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FACTOR-PRICES AND FACTOR SUBSTITUTION
IN U.S. FIRMS' MANUFACTURING AFFILIATES ABROAD

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Factor Prices and Factor Substitution in U.S. Firms' Manufacturing Affiliates Abroad

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ABSTRACT

Using confidential individual firm data from the Bureau of Economic Analysis survey of U.S. firms' manufacturing operations abroad, we investigate the determinants of capital intensity in affiliate operations. Host country labor cost, the scale of host country production, and the capital intensity of the parent firm's production in the United States, are all significant influences. The parent's capital intensity is the strongest and most consistent determinant of affiliate capital intensity. Affiliates that export are more sensitive to these factors in their choice of factor proportions than affiliates that sell only in their host countries.

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Introduction

It has been observed for a long time that multinationals' manufacturing operations in developing countries are much more labor intensive than those in developed countries. Partly, the difference is due to the selection of industries; parts of labor-intensive industries have tended to migrate from developed countries to developing countries or expand more rapidly in developing countries. However, that is not the entirety of the response to differences in wage levels. Within industries, operations in developing countries are more labor-intensive. Even within a single firm, its affiliates in developing countries tend to operate in a more labor-intensive manner than the parent or affiliates in developed countries.

The purpose of this paper is to dissect the factor proportions differences we can observe among U.S. affiliates in a variety of countries into various types of adaptation to factor price differences. For this purpose we make use of the confidential individual firm data available at the Bureau of Economic Analysis of the U.S. Department of Commerce, which can be used only at the BEA by BEA employees.

The simplest form of adaptation would be that a firm operates a single technology, but uses different factor proportions in developing and developed countries, responding to the lower prices of labor in developing countries. Such an adaptation is represented in Figure A. Another possibility is that a firm has more and less capital-intensive technologies to choose from, or operates in both more and less capital-intensive industries, and chooses the less capital-intensive technology or industry in countries with low labor costs and the more capital-intensive one in locations where labor costs are higher. That form of adaptation is represented in Figure B. That figure could also represent a situation in which different firms in an industry operate with different technologies at home, and those firms using the more capital-intensive technology tend to operate affiliates in higher-income countries, while those using the more labor-intensive technology place affiliates in countries with low labor costs.

If production functions are not homothetic, another possibility is that, for example, firms might produce in a more labor-intensive way in a small country, where large plants or machines would be uneconomical, than in a large country. That would be most likely if the product was not readily

transportable, or if the country were isolated from world markets. The combination of substitution within technologies, substitution between technologies, and scale effects is illustrated in Figure C.

During the 1970s, the extent of adaptation by multinational firms was discussed in the development literature in connection with the fear that multinationals often used “inappropriate” technology in their developing country production. They did this supposedly out of ignorance of labor-intensive techniques, because their experience was gathered in developed countries, or because adapting technologies was too expensive. As a result, their entry into a developing country failed to make optimum use of the country’s abundant labor resources, particularly unskilled labor.

Among the studies at the time, Cohen (1975) found no adaptation in the production of integrated circuits, where highly automated techniques were used, even in poor countries. Courtney and Leipziger (1975) found that there were differences in factor intensity between U.S. affiliates in developing countries in some industries, but that in half the cases, it was those in developing countries that used the more capital-intensive techniques. Morley and Smith (1974) found in Brazil that there were large differences between capital intensities in affiliates there and those in the parent companies at home, but attributed them mainly to differences in scale rather than to differences in wage costs. Lipsey, Kravis, and Roldan (1982) examined U.S. and Swedish multinational operations across countries, using individual firm data, and reported responses of capital intensities to both wage levels and scales of production. Small scale production and low wage levels were associated with high labor intensity. The differences in labor intensities among U.S.-owned affiliates could have resulted from either differences in industry mix among affiliates of a firm or from adaptation within industries. The two could not be distinguished well because the industry categories were broad. However, the Swedish data showed strong responses within the more detailed industries in their data.

U.S. firms’ manufacturing affiliate operations in developing countries are much more labor intensive than those in developed countries, as would be expected given the lower wage levels in developing countries. There are several different ways in which this response to differences in labor cost might take place. One is that firms in capital-intensive industries might place their foreign affiliates in

developed countries, while those in labor-intensive industries might place their affiliates in developing countries. Another is that firms in the same broad industry might specialize in sub-industries with different capital intensities. Even within narrowly defined sub-industries, firms might differ in the capital intensity of their production, which we interpret as differences in their technology, and the capital-intensive firms may operate in developed countries and the labor-intensive ones in developing countries. Firms themselves may operate in several industries, and may choose to allocate their operations according to their capital intensities and country labor costs. Finally, even within a given industry, a firm's affiliates may operate at different points on a given isoquant, in response to differences in labor costs.

We try in this paper to sort out which of these responses to differences in labor costs is taking place, and consider how each of them may affect location choices and their impacts. The statistical analysis of firm-level data on U.S. multinational companies reported in this study was conducted at the International Investment Division, U.S. Bureau of Economic Analysis, under arrangements that maintained legal confidentiality requirements.

Individual Firm Data on Wages and Factor Use

The data we use are from the 1999 Benchmark Survey of U.S. Direct Investment Abroad. That survey, the answers to which are compulsory, asks a series of questions about each individual affiliate of U.S. parent firms, including employment, labor compensation, fixed capital, industry, sales, and many others. The industry for each parent and affiliate is the detailed NAICS industry according to the list in Appendix Table 1. Data at that level of industry detail are not published and can be used only within the BEA. The wage faced by an affiliate is the average wage per hour for production workers paid by affiliates in the same NAICS industry in the same country. When the foreign affiliate's assets, liabilities, revenues, and expenses were denominated or measured in a foreign currency, the survey instructions require that they be translated into U.S. dollars in accordance with U.S. Generally Accepted Accounting Principles, specifically Financial Accounting Standards Board Statement 52 (FAS 52). Under FAS 52, revenue and expense items, such as sales and labor compensation, are translated into U.S. dollars using a weighted average exchange rate for the period. Assets and liabilities are translated into U.S. dollars using

end of the period exchange rates. Various other wage measures would be feasible, such as the average wage for all manufacturing affiliates in the country, but the assumption behind this measure is that firms in the same industry as the affiliate are more likely to hire comparable workers. The capital input measure used is the net stock of plant and equipment, as reported for the individual affiliate.

The difference in the capital intensity of manufacturing affiliate production between parents and their affiliates in developing countries is large, as can be seen in Table 1. The average PP&E (net property, plant, and equipment) per worker in parent operations in the United States was about \$106 thousand, and it was \$57 thousand in majority-owned nonbank developing country affiliates of those parents. In the 13 broad industries for which we have data, the parents were more capital-intensive in 12, and by close to 100 per cent in seven of them. The differences between affiliates in developed and developing countries are also large. Average manufacturing affiliate capital intensity in 1999 was \$75 thousand in developed countries and \$40 thousand in developing countries. That large response, presumably to the lower wages in developing countries, is characteristic of manufacturing. In other industries as a group, capital intensities in affiliates in developing countries were higher than in developed countries. What cannot be discerned from aggregate data such as these is what form the response to wage differences takes, and that is what the individual firm data can help us to discover.

Table 1
Capital Intensities^a of Parents and Developing Country Affiliates,
By Industry of Parent, 1999

	Parents	Affiliates in Developing Countries
All Manufacturing	105.7	56.7
Food	153.2	64.2
Beverages and tobacco	143.2	63.9
Textiles and apparel	51.3	30.2
Paper	142.3	69.2
Chemicals	150.0	74.7
Plastics and rubber	62.6	56.8
Nonmetallic minerals	93.3	104.9
Primary and fabricated metals	89.1	79.7
Machinery	51.4	28.3
Computers and electronic products	77.0	39.2
Electrical equipment	50.2	22.1
Transportation equipment	67.9	44.7
Other manufacturing	47.1	23.4

^a Property, plant, and equipment per worker, in thousands of dollars

Affiliate Capital Intensities and Country Wage Levels

We begin by asking how capital intensities in affiliates that are in the same detailed industries as their parents are affected by two variables that differ among affiliates in different countries. One is the wage level the affiliate faces in its industry in a country. The other is the scale of operations of the affiliate. We use the gross product of an affiliate other than profits as a measure of its scale of production, omitting profit-type returns because they can be volatile and give negative production scale estimates. We expect the coefficient on this variable to be positive. This calculation does not attempt to distinguish among the several mechanisms for adjustment mentioned above. We would expect that in locations with higher wage levels, affiliates would produce in a more capital-intensive way. We would also expect that larger affiliates would tend to be more capital intensive, because the economical use of some capital goods requires some minimum level of output.

These expectations are tested in Table 2, where affiliate capital intensities in manufacturing as a whole and in fifteen broad industry groups are compared across all countries. Both suppositions appear correct for manufacturing as a whole and for about half of the industry groups, more for labor cost and less for scale. However, not much of the cross-country variation in capital intensity--only 4 per cent for manufacturing as a whole and up to 10 to 15 per cent among the industry groups--was explained by these two variables.

If the comparisons are confined to developing countries, as in Table 3, several industries drop out because there are not enough developing country observations. The response to labor cost is larger for manufacturing as a whole. In those industries for which the labor price coefficient is significant, the labor price coefficient is larger for affiliates in developing countries than it is for affiliates in all countries, but fewer industries show significant responses. Scale is not a significant influence among the developing countries, and only about 2 per cent of the variance in affiliate capital intensities is explained.

Table 2
Relation of Affiliate Capital Intensity^a to Price of Labor and Scale of Production
Affiliates in All Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	R ²	Observations	Probability>F-stat
All manufacturing	1.76***	0.17***	0.04	3,357	<0.0001
Food	1.54	-0.04	0.001	135	0.66
Beverages and tobacco	5.98***	-0.08	0.15	61	0.003
Textiles and apparel	0.69	-0.01	0.002	77	0.44
Paper	1.74	0.52***	0.11	124	0.0004
Printing and related activities	-0.79	-0.20	0.11	31	0.07
Chemicals	2.03***	0.09	0.02	923	0.0001
Plastics and rubber	-0.23	-0.09	0.001	222	0.60
Nonmetallic minerals	-0.85	0.17	0.0001	41	0.76
Primary and fabricated metals	1.99	0.58**	0.03	198	0.02
Machinery	0.39*	0.10***	0.03	331	0.002
Computers and electronic products	0.78**	0.19***	0.05	427	<0.0001
Electrical equipment	0.87*	0.09	0.02	111	0.11
Transportation equipment	0.76**	0.02***	0.05	447	<0.0001
Furniture and related products	-0.06	0.14	0.0001	32	0.93
Other manufacturing	0.73*	0.27	0.02	184	0.06

^a Net property, plant, and equipment per worker

^b Average wage paid by affiliates in that industry and host country

^c Gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Table 3

Relation of Affiliate Capital Intensity^a to Price of Labor and Scale of Production

Affiliates in Developing Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	R ²	Observations	Probability>F-stat
All manufacturing	3.04***	0.05	0.02	1,068	<0.0001
Food	8.96**	-0.02	0.06	43	0.11
Beverages and tobacco	2.01	0.08	0.0001	32	0.82
Paper	8.90**	0.09	0.06	50	0.10
Chemicals	2.09	0.36	0.01	372	0.10
Plastics and rubber	0.72	-0.16	0.001	60	0.75
Primary and fabricated metals	4.83	0.05	0.02	39	0.26
Machinery	1.10	0.05	0.02	65	0.20
Computers and electronic products	2.17**	0.11	0.04	155	0.02
Electrical equipment	0.99	0.01	0.0001	27	0.80
Transportation equipment	5.76***	0.04	0.11	143	0.0001
Other manufacturing	1.53	0.01	0.001	43	0.67

^a Net property, plant, and equipment per worker^b Average wage paid by affiliates in that industry and host country^c Gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

One of the ways in which we thought the adjustment to wage differences might take place is through the selection among parent firms, and their individual technologies, within industries, as described by Figure B, above. Even if no firm produced differently in low-wage and high-wage countries, low wage countries might attract affiliates of labor-intensive parent firms within each industry, and high-wage countries might attract affiliates of capital-intensive parent firms. Another possibility is that within any host country, affiliates of low-wage, possibly low labor-force-skill, parents would produce using low-wage labor. These possibilities are tested in Tables 4 and 5, where the capital intensity of the parent is added as an explanatory variable.

The addition of parent capital intensity raises the explanatory power of the equations substantially. Almost all the coefficients for that variable are significant, as are most of those for the price of labor. Across all countries, 17 per cent of the variance in affiliate capital intensities for manufacturing as a whole is explained, along with higher shares for some industry groups, several much higher. We interpret this result as showing that the selection among parents is important: more capital-intensive parents within an industry group tend to produce in a more capital-intensive way, in any country or to invest in higher-wage countries. That selectivity may reflect differences among sub-industries within these industry groups, or it could reflect individual firm characteristics even within the sub-industries. Taking account of parent selectivity also clarifies the relationship within firms of affiliate capital intensity to the price of labor, but somewhat reduces the influence of the affiliate's scale of production.

A similar analysis is performed on the affiliates located in developing countries in Table 5. The results are not quite as strong as those comparing across all countries, but the addition of parent capital intensity adds substantially to the degree of explanation of affiliate capital intensity, over 20 per cent in six of the industries. Parent capital intensity is almost always positively related to affiliate capital intensity. The number of industries showing significant relationships between the price of labor and affiliate capital intensity is smaller, and scale is not a significant influence.

Table 4

Relation of Affiliate Capital Intensity^a to the Price of Labor, Scale of Production, and Parent Capital Intensity

Affiliates in All Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	Parent capital intensity	R ²	Observations	Probability> F-stat
All manufacturing	1.67***	0.14***	0.55***	0.17	3,353	<0.0001
Food	1.57	0.02	0.56***	0.11	135	0.0003
Beverages and tobacco	5.90***	-0.11	0.63***	0.26	61	0.0001
Textiles and apparel	0.39	0.04	0.44***	0.38	77	<0.0001
Paper	2.04*	0.39**	0.12*	0.13	124	0.0003
Printing and related activities	-0.78	-0.20	0.08	0.12	31	0.10
Chemicals	2.09***	0.10	0.54***	0.18	923	<0.0001
Plastics and rubber	-0.19	-0.09	0.40***	0.05	220	0.002
Nonmetallic minerals	-1.04	0.11	0.50**	0.10	41	0.08
Primary and fabricated metals	2.16	0.53**	0.23*	0.04	196	0.01
Machinery	0.37*	0.07**	0.23***	0.11	331	<0.0001
Computers and electronic products	0.97**	0.16***	0.21***	0.09	427	<0.0001
Electrical equipment	1.02**	0.09	0.47***	0.16	111	0.0001
Transportation equipment	0.89***	0.01*	0.33***	0.13	447	<0.0001
Furniture and related products	-1.32	-0.17	1.23***	0.24	32	0.01
Other manufacturing	0.73*	0.27	-0.001	0.02	184	0.13

^a Net property, plant, and equipment per worker

^b Average wage paid by affiliates in that industry and host country

^c Gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Table 5

Relation of Affiliate Capital Intensity^a to the Price of Labor, Scale of Production, and Parent Capital Intensity

Affiliates in Developing Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	Parent capital intensity	R ²	Observations	Probability >F-stat
All manufacturing	2.39***	0.05	0.32***	0.11	1,068	<0.0001
Food	1.60	0.02	0.46***	0.42	43	<0.0001
Beverages and tobacco	-0.87	-0.27	0.76***	0.19	32	0.03
Paper	10.43**	-0.18	0.20	0.07	50	0.11
Chemicals	2.20	0.44*	0.35***	0.07	372	<0.0001
Plastics and rubber	0.62	-0.17	0.61	0.001	60	0.46
Primary and fabricated metals	4.12	-0.13	1.16***	0.26	39	0.004
Machinery	0.42	0.05	0.46***	0.24	65	0.0002
Computers and electronic products	2.37***	0.07	0.16***	0.09	155	0.001
Electrical equipment	1.34	0.02	0.35	0.001	27	0.52
Transportation equipment	5.45***	0.03	0.21***	0.15	143	<0.0001
Other manufacturing	1.47	-0.03	0.06	0.0001	43	0.83

^a Net property, plant, and equipment per worker

^b Average wage paid by affiliates in that industry and host country

^c Gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

In tables 6 and 7, we expand our interest to the operations of each firm's affiliates in all manufacturing industries, rather than only those in the narrowly defined main industry of the parent. A parent may have affiliates in several industries and one response to differences in labor costs among potential affiliate locations might be to place those affiliates that are in more labor-intensive industries in countries with lower labor prices.

The addition of the full range of manufacturing affiliates raises the number of affiliates in all countries (Table 6) by more than half in manufacturing as a whole. These affiliates outside the main parent industries were most important in Paper, Metals, Electrical equipment, and Transportation equipment. One effect of adding these affiliates in other industries was to reduce the explanatory power of the equations and the size of the labor price coefficients. The two main exceptions were Computers and electronic products, where both the degree of explanation and the labor price coefficient were higher for the all-industry affiliate equations, and Transportation equipment, where the labor price coefficient was much higher, but the degree of explanation was lower. One could interpret this result as indicating that parent firms in these two industries owned affiliates outside their main detailed industries that they allocated to locations in a way that took advantage of labor cost differences. Such allocation is another example of the choices shown in Figure B. In Electrical equipment, where the number of affiliates in all manufacturing industries was more than double the number in parents' main industries, the addition of the affiliates in other industries destroyed the explanation of affiliate capital intensity.

The same variables explain about the same share of the variance in capital intensities among developing countries for manufacturing as a whole, but less in the individual industry groups (Table 7). Chemicals were an exception, with higher coefficients for both wage levels and parent capital intensities, indicating strong responses in the capital intensities and selection of parents in the affiliates outside parents' main industries. In Transportation equipment, however, there seemed to be no response of affiliate capital intensities to wage differences when affiliates outside parent industries were added to the list, even though there had been a strong response among affiliates in parents' main industries.

Table 6

Relation of Affiliate Capital Intensity^a to the Price of Labor, Scale of Affiliate Production, and Parent Capital Intensity

Affiliates in All Countries in All Manufacturing Industries

Industry	Price of labor ^b	Scale ^c	Parent capital intensity	R ²	Observations	Prob>F-stat
All manufacturing	1.39***	0.10***	0.57***	0.15	5,308	<0.0001
Food	0.82	-0.06	0.54***	0.07	213	0.001
Beverages and tobacco	4.12***	0.004	0.66***	0.23	97	<0.0001
Textiles and apparel	0.40	0.07	0.44***	0.32	92	<0.0001
Paper	2.00***	0.26***	0.16***	0.12	234	<0.0001
Printing and related activities	-0.31	-0.20	0.08	0.004	36	0.38
Chemicals	1.82***	0.05	0.54***	0.11	1,390	<0.0001
Plastics and rubber	-0.19	-0.08	0.41***	0.05	292	0.0003
Nonmetallic minerals	-0.29	0.11	0.55***	0.09	70	0.03
Primary and fabricated metals	-0.18	0.32**	0.18**	0.02	378	0.02
Machinery	0.34	0.09**	0.24***	0.05	515	<0.0001
Computers and electronic products	1.45***	0.12**	0.43***	0.16	533	<0.0001
Electrical equipment	-1.88	-0.01	0.12	0.002	249	0.34
Transportation equipment	1.34***	0.001	0.62***	0.08	844	<0.0001
Furniture and related products	0.06	-0.42	1.09***	0.17	49	0.01
Other manufacturing	0.64*	0.40***	0.02	0.04	262	0.005

^a Net property, plant, and equipment per worker

^b Average wage paid by affiliates in that industry and host country

^c Gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Table 7

Relation of Affiliate Capital Intensity^a to the Price of Labor, Scale of Affiliate Production, and Parent Capital Intensity

Affiliates in Developing Countries in All Manufacturing Industries

Industry	Price of labor ^b	Scale ^c	Parent capital intensity	R ²	Observations	Prob>F-stat
All manufacturing	2.55***	0.04	0.50***	0.12	1,590	<0.0001
Food	1.29	-0.19	0.46**	0.03	77	0.14
Beverages and tobacco	-2.31	0.07	0.61***	0.16	44	0.02
Textiles and apparel	1.27	-0.46	0.51	0.001	19	0.43
Paper	6.34**	0.13	0.15	0.05	79	0.07
Chemicals	3.38***	0.34	0.47***	0.09	545	<0.0001
Plastics and rubber	1.48	-0.20	0.43	0.001	68	0.54
Primary and fabricated metals	3.66**	-0.06	0.91***	0.23	62	0.0004
Machinery	0.31	0.08	0.58***	0.24	104	<0.0001
Computers and electronic products	2.19***	0.09	0.15***	0.09	175	0.0002
Electrical equipment	-4.48	-0.44	-0.13	0.0001	60	0.90
Transportation equipment	0.29	0.02	0.46***	0.06	254	0.001
Other manufacturing	1.76	-0.23	0.09	0.001	61	0.67

^a Net property, plant, and equipment per worker

^b Average wage paid by affiliates in that industry and host country

^c Gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

If we fit log equations to the same sets of data and make the necessary assumptions about the nature of the production functions,¹ we can calculate elasticities of substitution between capital and labor (Table 8). Across all affiliate locations, the elasticity is 30 percent for affiliates in parents' main industries in manufacturing as a whole. The industry coefficients significant at the 1 per cent level or better, covering 9 of the 13 industries, with one exception, are higher, ranging from 32 to 55 per cent. Larger scale is also associated with higher capital intensity, overall and in most of the individual manufacturing industry groups. Parent capital intensity is significant in almost all industries, with elasticities indicating that a parent capital intensity higher by 10 per cent is associated with an affiliate capital intensity higher by 6 to 8 per cent in most industries. The log equations fit better than the corresponding arithmetic equations (Table 4), overall and in the individual industries.

If we confine the calculation to affiliates in developing countries alone (Table 9), fewer industries show evidence that affiliate operations in the parents' industries are more labor-intensive where the price of labor is lower. Where there is a significant response, it is stronger among the developing countries in most cases, especially in Computers and electronic products and in Transportation equipment. Parent capital intensity remains a strong influence on affiliate capital intensity.

¹ It must be assumed that the production functions have a constant elasticity of substitution between factors and that capital costs do not differ among countries.

Table 8

Log Equations Relating Affiliate Capital Intensity^a
To the Price of Labor, Scale of Affiliate Production, and Parent Capital Intensity

Affiliates in All Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	Parent capital intensity ^d	R ²	Observations	Prob>F-stat
All manufacturing	0.30***	0.12***	0.55***	0.24	3,344	<0.0001
Food	0.29***	0.10*	0.62***	0.28	135	<0.0001
Beverages and tobacco	0.55***	0.20**	0.53*	0.26	60	0.0002
Textiles and apparel	0.36**	0.19**	0.83***	0.41	77	<0.0001
Paper	0.51***	0.17***	0.44***	0.32	124	<0.0001
Chemicals	0.39***	0.16***	0.62***	0.21	918	<0.0001
Plastics and rubber	0.09	0.05	0.60***	0.08	220	0.0001
Nonmetallic minerals	0.04	0.14	0.76***	0.25	41	0.004
Primary and fabricated metals	0.14	0.02	0.67***	0.21	196	<0.0001
Machinery	0.02	0.15***	0.35***	0.14	331	<0.0001
Computers and electronic products	0.32***	0.21***	0.20***	0.14	425	<0.0001
Electrical equipment	0.54***	0.21***	0.73***	0.35	110	<0.0001
Transportation equipment	0.40***	-0.01	0.76***	0.23	447	<0.0001
Other manufacturing	0.46***	0.14**	-0.05	0.10	184	0.0001

^a Log of net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

^d Log of parent net property, plant, and equipment per worker

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Table 9

Log Equations Relating Affiliate Capital Intensity^a
To the Price of Labor, Scale of Affiliate Production, and Parent Capital Intensity

Affiliates in Developing Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	Parent capital intensity ^d	R ²	Observations	Prob>F-stat
All manufacturing	0.29***	0.09***	0.56***	0.18	1,065	<0.0001
Food	-0.09	0.08	0.98***	0.40	43	<0.0001
Beverages and tobacco	0.48	0.12	0.93**	0.21	31	0.03
Paper	0.84***	0.30**	0.09	0.27	50	0.001
Chemicals	0.23**	0.17***	0.74***	0.17	370	<0.0001
Plastics and rubber	-0.10	0.10	0.65	0.01	60	0.34
Primary and fabricated metals	-0.02	0.08	1.08***	0.29	39	0.002
Machinery	0.06	0.11*	0.57***	0.23	65	0.0003
Computers and electronic products	0.63***	0.10	0.27***	0.17	155	<0.0001
Electrical equipment	0.45	0.002	1.22***	0.31	27	0.01
Transportation equipment	0.66***	-0.09*	0.68***	0.16	143	<0.0001
Other manufacturing	0.46	0.02	-0.03	0.0001	43	0.59

^a Log of net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

^d Log of parent net property, plant, and equipment per worker

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

If we relate the same independent variables to capital intensities in all manufacturing affiliates of each parent, rather than only those in the parent's main industry, we increase the number of affiliates by more than half and get the relationships shown in Tables 10 and 11. For affiliates in all countries (Table 10), the coefficients for the price of labor are mostly similar to those for affiliates in the parents' industries, except that the elasticity in Textiles and apparel is much higher and those in Paper and Electrical equipment are much lower. Most of the effects of adding affiliates not in their parents' main industries in developing countries are similar to those for all countries. One exception is Transportation equipment, where the elasticity of response to the price of labor is reduced to insignificance.

Table 10

Log Equations Relating Affiliate Capital Intensity^a
To the Price of Labor, Scale of Affiliate Production, and Parent Capital Intensity

Affiliates in All Countries in All Manufacturing Industries

Industry	Price of labor ^b	Scale ^c	Parent capital intensity ^d	R ²	Observations	Prob>F-stat
All manufacturing	0.27***	0.11***	0.62***	0.24	5,298	<0.0001
Food	0.34***	-0.01	0.59***	0.20	213	<0.0001
Beverages and tobacco	0.44***	0.20***	0.58***	0.29	96	<0.0001
Textiles and apparel	0.55***	0.16	0.74***	0.39	92	<0.0001
Paper	0.36***	0.20***	0.46***	0.27	234	<0.0001
Chemicals	0.31***	0.13***	0.63***	0.17	1,385	<0.0001
Plastics and rubber	0.08	0.07*	0.71***	0.12	292	<0.0001
Nonmetallic minerals	0.09	0.21**	0.76***	0.24	70	0.0001
Primary and fabricated metals	-0.06	0.04	0.56***	0.13	378	<0.0001
Machinery	0.09	0.15***	0.35***	0.12	515	<0.0001
Computers and electronic products	0.30***	0.18***	0.30***	0.15	531	<0.0001
Electrical equipment	0.30***	0.14***	0.61***	0.22	247	<0.0001
Transportation equipment	0.35***	0.03	0.80***	0.16	844	<0.0001
Other manufacturing	0.41***	0.17***	0.01	0.11	262	<0.0001

^a Log of net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

^d Log of parent net property, plant, and equipment per worker

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Table 11

Log Equations Relating Affiliate Capital Intensity^a
To the Price of Labor, Scale of Affiliate Production, and Parent Capital Intensity

Affiliates in Developing Countries in All Manufacturing Industries

Industry	Price of labor ^b	Scale ^c	Parent capital intensity ^d	R ²	Observations	Prob>F-stat
All manufacturing	0.29***	0.06***	0.67***	0.20	1,586	<0.0001
Food	0.17	-0.08	0.77***	0.19	77	0.0004
Beverages and tobacco	0.34	0.13	0.95**	0.24	43	0.004
Paper	0.61***	0.21**	0.19	0.19	79	0.0003
Chemicals	0.21**	0.13***	0.84***	0.18	543	<0.0001
Plastics and rubber	0.07	0.08	0.68	0.02	68	0.25
Primary and fabricated metals	0.06	0.05	1.03***	0.25	62	0.0002
Machinery	0.12	0.09	0.61***	0.15	104	0.0002
Computers and electronic products	0.58***	0.11*	0.25***	0.16	175	<0.0001
Electrical equipment	0.44*	0.09	1.08***	0.33	59	<0.0001
Transportation equipment	0.21	-0.05	0.84***	0.09	254	<0.0001
Other manufacturing	0.59**	-0.03	0.02	0.02	61	0.24

^a Log of net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

^d Log of parent net property, plant, and equipment per worker

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Putting aside the dominant role that the parent's capital intensity often plays in the affiliate's capital intensity, we can try to isolate the capital-labor substitution that occurs among the affiliates of a firm in response to local circumstances, the price of labor and the scale of production. To do this, we fit log equations relating the ratio of the affiliate's capital intensity to its parent's capital intensity, a measure of the adaptation within the individual firm, to host country labor cost and affiliate scale, as in Figure C, above.

Table 12 shows the results for only those affiliates in the same detailed industry as the parent in all countries. The elasticity for the ratio is a little higher than for the affiliate capital intensity itself, in Table 8. Affiliates in higher wage countries are more like their parents in capital intensity than those in low wage countries. Affiliate scale is also significant in about half the industries. The difference between the degree of explanation of the variance in Table 8 and that in Table 12 is an indication that about three quarters of the differences in capital intensities across affiliates in all countries can be accounted for by differences in parent capital intensity and about one quarter by host country differences in the price of labor.

For affiliates in developing countries only, Table 13 shows the results of the same within- firm adjustment to differences in labor cost and scale. The elasticity of response to host-country labor cost is lower in developing countries than across all countries, and lower also relative to parent capital intensity than when parent capital intensity is treated as a separate influence (Table 9). Less of the variance in affiliate capital intensities is explained, indicating that parent capital intensity plays a larger role in developing countries relative to host country wage levels. Thus, a large part of the results reported in Table 12 involves the comparison between developed and developing countries. There are a few industries where there is a large response to host country wage levels across developing countries, particularly Paper, Computers and electronic products, and Transportation equipment.

Table 14 shows the results of the within firm adjustment to differences in labor cost and scale for all manufacturing affiliates, including those outside the parents' main industries, located in all countries. Mostly, the elasticities are a little smaller for affiliates in all industries, but there are two exceptions,

Table 12

Log Equations Explaining the Ratio of Affiliate to Parent Capital Intensity^a

To the Price of Labor and the Scale of Affiliate Production

Affiliates in All Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	R ²	Observations	Prob>F-stat
All manufacturing	0.32***	0.09***	0.07	3,344	<0.0001
Food	0.28**	0.11*	0.08	135	0.001
Beverages and tobacco	0.55***	0.17**	0.19	60	0.001
Textiles and apparel	0.34**	0.20**	0.13	77	0.002
Paper	0.64***	0.09	0.24	124	<0.0001
Chemicals	0.42***	0.15***	0.11	918	<0.0001
Plastics and rubber	0.10	0.03	0.001	220	0.34
Nonmetallic minerals	0.03	0.12	0.001	41	0.42
Primary and fabricated metals	0.18*	-0.02	0.01	196	0.15
Machinery	0.03	0.09***	0.02	331	0.02
Computers and electronic products	0.42***	0.06	0.06	425	<0.0001
Electrical equipment	0.56***	0.21***	0.23	110	<0.0001
Transportation equipment	0.42***	-0.02	0.11	447	<0.0001
Other manufacturing	0.50***	0.06	0.06	184	0.002

^a Net property, plant, and equipment per worker^b Log of average wage paid by affiliates in that industry and host country^c Log of gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Table 13

Log Equations Relating the Ratio of Affiliate to Parent Capital Intensity^a
to the Price of Labor and Scale of Affiliate Production

Affiliates in Developing Countries in Same Detailed Industry as Parent

Industry	Price of labor ^b	Scale ^c	R ²	Observations	Prob>F-stat
All manufacturing	0.21***	0.07***	0.02	1,065	<0.0001
Food	-0.10	0.08	0.001	43	0.67
Beverages and tobacco	0.47	0.12	0.02	31	0.27
Paper	1.17***	0.15	0.27	50	0.0003
Chemicals	0.24**	0.18***	0.05	370	<0.0001
Plastics and rubber	-0.10	0.10	0.0001	60	0.57
Primary and fabricated metals	-0.03	0.10	0.0001	39	0.75
Machinery	-0.0004	0.07	0.0001	65	0.58
Computers and electronic products	0.69***	-0.05	0.11	155	0.0001
Electrical equipment	0.40	0.01	0.001	27	0.43
Transportation equipment	0.65***	-0.11*	0.08	143	0.001
Other manufacturing	0.49	-0.07	0.0001	43	0.53

^a Net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Textiles and apparel, and Machinery. The latter group, in particular, showed no response to labor cost within the parents' industries but a significant one for affiliates in all manufacturing industries. In Primary and fabricated metals, however, the marginally significant response to labor cost within parents' industries disappeared when all manufacturing affiliates were included.

For all manufacturing affiliates located in developing countries (Table 15), the results are mostly similar to those for affiliates in all countries. The elasticity of the response to labor cost is much reduced in the Transportation equipment industry, but it is greatly increased in Textiles and apparel, Paper, and Computers and electronic products. In many industries, the equations are not statistically significant, and the comparison with Table 11 indicates that, in general, parent capital intensity outweighs host country wage levels as a determinant of affiliate capital intensity.

The conclusion about capital intensity responses within firms to labor cost difference is that they are significant and fairly large, with elasticities for manufacturing as a whole in the .25 to .35 range. Quite a few for individual industries are in the neighborhood of .50. However, they account for less of the affiliates' total response to labor cost than the selection among parents, with their presumably different technologies.

Table 14

Log Equations Explaining the Ratio of Affiliate to Parent Capital Intensity^a
To the Price of Labor and the Scale of Affiliate Production

Affiliates in All Countries in All Manufacturing Industries

Industry	Price of labor ^b	Scale ^c	R ²	Observations	Probability>F-stat
All manufacturing	0.30***	0.08***	0.06	5,298	<0.0001
Food	0.31***	-0.002	0.05	213	0.002
Beverages and tobacco	0.51***	0.17***	0.22	96	<0.0001
Textiles and apparel	0.51***	0.16	0.15	92	0.0003
Paper	0.43***	0.16***	0.18	234	<0.0001
Chemicals	0.32***	0.12***	0.07	1,385	<0.0001
Plastics and rubber	0.09	0.06	0.01	292	0.15
Nonmetallic minerals	0.09	0.19**	0.06	70	0.05
Primary and fabricated metals	0.01	-0.01	0.0001	378	0.98
Machinery	0.15**	0.10***	0.03	515	0.0001
Computers and electronic products	0.36***	0.06*	0.04	531	<0.0001
Electrical equipment	0.37***	0.10**	0.09	247	<0.0001
Transportation equipment	0.38***	0.01	0.07	844	<0.0001
Other manufacturing	0.45***	0.10	0.06	262	0.0001

^a Net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Table 15

Log Equations Relating the Ratio of Affiliate to Parent Capital Intensity^a
to the Price of Labor and the Scale of Affiliate Production

Affiliates in Developing Countries in All Manufacturing Industries

Industry	Price of labor ^b	Scale ^c	R ²	Obser- vations	Probability>F -stat
All manufacturing	0.23***	0.05**	0.02	1,586	<0.0001
Food	0.12	-0.08	0.001	77	0.57
Beverages and tobacco	0.33	0.12	0.04	43	0.17
Textiles and apparel	1.08*	0.83	0.15	19	0.10
Paper	0.74***	0.14	0.16	79	0.001
Chemicals	0.20**	0.13***	0.03	543	0.0001
Plastics and rubber	0.07	0.07	0.001	68	0.65
Primary and fabricated metals	0.06	0.06	0.0001	62	0.83
Machinery	0.09	0.05	0.0001	104	0.46
Computers and electronic products	0.62***	-0.03	0.09	175	0.0001
Electrical equipment	0.42*	0.10	0.06	59	0.08
Transportation equipment	0.22	-0.06	0.003	254	0.24
Other manufacturing	0.55*	-0.10	0.01	61	0.25

^a Net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Export orientation and affiliate capital intensity response to labor cost

It might be expected that an affiliate competing in world markets would be more sensitive to producing in a way that minimizes costs than one selling only in a host country market, especially if it is a protected market. Affiliates established to serve local markets may be more affected by factors such as market size or per capita income.

As a first step in examining this possibility, we divided the affiliates into two groups, those that exported and those that did not. An alternative approach might be to use some measure of the openness of the host economy as an independent variable, assuming that the export decision might itself depend on the degree of adaptation to host country factor prices. We fitted an equation like those of Tables 8 through 11, separating the effect of the host country price of labor from that of parent capital intensity (the dependent variable is the log of affiliate capital intensity). We once again looked at those affiliates in the same industry as their parent separately from all manufacturing affiliates (table 16).

For those affiliates in the same industry as their parent, across all countries, the capital intensities in the exporting affiliates respond more strongly to the price of labor and parent capital intensity than those in non-exporting affiliates, and much more of the variance in capital intensities is explained. When the analysis is confined to the much smaller group of affiliates in developing countries, the elasticity of the response to the price of labor is twice as high in the exporting affiliates. The proportion of exporters among the affiliates in developed countries is much higher, almost twice as high, in developed countries as in developing countries, a fact that may explain some of the weaker results in the equations confined to developing countries.

When we look at all manufacturing affiliates, rather than only those in the parents' main industries, we find again there is a greater response to differences in the price of labor among those that export. When the analysis is performed on only those affiliates in developing countries, the difference in responsiveness to labor cost between exporters and non-exporters is even greater.

Table 16

Log Equations Relating Affiliate Capital Intensity^a
To the Price of Labor, Scale of Affiliate Production, and Parent Capital Intensity

Exporting and Non-exporting Affiliates

Affiliates in Same Industry as the Parent				
	All Countries		Developing Countries	
	Non-exporters	Exporters	Non-exporters	Exporters
Price of labor ^b	0.22***	0.34***	0.18**	0.38***
Scale ^c	0.11***	0.09***	0.12**	0.03
Parent capital intensity ^d	0.44***	0.64***	0.53***	0.61***
R ²	0.13	0.30	0.13	0.23
Observations	1,206	2,138	450	615
Probability>F-stat	<0.0001	<0.0001	<0.0001	<0.0001
Affiliates in All Manufacturing Industries				
	All Countries		Developing Countries	
	Non-exporters	Exporters	Non-exporters	Exporters
Price of labor ^b	0.20***	0.33***	0.18**	0.38***
Scale ^c	0.07***	0.10***	0.05	0.03
Parent capital intensity ^d	0.56***	0.65***	0.65***	0.70***
R ²	0.14	0.30	0.15	0.25
Observations	1,920	3,378	684	904
Probability>F-stat	<0.0001	<0.0001	<0.0001	<0.0001

^a Net property, plant, and equipment per worker

^b Log of average wage paid by affiliates in that industry and host country

^c Log of gross product less operating profits

^d Log of parent net property, plant, and equipment per worker

*** Significant at 1 per cent level

** Significant at 5 per cent level

* Significant at 10 per cent level

Conclusions

U.S. affiliates in developing countries differ from their parent firms and from affiliates in developed countries in capital intensity, as measured by property, plant, and equipment per worker. The difference is largest in manufacturing, where U.S. affiliates in developed countries were almost twice as capital-intensive as those in developing countries. This difference might represent a response of firms to differences in labor costs by producing the same products in different ways, but may reflect the fact that the firms investing in developed countries, even within detailed industries, could be producing different products or using different technologies from those investing in developing countries.

The extent to which U.S. multinational firms are responding to differences in labor costs by adapting their methods of production can be examined by measuring capital intensities within individual firms. The narrowest view of adaptation is that among a firm's affiliates in the same detailed industry as the parent. A significant part of the differences in capital intensities across host countries can be explained by three factors. One is the price of labor. Where the price of labor is high, more capital-intensive production methods are used. A second factor is the size of the affiliate's production. The larger the affiliate's output, compared to other affiliates of the firm in that industry, the more capital-intensive the method of producing it. The third factor is the parent's capital intensity. Within almost every industry, the more capital-intensive the parent's production in the United States, the more capital-intensive the affiliate's production is.

Among affiliates in developing countries alone, the influence of the price of labor was even stronger. That is, the coefficients on the price of labor were larger, where they were significant. The influence of scale of production and of parent capital intensity was a little smaller, however.

If the capital intensities of affiliates in different countries, facing different prices of labor, are thought of as providing observations of different points on each firm's production function for a detailed industry, they can be used to calculate elasticities of substitution between capital and labor. There is a significant response by affiliates in the same industries as their parent firms to differences in labor costs

across the whole range of developed and developing countries. Among the developing countries, less of the variation in factor proportions is explained, and in fewer industries, but in the industries in which labor cost is statistically significant in developing countries, the coefficient is larger than for all countries.

Within individual multinationals, there are still strong responses of affiliate capital intensity relative to parent capital intensity to labor price differences, especially across all countries, developed and developing. The elasticities are similar to those in equations for affiliate capital intensity that use parent capital intensity as an independent variable, but the degree of explanation of affiliate factor proportions relative to those of their parents is much smaller (Tables 13 and 14). A large proportion of the variance in affiliate capital intensities, about three quarters across all countries and more across developing countries alone, is explained by differences in parent capital intensities. That parent variation may represent differences within industries in parent technology or in the composition of production.

The export behavior of an affiliate affected its response to labor cost. Affiliates that exported any part of their production, particularly in developing countries, showed a greater responsiveness to labor cost than affiliates that did not export. This held true for affiliates in the same industry as the parent and for all manufacturing affiliates. These differences could reflect country trade regimes, where more open economies forced more efficient modes of production. Or they could reflect differences in the strategies of individual multinationals, either to serve only local host country markets or to serve world markets from their foreign affiliates.

Appendix Table 1

List of Detailed Manufacturing Industries

Food

Animal foods

Grain and oilseed milling

Sugar and confectionery products

Fruit and vegetable preserving and specialty foods

Dairy products

Animal slaughtering and processing

Meat products

Seafood product preparation and packaging

Bakeries and tortillas

Other food products

Beverages and tobacco products

Beverages

Tobacco products

Textiles, apparel, and leather products

Textile mills

Textile product mills

Apparel

Leather and allied products

Wood products

Paper

Pulp, paper, and paperboard mills

Converted paper products

Printing and related support activities

Petroleum and coal products

Integrated petroleum refining and extraction Petroleum
refining excluding oil and gas extraction Asphalt and
other petroleum and coal products

Chemicals

- Basic chemicals

- Resins and synthetic rubber, fibers, and filaments

- Pesticides, fertilizers, and other agricultural chemicals

- Pharmaceuticals and medicines

- Paints, coatings, and adhesives

- Soap, cleaning compounds, and toilet preparations

- Other chemical products and preparations

Plastics and rubber products

- Plastics products

- Rubber products

Nonmetallic mineral products

- Clay products and refractories

- Glass and glass products

- Cement and concrete products

- Lime and gypsum products

- Other nonmetallic mineral products

Primary and fabricated metals

- Primary metals

- Iron and steel mills and ferroalloys

- Steel products from purchased steel

- Alumina and aluminum production and processing

- Nonferrous metal (except aluminum) production and processing

- Foundries

- Fabricated metal products

- Forging and clamping

- Cutlery and handtools

- Architectural and structural metals

- Boilers, tanks, and shipping containers

- Hardware

- Spring and wire products

- Machine shops, turned products, and screws, nuts, and bolts

- Coating, engraving, heat treating, and allied activities

- Other fabricated metal products

Machinery

- Agriculture, construction, and mining machinery
- Industrial machinery
- Commercial and service industry machinery
- Ventilation, heating, air conditioning, and commercial refrigeration
- Metalworking machinery
- Engines, turbines, and power transmission equipment
- Other general purpose machinery

Computers and electronic products

- Computers and peripheral equipment
- Communications equipment
- Audio and video equipment
- Semiconductors and other electronic components
- Navigational, measuring, and other instruments
- Magnetic and optical media

Electrical equipment, appliances, and components

- Electric lighting equipment
- Household appliances
- Electrical equipment
- Other electrical equipment and components

Transportation equipment

- Motor vehicles, bodies and trailers, and parts
 - Motor vehicles
 - Motor vehicle bodies and trailers
 - Motor vehicle parts
- Other
 - Aerospace products and parts
 - Railroad rolling stock
 - Ship and boat building
 - Other transportation equipment

Furniture and related products

Miscellaneous manufacturing

- Laboratory Apparatus and Furniture Manufacturing
- Surgical and Medical Instrument Manufacturing

Surgical Appliance and Supplies Manufacturing
Dental Equipment and Supplies Manufacturing
Ophthalmic Goods Manufacturing
Dental Laboratories
Jewelry (except Costume) Manufacturing
Silverware and Hollowware Manufacturing
Jewelers' Material and Lapidary Work Manufacturing
Costume Jewelry and Novelty Manufacturing
Sporting and Athletic Goods Manufacturing
Doll and Stuffed Toy Manufacturing
Game, Toy, and Children's Vehicle Manufacturing
Pen and Mechanical Pencil Manufacturing
Lead Pencil and Art Good Manufacturing
Marking Device Manufacturing
Carbon Paper and Inked Ribbon Manufacturing
Sign Manufacturing
Gasket, Packing, and Sealing Device Manufacturing
Musical Instrument Manufacturing
Fastener, Button, Needle, and Pin Manufacturing
Broom, Brush, and Mop Manufacturing
Burial Casket Manufacturing
All Other Miscellaneous Manufacturing

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Figure A

One Technology and Two Factor Price Ratios

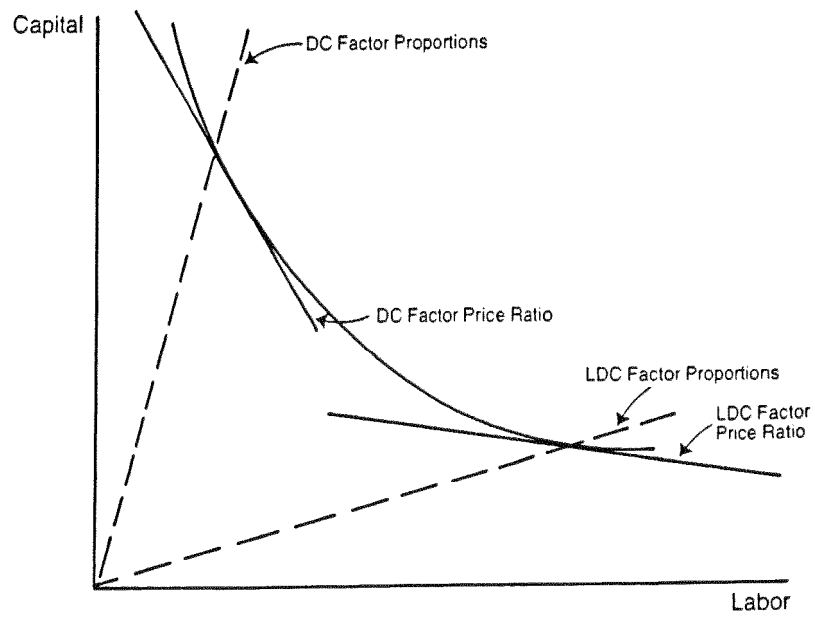


Figure B

Two Technologies and Two Factor Price Ratios

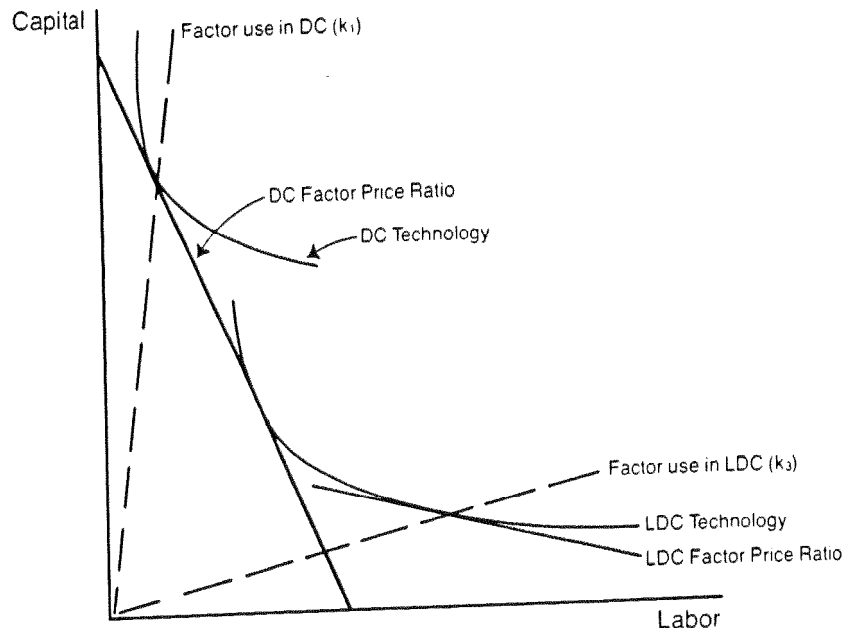


Figure C

One Technology, Two Scales of Production

