac{k_a}{k_c} = EXP\ (\beta)\ \left(\frac{w_a}{w_c}\right)^{\sigma} \qquad (17')$$

where the choice of technology effect T = EXP (β) and the factor substitution effect S = $(w_a/w_c)^{\sigma}$. The parameter β is a direct test for the existence of the technology choice effect; if β is statistically not different from zero, T will equal 1.

The regression results are presented in Table 21. The coefficient for the dummy variable is statistically not significant in four cases, implying that T equals 1. Three of these cases were analyzed with the first estimation method, reaching the same conclusion (See Table 19). The fourth industry shows the dummy coefficient to be statistically not different from zero. Table 21 also shows the elasticity estimates as being not statistically significant in two cases. These results can be explained by the downward bias that afflicts the estimates obtained from equation (20). The fact that the estimates for σ are found to be not statistically different from zero raises problems of interpretation for β, the coefficient of the dummy variable--since it is defined as the product of α times σ--for the three industries mentioned. For this reason we have opted not to present estimates for k_a/k_c for these industries.

Table 22 presents the results for the technology (T) and substitution (S) effects and the product of the two, the k_a/k_c estimates, for the remaining industries. The choice of technology effect is smaller or at the most equal to 1, indicating that multinational firm affiliates tend to utilize technologies of capital intensity lesser than or equal to that of host-country firms. This conclusion is also supported by Table 19, where the estimates for T are very similar, and by the Leipziger [ ] study. The substitution effect S works in the predicted direction, making affiliates relatively more capital intensive than host-country firms, given the common value for σ and the higher wages paid by the affiliates.

TABLE 21

Regression Equations to Estimate Elasticity of Substitution and Factor Intensity for Affiliates and Host-Country Firms, Pooled with Dummy Term

$\ln rK/L = \sigma \ln s/(1-s) + \beta D + \sigma \ln w$

Industry	$\sigma \ln s/(1-s)$	β	σ	$\bar{R}^2$	F	No. obs.
Food Products 1966	-3.364 (5.84)	-0.676 (5.78)	0.388 (4.39)	.486	21.3	44
Beverages 1966	-1.326 (.89)	0.025 (.08)	0.645 (2.80)	.205	4.74	34
All Chemicals 1966	-2.881 (3.56)	-0.407 (2.87)	0.431 (3.27)	.227	7.61	46
Electrical Machinery 1966	-5.621 (6.75)	-0.458 (2.99)	0.094 (.702)	.153	4.51	40
Food Products 1970	-3.989 (4.98)	-0.605 (3.43)	0.281 (2.27)	.179	6.75	54
Paper 1970	-3.317 (3.07)	-0.200 (.95)	0.387 (2.09)	.066	2.45	44
All Chemicals 1970	-2.305 (2.58)	-0.349 (1.90)	0.512 (3.43)	.178	6.32	50
Other Chemicals 1970	-2.557 (2.71)	-0.604 (3.15)	0.455 (2.98)	.248	6.76	36
Electrical Machinery 1970	-4.309 (4.06)	-0.489 (2.54)	0.286 (1.68)	.103	3.82	50
Non-Electrical Machinery 1970	-1.597 (1.88)	0.196 (.92)	0.774 (5.52)	.516	18.59	36

TABLE 22

Estimated Relative Capital-Labor Ratios, Technology (T) and Substitution (S) Effects for Affiliates (A) and Host Countries (C)

$$\ln rK/L = \sigma \ln (s/1-s) + \beta D + \sigma \ln W$$

Industry	k_a/k_c	T	S
Food Products 1966	0.61	0.509	1.202
Beverages 1966	1.28	1.000	1.282
All Chemicals 1966	0.74	0.666	1.106
Food Products 1970	0.63	0.546	1.159
All Chemicals 1970	1.25	1.000	1.248
OtherChemicals 1970	0.64	0.547	1.172
Non-Electrical Machinery 1970	1.29	1.000	1.294

With respect to the elasticities of substitution, the main result appears to be the absence of statistically significant differences in the estimates. Although the magnitude of the biases to which those estimates could be subject might affect this conclusion, we have pointed out that at least in one of the estimation equations (equation (20)) the direction of the biases that could be present are similar for both data set. This fact would tend to further support the notion of similarity of the elasticities of substitution between affiliates and host-country firms.

When predicted differences in factor intensities are viewed as the product of a choice of technology effect and a factor substitution effect, multinational firm affiliates are shown to utilize technologies of lesser or equal capital intensity than host-country firms. However, the substitution effect is always larger than 1, making affiliates relatively more capital intensive than host-country firms, given the common (or larger for the affiliates) value for the elasticity of substitution, and more importantly, the higher wages paid by affiliates. Thus the higher estimated capital intensities of affiliates are attributed entirely to higher wages and, in a few cases, higher elasticities of substitution, but not at all to their choice of technology.

Results of Other Studies

The study most similar to ours was that of Courtney and Leipziger [1975] who used the same data on U.S. affiliates abroad. As already noted, their study concentrated on the issue of separating observed differences in capital intensity between affiliates in developed countries and those in LDC's (k_1 and k_3 in Figure 3) into the unobserved differences in the choice of technology (k_1 and k_2), or "ex ante substitution" in their terms, and the unobserved substitution within the chosen technology (k_2 and k_3), or "ex post substitution." Courtney and Leipziger assumed two technologies in each industry, one for developed country affiliates and one for affiliates in LDC's, instead of the many that we allowed for.

Their results contained some of the same puzzling findings as those of our production functions. They found significant differences in technology between affiliates in developed countries and those in LDC's in 6 out of 11 industries and in three of these it was the affiliates in LDC's that were using the more capital-intensive technology: that is, they were using, by the authors' interpretation, more capital-intensive plant designs. However, the response to lower labor costs in LDC's was so large that even industries using more capital-intensive technologies in LDC's ended up with comparatively labor-intensive production there. Since the most capital-intensive technologies in LDC's, relative to developed countries, were associated with the highest elasticities of substitution, there is a question, as in our own results, as to whether the authors were really successful in separating the choice of technology or plant design from the response to factor prices.

Other studies of factor use in multinational firms' operations in LDC's have been mainly case studies of particular industries or groups of plants. On the whole, the results have been inconclusive, with some reporting extensive adaptation and others virtually none. Since adaptation is not always clearly defined, or the definitions differ among studies, and since most studies refer to narrow segments of industry, it is not certain whether they contradict each other or simply observe actual differences in behavior among industries or countries.

A study by Morley and Smith [1974] examined the choice of technology by multinational firms in Brazil, largely on the basis of interviews and the authors' views rather than any substantial statistical evidence on the operation of plants. Their main conclusion was that there were very large differences in technology between the U.S. firms at home and their affiliates in Brazil. However, they explained the difference as an adaptation to differences in the scale of production rather than in relative factor prices. They argued that the production function is not homothetic and that at any factor prices small-scale production would be relatively labor intensive and large-scale production capital intensive.

It is worth mentioning that a major role for scale in determining factor proportions does not preclude a role for factor costs in adaptation even if there is no response to factor prices at a given level of production. It may be only the cheapness of labor in LDC's that permits the existence of small, labor-intensive plants which could not survive in the high labor-cost environment of the developed countries. The amount of protection required to sustain small-scale, labor-intensive production may be much less in an LDC, with low wages, than in a developed country with its high wage levels. The adaptation by multinational firms may thus be attributable to both the smallness of LDC markets and the low labor costs.

Examples of adaptation in the sense of both selection of stages of production and selection of production techniques were found in a study by Finan [1975] of U.S. direct investment and technology transfer in the semi-conductor industry. American firms tended to place the labor-intensive assembly stage of production in low-wage foreign countries, while confining the more capital-intensive and technology-intensive wafer fabrication stage to the United States and to affiliates in developed countries. However, within the assembly stage, production was more capital-intensive in the United States than abroad. A substantial number of automated assembly lines were in operation in the United States, but none in foreign operations.

Cohen [1975], in a study of foreign- and locally-owned plants in Taiwan, South Korea, and Singapore, not identified by industry, found the foreign firms more mechanized than local firms in Taiwan but not consistently so in the other two countries. No generalization seems possible from the data he presents. Outside of his sample of firms supplying statistical data on mechanization, he reported his impression that General Electric and Philips were more capital-intensive than local firms in radio manufacturing, although Philips did adapt somewhat to local conditions. National Semiconductor and Texas Instruments were producing integrated circuits using very automated techniques in these countries, a fact that he interprets as lack of adaptation although he presents no comparison with home country methods of production. The finding from his questionnaires that there was little or no difference between foreign and locally-owned firms in several industries presumably implies adaptation by the foreign-owned firms relative to their home-country production.

In a study comparing 14 U.S.-owned operations with locally-owned counterparts spread over nine industries in the Philippines and Mexico Mason [1971] found that U.S. firms used more total capital assets and more buildings but nor more equipment per employee than local firms. By measures of the flow of capital and labor services the difference was not significant, although it was in the expected direction.

Wells [1975], comparing foreign-owned with domestically-owned plants in Indonesia, reported that the former almost all used what he classified as "capital-intensive" technology, and the latter almost all "intermediate" or "labor-intensive" technology. No ratios of capital to labor input were used, but he defined the characteristics of each level of technology for each of his six industries: cigarettes, flashlight batteries, soft drinks, tires, woven bags, and plastic sandals. He attributed the differences to presumably lower capital costs and much higher wages for the foreign companies. The wage differences, for "comparable jobs...in each industry," were particularly striking between foreign and domestic firm costs of unskilled labor, with the foreign firms paying wages about 2 1/2 times those of private domestic firms.

Conclusions

The purpose of our investigation was to learn whether multinational firms responded to differences among countries in labor cost by using more labor-intensive methods of production in low-wage countries. We found that for both Swedish and U.S. multinational firms, parent company or home country capital intensities of production, as measured by total assets per worker or by fixed assets alone, were higher than those of affiliates in developed countries and that these in turn were higher than those of affiliates in less developed countries. These differences were not the result of industry selection; in fact in some cases it was capital-intensive industries which tended to invest abroad, particularly in less developed countries.

Among countries in which affiliates were located, higher labor costs were associated with higher capital intensities of affiliates in the aggregate for all manufacturing and within manufacturing industries. Some of the relation for manufacturing as a group represented a tendency for affiliates in labor-intensive industries to settle in low-wage countries but the main element was the relation of capital intensity to wage levels within industries.

Within individual companies there is again a strong effect of labor cost on capital intensity. Some of the intra-industry effect noted above was the result of selection among companies, more labor-intensive companies being more attracted to low-wage countries. However, the main intra-industry effect was the result of adaptation within companies. We also found, in the data for individual companies, a strong effect of scale of operations on capital intensity when that was defined as property, plant and equipment per worker. Scale had very little effect, and sometimes a negative one, on capital intensity measured by total assets per worker.

We attempted with the use of fitted production functions to separate capital intensity differences among affiliates into differences in the choice of technology and those in the method of operation within each technology. We found that multinational firms appeared to choose more capital-intensive technologies in low income countries but then to operate them in a more labor-intensive manner than in higher-income countries to such a degree as to more than offset the capital intensity of the technology itself. This choice seems paradoxical and we are far from certain as to our ability to distinguish between technology choices and methods of operation within any technology. This is especially true because we are operating with data not collected with a view to making such distinctions.

Our attempt to use production functions to study differences between U.S. affiliates and native firms in host countries produced similarly surprising results. U.S. affiliates were found to use technologies of the same capital intensity as native firms or even lower capital intensity. They nevertheless operated in a more capital-intensive way, partly because their elasticities of substitution were higher than those of native firms but mainly because they faced higher labor costs.

APPENDIX A

Effect of Protection on Measured Economies of Scale When Value Added is Used as the Production Measure

The observed value added $\overline{V}$ equals the true value added V (value of services of production factors measured at zero effective protection level) plus a surplus derived from protection. We chose to describe it here as $T \cdot V$, where T is the rate of effective protection, i.e.,

$$\overline{V} = V(1+T) \tag{21}$$

The presumed regression model for the Cobb-Douglas production function is

$$\ln V = C + \alpha \ln K + \beta \ln L + u \tag{22}$$

The observed dependent variable will be

$$\ln \overline{V} = \ln V + \ln (1+T) \tag{23}$$

Replacing (23) in (22) would give the regression equation that would be correct to estimate

$$\ln \overline{V} - \ln (1+T) = C + \alpha \ln K + \beta \ln L + u \tag{24}$$

However, due to lack of information on T we estimate in fact the following expression

$$\ln \overline{V} = C + \alpha \ln K + \beta \ln L + v \tag{25}$$

the error term will now be

$$v = u + \ln (1+T) \tag{26}$$

Since the level of protection can be assumed to influence the employment of capital or labor, the error term will be correlated with the independent variables giving rise to a simultaneous equation type of bias.

The expression for the bias can be obtained as follows. In order to simplify the notation let us write expression (25) in deviation form (so we can ignore the constant term) as

$$Y = \alpha Z + \beta x + v \tag{27}$$

where $y = \ln \overline{VA}$, $Z = \ln K$ and $x = \ln L$ and v is given by expression (26). In general terms, for the equation $Y = X\beta + u$, the asymptotic bias will be given by the expression

$$\text{plim } (\hat{\beta}-\beta) = \text{plim } (\frac{1}{n} X'X)^{-1} \cdot \text{plim } (\frac{1}{n} X'u)$$

where $\hat{\beta}$ is the ordinary least squares estimator of β. Applying the formula for equation (27) we get

$$\text{plim } (\hat{\alpha}-\alpha) = \frac{b_{vz} - b_{vx}\, b_{xz}}{1-r^2_{xz}} \tag{28}$$

and

$$\text{plim } (\hat{\beta}-\beta) = \frac{b_{vx} - b_{vz}\, b_{zx}}{1-r^2_{xz}} \tag{29}$$

the returns to scale are measured by $h = \alpha+\beta$ and the asymptotic bias for it will be given by $\text{plim } ((\hat{\alpha}+\hat{\beta}) - (\alpha+\beta))$, i.e.,

$$\text{plim } (\hat{h}-h) = \frac{b_{vz}(1-b_{zx}) + b_{vx}(1-b_{xz})}{1 - r^2_{xz}} \tag{30}$$

where the terms b_{ij} denote the coefficient in the regression of the variable j on variable i (equation $i = a + bj$), and r_{xz} denotes the correlation coefficient between x and z.

The denominator in (30) is positive, then the sign of the bias will be given by the sign of the numerator. We know that $(1-b_{zx}) > 0$ and $(1-b_{xz}) > 0$. In order to advance further conclusions we need to make specific assumptions about b_{vz} and b_{vx}, i.e., on the correlation between the effective protection and the employment of capital and labor.

The case for $b_{vz} < 0$ and $b_{vx} < 0$ can be made for a particular industry having a cross-section of countries. If there are large economies of scale the industry could not exist in small countries without high protection. The smaller the country, the higher the level of protection needed. Then capital and labor input will be negatively related to the level of protection, i.e., $b_{vz} < 0$ and $b_{vx} < 0$.

REFERENCES

Cohen, Benjamin I. [1975], Multinational Firms and Asian Exports, Yale University Press, New Haven and London.

Courtney, William H. and Danny M. Leipziger [1975], "Multinational Corporations in LDC's: The Choice of Technology, Oxford Bulletin of Economics and Statistics, Vol. 57, No. 4, November.

Denison, Edward [1967], Why Growth Rates Differ, Brookings, Washington, D.C.

Finan, William [1975], "The International Transfer of Semiconductor Technology through U.S.-Based Firms," NBER Working Paper 118, December.

Harbison, Frederick and Charles A. Myers [1964], Education, Manpower, and Economic Growth, Macmillan, New York.

Kravis, Irving B., Alan W. Heston, and Robert Summers [1978a], United Nations International Comparison Project: Phase II; International Comparisons of Real Product and Purchasing Power, Johns Hopkins University Press, Baltimore and London.

_____ [1978b], "Real GDP Per Capita for More than One Hundred Countries," The Economic Journal, June.

Kravis, Irving B., Zoltan Kenessey, Alan Heston, and Robert Summers [1975], A System of International Comparisons of Gross Product and Purchasing Power, Johns Hopkins University Press, Baltimore and London.

Krueger, Anne O. [1968], "Factor Endowments and Per Capita Income Differences Among Countries," Economic Journal, 73, September.

Lary, Hal B. [1968], Imports of Manufactures from Less Developed Countries, NBER.

Leipziger, Danny M. [ ], "Production Characteristics in Foreign Enclave and Domestic Manufacturing: The Case of India," World Development, 4.

Mason, R. Hal [1971], The Transfer of Technology and the Factor-Proportions Problem: The Philippines and Mexico, UNITAR Research Report No. 10.

Minhas, Bagicha [1963], An International Comparison of Factor Costs and Factor Use, Amsterdam, North-Holland.

Morley, Samuel A. and Gordon W. Smith [1974], "The Choice of Technology: Multinational Firms in Brazil," Paper No. 58, Rice University Program of Development Studies, Fall.

McCabe, James and Constantine Michalopoulos [1971], "Investment Composition and Employment in Turkey," AID Discussion Paper No. 22, October.

Roldan, Romualdo [1978], "Multinational Corporations' Factor Intensities," University of Pennsylvania, dissertation.

Swedenborg, Birgitta [1973], Den svenska industrins investeringar i utlandet, Industriens Utredningsinstitut, Stockholm.

Sweden, Statistiska Centralbyran [1972a], Företagen 1970, Ekonomisk redovisning.

______ [1972b], Industri 1970, Del. 1 Data fördelade enligt Standard för svensk näringsgrensindelning (SNI).

______ [1976a], Företagen 1974, Ekonomisk redovisning.

______ [1976b], Industri 1974, Del. 1, Data fördelade enligt Standard för svensk näringsgrensindelning (SNI).

U.S. Department of Commerce [1972], Special Survey of U.S. Multinational Companies, 1970, Bureau of Economic Analysis.

______ [1975], U.S. Direct Investment Abroad, 1966: Final Data, Bureau of Economic Analysis.

Wells, Louis T., Jr. [1975], "Economic Man and Engineering Man: Choice of Technology in a Low-Wage Country," in The Choice of Technology in Developing Countries, Some Cautionary Tales, by C. Peter Timmer, John Woodward Thomas, Louis T. Wells, Jr. and David Morawetz, Center for International Affairs, Harvard University.