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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

U.S. manufacturing multinationals employed over a third of their labor force in countries outside the United States in 2004 (Mataloni and Yorgason, 2006, p. 57). What distinguishes the parts of their operations that they place in foreign countries? The supposed rise in the fragmentation of production presumably permits firms to match parts of their production that they wish to keep under their control to the factor prices of individual locations. They might do this either by selecting among parts of their output or by adapting production methods to different factor prices in different locations. One well-documented fact is that U.S. multinationals' operations in developing countries are much more labor-intensive than those in developed countries, and those, in turn, are more labor-intensive than U.S. parent firms' domestic operations. Do the multinationals simply shift their more labor-intensive operations abroad, or do they take advantage of lower labor costs to produce their range of output in a more labor-intensive fashion where labor is relatively cheap?

While the main differences in the factor intensity of production in different countries are clear in the aggregate data, it has been impossible to measure the extent and nature of choice of activities or adaptation of methods of production in a comprehensive way within detailed industries, within individual countries, or particularly within individual firms. The reason is that there are no publicly available data that link individual affiliates outside the United States to their own parents. The main contribution of this paper is to use the unique matched data from the foreign investment survey of the Bureau of Economic Analysis of the U.S. Department of Commerce to observe the size and nature of adaptations to foreign factor prices and other foreign market conditions. Another is to examine how the choice of factor proportions is related to the use of foreign affiliates to export to other markets.

One possible explanation for differences in capital intensity is that the multinationals (MNCs) produce the same things everywhere, but adapt to differences in wage levels by using more labor and less capital in production where labor is cheap. Another possibility is that multi-industry firms do not produce the same things everywhere, but put their production in labor-intensive industries in developing countries and their production in capital-intensive industries at home or in developed countries. A third possibility is that affiliates of different firms, with different technologies at home, produce with different capital intensities abroad. Perhaps, firms that use labor-intensive technologies at home in the United States place affiliates in developing countries, where labor is cheap, and firms that use capital-intensive technologies at home place affiliates in developed, or higher-wage countries. A fourth possibility is that affiliates in small markets, typically in developing countries, produce on a small scale, not suited to capital-intensive production techniques, while affiliates in countries with large markets, more likely developed countries or countries with more open trade regimes, produce on a large scale that lends itself to capital-intensive production methods.

It has been difficult for researchers to figure out what determines these affiliate capital intensities, because the data for individual parent firms and their affiliates have not been publicly accessible. For this paper, we were able to obtain access to data for individual U.S. parent firms and their affiliates from the 1999 Benchmark Survey of the Bureau of Economic Analysis (BEA), and can therefore dissect the relationship between parent and affiliate capital intensities into several elements.

Earlier studies

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.

A study of multinationals in Taiwan's electronics industry (Chen, 1992) found that multinationals' affiliates did adapt to the local environment and adapted increasingly over time, substituting less-skilled for more skilled labor and increasing the share of value added within

Taiwan. Exporting affiliates adjusted their technology more quickly than firms catering to local markets.

More recent studies have been fostered by the interest in the "fragmentation" of production and the greatly increased competition among countries for segments of fragmented production, or roles in multinational firms' international production networks. "Inexpensive labor" was cited by Japanese firms as a strong point in favor of many Asian nations in Japanese firms' location decisions, in a survey quoted by Kimura and Ando (2006, p. 95), although the possibility of changing factor proportions is not mentioned. Tran Van Tho (2006), in the same volume, relates the export propensities of foreign-owned firms in Viet Nam to their capital intensities and found that there was a strong negative relationship, reflecting Vietnam's comparative advantage (pp. 402-403).

Much of the literature on fragmentation refers to international trade in intermediate goods, but not specifically to intrafirm trade. The same differences in factor prices are at work, but not the choices of factor proportions by a single decision maker (see, for example, Helg and Tajoli, 2005). Data on intrafirm trade are difficult to obtain, except for the United States. A study of intrafirm shipments of intermediate inputs between U.S. parent companies and their affiliates related the propensity of affiliates to source such inputs from their parents to characteristics of parents and affiliates, and suggested a division of labor that placed higher-skilled activities with parents and lower –skilled activities with the affiliates (Borga and Zeile, 2004).

Data

The data we use are from the 1999 Benchmark Survey of U.S. Direct Investment Abroad, conducted by the Bureau of Economic Analysis of the U.S. Department of Commerce. The

survey, answers to which are compulsory, asks each parent firm questions about its own operations and those of each of its affiliates, including primary industry, employment, labor compensation, fixed capital, sales, and many other topics. The industry is the detailed NAICS industry, of which there are almost 100 in manufacturing. The wage level faced by an affiliate in a country is the average wage per hour for production workers paid by affiliates in the same NAICS industry in the same country. The assumption implied is that affiliates in the same industry probably hire workers similar to those the affiliate is hiring.

Affiliate assets, liabilities, revenues, and expenses denominated in a foreign currency must be translated into U.S. dollars in accordance with Generally Accepted Accounting Principles, specifically FASB Statement 52. Under FASB 52, revenue and expense items, such as sales and labor compensation, are translated into U.S. dollars using a weighted exchange rate for the period. Assets and liabilities are translated by end-of-period exchange rates. The capital input measure is the net stock of plant and equipment. Since an exchange rate conversion is used, we are, in effect, assuming that a multinational firm buys capital equipment in a worldwide market rather than for each affiliate in its own host-country market, possibly a non-existent local market in the case of at least some developing countries. Scale of production is measured by gross product minus operating profits. Profits are excluded because they are volatile, sometimes negative, and sometimes their inclusion produces negative gross product measures, not a good measure of scale of operations.

Affiliate Capital Intensities

Part of the story we are trying to understand better can be summarized in Table 1. The average net property, plant, and equipment (PP&E) per worker in manufacturing parent operations in the United States was about $106,000, while it was $57,000 in majority-owned

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

nonbank affiliates of these parents in all industries in developing countries. Even within the 13 broad industries shown in Table 1, there were large differences, and although there were a couple of industries in which the capital/labor ratios in affiliates were similar to those of the parents, and even one where the affiliates were more capital intensive, the parents were twice as capital intensive or more in seven of the industries. The differences between affiliates in developed countries and those in developing countries were also large. For manufacturing affiliates alone, the capital intensity in developed countries averaged $75,000 and that in developing countries, $40,000.

That large difference in capital intensities between affiliates in developed and developing countries is peculiar to manufacturing. In other industries, capital intensities of affiliates in developing countries were higher than those in developed countries in the aggregate. What cannot be discerned in aggregate data such as these is what determines these differences in capital intensity in manufacturing industries. The individual firm data can help us to discover that.

Determinants of Differences in Capital Intensities

U.S. firms operating abroad could respond in many different ways to the fact that wage rates and market sizes differ enormously among potential host countries and that parent firms differ greatly in capital intensity. Firms could produce abroad the same products they produce at home, and with essentially the same technology, but altering factor proportions by using more labor input relative to capital input to take advantage of the lower wages in some countries. We test that possibility by comparing the capital/labor ratios in low-wage and high-wage countries and at home in the narrowly defined main industry of the parent. Firm might also find, even if they do not alter factor use in response to wage costs, that capital-intensive methods of

production require larger volumes of production than labor-intensive methods. They would, therefore use more labor-intensive methods in markets where the scale of production was low.

Even within the same narrowly defined industry, there are U.S. firms using more capital-intensive production methods at home and firms using less capital-intensive methods. A possible explanation for differences in affiliate capital intensities might be that affiliates of capital-intensive firms bring capital –intensive technologies to host countries, while affiliates of labor-intensive parent firms carry labor-intensive technologies. Even if each firm's affiliates in its parent's industry produced with the same capital/labor ratios everywhere, affiliates of capital-intensive firms might tend to gravitate to high-wage countries, while affiliates of labor-intensive parent firms might gravitate to low-wage countries. In that case, differences in parent capital intensity would help to explain the apparent response of affiliate capital intensities to country wage levels. Still another type of adjustment to wage levels could be associated with the fact that most parents own affiliates in manufacturing industries other than the main industries of the parents. In that case, firms might adapt to wage level differences by placing affiliates in labor-intensive industries in low-wage countries and affiliates in high-wage industries in high-wage countries.

Several determinants of affiliate capital intensities are tested in Table 2, across all affiliate locations. If we fit log equations to the 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 2). Across all affiliate locations, the elasticity is 30 percent for affiliates in the parents' main industries in manufacturing as a whole. The industry elasticity coefficients

[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 2

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	Obser-vations	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

that are significant at the 1 per cent level or better, covering 9 of the 13 industries, are higher, with one exception, ranging from 29 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. Parent capital intensity is the dominant influence on the capital intensities of affiliates, significant in almost every industry group.

In Table 3, the capital intensities of the affiliates are calculated relative to those of each affiliate's parent firm in the United States. The degree to which these ratios are explained is much smaller than the degree to which the affiliate capital intensities are explained in Table 2, 7 per cent as compared with 24 per cent. In other words, about three quarters of the variance in affiliate capital intensities is explained by the capital intensities of the parent firms. The technology or product mix of the parent mostly determines the capital intensity of the affiliate.

However, there is still strong evidence that adaptation to local conditions affects how affiliates produce. In most industry groups, and in manufacturing as a whole, labor is used more intensively in production where wages are low. And in about half of the industry groups, and in manufacturing as a whole, labor is used more intensively where the scale of production is smaller.

Since parent capital intensity is such a strong determinant of affiliate capital intensity, an additional method of adaptation to local conditions would be if high capital intensity parents tended to place affiliates in high-wage countries and low capital intensity parents concentrated theirs in low-wage countries. That possibility is tested in Table 4 where parent capital intensity is related to average host-country per capita income. The idea that part of the adaptation to low

Table 3

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	Obser-vations	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 4

Relation of the Average Real per Capita GDP of the Host Countries of Affiliates to their Parent's Capital Intensity[a]

Affiliates in All Countries in Same Detailed Industry as Parent

Industry	Parent capital intensity	R^2	Observations	Probability >F-stat
All manufacturing	-0.007***	0.02	845	0.0001
Food	-0.02	0.03	37	0.15
Beverages and tobacco	-0.004	0.0001	10	0.91
Textiles and apparel	-0.002	0.0001	35	0.88
Paper	-0.002	0.0001	25	0.70
Printing and related activities	-0.01	0.0001	16	0.56
Chemicals	-0.01**	0.02	136	0.05
Plastics and rubber	0.01	0.0001	49	0.45
Nonmetallic minerals	0.02	0.08	18	0.13
Primary and fabricated metals	0.003	0.0001	77	0.50
Machinery	-0.02*	0.02	111	0.09
Computers and electronic products	-0.02***	0.04	143	0.001
Electrical equipment	-0.04	0.03	39	0.14
Transportation equipment	-0.03***	0.10	64	0.001
Furniture and related products	0.07	0.0001	12	0.44
Other manufacturing	-0.005	0.0001	63	0.78

[a] 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

wages is for capital intensive parents to place affiliates in high-wage countries and labor-intensive parents to place theirs in low-wage countries is firmly refuted by these results. Although the relationship is not strong, and in many industry groups not significant, where it is significant it indicates that, on average, capital intensive parents tend to operate not in high-wage countries but in low-wage countries. And labor-intensive parents appear to locate in high-wage countries. The selection of locations for affiliates to match the factor intensities of the parents does not at all explain the low capital intensities of affiliates in low-wage countries.

Differences in the price of labor and the scale of production may be only two out of many determinants of affiliate factor proportions in a host country. To test whether there are other country determinants of factor proportions, we add country dummies to the equations of Table 2 and show the all-industry and major sector equations in Table 5. Many of the labor price coefficients disappear and the labor price coefficient for all industries shrinks, but it remains statistically significant. The scale coefficients are much less affected, and the parent capital intensity coefficients hardly at all. The degree of explanation is improved slightly. Thus, given all the characteristics of a location, large scale of operations and high capital intensity in the parent both promote high capital intensity in production. Across all industries, high wages in a country lead to more capital-intensive production. In individual industry groups, the wage effect is incorporated into the country dummies, along with some other country influences.

Since we have linked parent and affiliate data, we can examine the choices made by individual parents by including parent dummy variables in the regressions. That procedure removes all the idiosyncratic elements of the parent, including its factor proportions, to reveal how individual parents respond to local factor prices. On the whole, the individual parent response to factor prices is the same as the aggregate response reported in Table 2. For an

Table 5

Log Equations Explaining Affiliate Capital Intensity[a]

Affiliates in All Countries in Same Detailed Industry as Parent
With country dummy variables (not shown)

Industry	Price of labor[b]	Scale[c]	Parent capital intensity[d]	R^2	Obser-vations	Prob>F-stat
All manufacturing	0.18***	0.12***	0.59***	0.27	3,344	<0.0001
Food	-0.45*	0.08	0.78***	0.46	135	<0.0001
Beverages and tobacco	0.80	0.05	-0.21	0.53	60	0.002
Textiles and apparel	0.61	0.14	0.80***	0.45	77	<0.0001
Paper	0.71	0.18**	0.38***	0.38	124	<0.0001
Chemicals	0.01	0.13***	0.64***	0.28	918	<0.0001
Plastics and rubber	-1.02***	0.04	0.59***	0.22	220	<0.0001
Nonmetallic minerals	-0.17	0.13	0.82***	0.42	41	0.01
Primary and fabricated metals	0.39	-0.002	0.60***	0.30	196	<0.0001
Machinery	0.11	0.14***	0.31***	0.14	331	<0.0001
Computers and electronic products	0.40	0.23***	0.16***	0.21	425	<0.0001
Electrical equipment	0.12	0.21***	0.60***	0.43	110	<0.0001
Transportation equipment	0.90***	-0.001	0.69***	0.29	447	<0.0001
Other manufacturing	0.76	0.16**	0.05	0.27	184	<0.0001

[a] Log of affiliate net property, plant, and equipment per worker
[b] Log of average wage paid by affiliates in that industry and host country
[c] Log of affiliate 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

individual parent, high wage levels in a country and larger affiliate scale promote the establishment or operation of relatively capital-intensive operations (Table 6). A similar equation for affiliates in developing countries explained even more of the variation in capital intensities, but scale is less important. Presumably, the parent dummies, representing, among other influences, parent capital intensity, are more important (Table 7).

The behavior of individual parents is highlighted by the relationship of affiliate to parent capital intensity. For manufacturing as a whole and for most of the manufacturing groups, for any given parent, higher affiliate country capital intensities result from higher wages and larger scale production (Table 8). Among affiliates in developing countries, about a third of the variance in capital intensities relative to the parent is explained, as compared with half across all countries, and fewer individual industries are well enough explained to have statistically significant coefficients, but the main outlines are similar. One reason for the weaker results is that there are few affiliates to compare across parents in some industries in developing countries (Table 9).

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 local market size or per capita income, especially if host country trade regimes do not encourage production for wider markets.

To examine this possibility, we divided the affiliates into two groups, those that exported and those that did not. We fitted an equation like those of Table 2, separating the effect of the

Table 6

Log Equations Explaining Affiliate Capital Intensity[a]

Affiliates in All Countries in Same Detailed Industry as Parent
With parent dummy variables (not shown)

Industry	Price of labor[b]	Scale[c]	R^2	Obser-vations	Prob>F-stat
All manufacturing	0.25***	0.15***	0.53	3,344	<0.0001
Food	0.20	0.15*	0.21	135	0.01
Beverages and tobacco	0.28	-0.01	0.55	60	<0.0001
Textiles and apparel	0.31	0.15	0.45	77	0.001
Paper	0.41***	0.26***	0.33	124	<0.0001
Chemicals	0.21***	0.24***	0.40	918	<0.0001
Plastics and rubber	-0.09	0.15***	0.28	222	<0.0001
Nonmetallic minerals	-0.16	0.06	0.57	41	0.002
Primary and fabricated metals	0.37***	0.09	0.23	198	0.003
Machinery	-0.09	0.22***	0.18	331	0.001
Computers and electronic products	0.36***	0.22***	0.31	425	<0.0001
Electrical equipment	0.30**	0.32***	0.48	110	<0.0001
Transportation equipment	0.37***	-0.03	0.31	447	<0.0001
Other manufacturing	0.41***	0.05	0.21	184	0.004

[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 7

Log Equations Explaining Affiliate Capital Intensity[a]

Affiliates in Developing Countries in Same Detailed Industry as Parent
With parent dummy variables (not shown)

Industry	Price of labor[b]	Scale[c]	R^2	Obser-vations	Prob>F-stat
All manufacturing	0.22***	0.07**	0.61	1,065	<0.0001
Food	-0.21	0.08	0.21	43	0.13
Beverages and tobacco	0.16	-0.06	0.49	31	0.001
Textiles and apparel	0.05	0.82	0.90	15	0.24
Paper	0.75**	0.43***	0.26	50	0.02
Chemicals	0.09	0.21***	0.46	370	<0.0001
Plastics and rubber	-0.03	0.19	0.10	60	0.23
Primary and fabricated metals	0.39	-0.03	0.61	39	0.003
Machinery	-0.44**	0.08	0.54	65	0.001
Computers and electronic products	0.44**	0.01	0.33	155	0.0003
Electrical equipment	0.27	0.12	0.76	27	0.01
Transportation equipment	0.33*	-0.13**	0.31	143	<0.0001
Other manufacturing	0.19	-0.24	0.38	43	0.04

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

*** Significant at 1 per cent level
** Significant at 5 per cent level
* Significant at 10 per cent level

Table 8

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

Affiliates in All Countries in Same Detailed Industry as Parent
With parent dummy variables (not shown)

Industry	Price of labor[b]	Scale[c]	R^2	Obser-vations	Prob>F-stat
All manufacturing	0.25***	0.15***	0.50	3,344	<0.0001
Food	0.20	0.15*	0.09	135	0.12
Beverages and tobacco	0.28	-0.01	0.52	60	<0.0001
Textiles and apparel	0.31	0.15	0.19	77	0.11
Paper	0.41***	0.26***	0.34	124	<0.0001
Chemicals	0.21***	0.24***	0.36	918	<0.0001
Plastics and rubber	-0.09	0.15***	0.24	220	<0.0001
Nonmetallic minerals	-0.16	0.06	0.42	41	0.02
Primary and fabricated metals	0.38***	0.09	0.08	196	0.16
Machinery	-0.09	0.22***	0.24	331	<0.0001
Computers and electronic products	0.36***	0.22***	0.46	425	<0.0001
Electrical equipment	0.30**	0.32***	0.40	110	0.0001
Transportation equipment	0.37***	-0.03	0.22	447	<0.0001
Other manufacturing	0.41***	0.05	0.47	184	<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 9

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

Affiliates in Developing Countries in Same Detailed Industry as Parent
With parent dummy variables (not shown)

Industry	Price of labor[b]	Scale[c]	R^2	Obser-vations	Prob>F-stat
All manufacturing	0.22***	0.07**	0.37	1,065	<0.0001
Food	-0.21	0.08	-0.38	43	0.99
Beverages and tobacco	0.16	-0.06	0.35	31	0.01
Textiles and apparel	0.32	0.82	0.86	15	0.28
Paper	0.75**	0.43***	0.35	50	0.003
Chemicals	0.09	0.21***	0.40	370	<0.0001
Plastics and rubber	-0.03	0.19	0.07	60	0.29
Primary and fabricated metals	0.39	-0.03	0.42	39	0.04
Machinery	-0.44**	0.08	0.44	65	0.01
Computers and electronic products	0.44**	0.01	0.46	155	<0.0001
Electrical equipment	0.27	0.12	0.64	27	0.04
Transportation equipment	0.33*	-0.13**	0.26	143	0.0004
Other manufacturing	0.19	-0.24	0.59	43	0.002

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

*** Significant at 1 per cent level
** Significant at 5 per cent level
* Significant at 10 per cent level

host country price of labor from that of parent capital intensity (the dependent variable is the log of affiliate capital intensity) (Table 10).

For 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.

There are several ways to explain these results. One is that affiliates with factor proportions unsuitable to their environments (e.g., capital-intensive in low-wage countries, or labor-intensive in high-wage countries) are high-cost producers for their countries and therefore unable to compete in world markets. Another interpretation would be that in open, trade-oriented economies, affiliates must adapt to local conditions in order to export, but that in closed economies, firms face less competitive markets and do not need to undertake the costs of adaptation of their production methods to survive.

What determines whether a firm will be an exporter or a non-exporter? Table 11 represents an attempt to relate the probability of being an exporter to affiliate scale and deviations of its capital intensity from that predicted from labor costs, scale of operations, and parent capital intensity, called the Residual. For manufacturing as a whole, across all countries, and for developing countries, the residual, indicating higher capital intensity than expected, was a positive influence, but it was a statistically significant influence only in Chemicals. Scale of operations, on the other hand, was a significant positive influence overall and in every industry

Table 10

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

[a] Affiliate Net property, plant, and equipment per worker
[b] Log of average wage paid by affiliates in that industry and host country
[c] Log of affiliate 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

Equations Explaining Affiliates' Probability of Exporting
(Dummy variable=1 if they export)

Algebraic value of the residual

Affiliates in All Countries in Same Detailed Industry as Parent

Industry	Residual	Scale	Pseudo-R^2	Observations	Prob>Chi-sq.
All manufacturing	0.001**	0.68***	0.13	3,344	<0.0001
Food	-0.001	0.76***	0.14	135	<0.0001
Beverages and tobacco	-0.004	-0.07	0.03	60	0.32
Textiles and apparel	-0.01	0.66***	0.09	77	0.01
Paper	0.01	1.91***	0.49	124	<0.0001
Chemicals	0.003***	0.82***	0.18	918	<0.0001
Computers and electronic products	0.0004	0.66***	0.11	425	<0.0001
Electrical equipment	0.01	0.68***	0.13	110	0.0001
Transportation equipment	0.004	0.66***	0.14	447	<0.0001
Other manufacturing	-0.0003	0.69***	0.10	184	<0.0001

Affiliates in Developing Countries in Same Detailed Industry as Parent

Industry	Residual	Scale	Pseudo-R^2	Observations	Prob>Chi-sq.
All manufacturing	0.002*	0.65***	0.12	1,065	<0.0001
Paper	0.002	1.90***	0.45	50	<0.0001
Chemicals	0.002*	0.84***	0.17	370	<0.0001
Computers and electronic products	0.004	0.49***	0.08	155	0.01
Transportation equipment	0.007	0.49***	0.10	143	0.0001

*** Significant at 1 per cent level
** Significant at 5 per cent level
* Significant at 10 per cent level

group but one. These results were mirrored in the equations for developing countries, although only four industries provided enough observations for the analysis.

Conclusions

Affiliates of U.S. MNCs carry their parents' technology with them when they produce abroad, in the sense that affiliates of relatively capital intensive parents produce in a relatively capital intensive manner wherever they are located. U.S.MNCs adapt to low wage production locations by producing in a more labor intensive manner than in high-wage locations. They adapt to small scales of production by producing in a more labor-intensive way than in larger operations.

Capital-intensive U.S. parent firms do not tend to concentrate their affiliate production in relatively high-wage locations. There is no such concentration that would help to explain the relationship between high wages and capital-intensive affiliate production.

Equations with country dummy variables show that even within individual countries, parent capital intensity strongly affects affiliate capital intensity: more capital-intensive parents own more capital-intensive affiliates. Larger scale of operations is associated with higher capital intensity overall and in about half the industries.

Equations with parent firm dummy variables show that an individual firm adapts to low labor costs by producing in a more labor-intensive way and responds to operating at a larger scale by operating in a more capital-intensive manner.

Affiliates that export are more responsive in their factor proportions to the price of labor than affiliates that sell only in their host countries. The responsiveness to labor cost is particularly strong among affiliates in developing host countries. But scale of operations is not a significant influence on capital intensity among exporting affiliates in developing countries. The

greater responsiveness of exporting firms echoes the findings of Chen's (1992) study of electronics affiliates in Taiwan, which found that export-oriented affiliates adjusted their technology faster than domestically-oriented firms, because "…competitive pressure in the international market forces firms to tighten up on managerial slack and to move quickly toward more efficient use of primary factors, including taking advantage of cheap unskilled labor," while "…a more permissive domestic market enables multinationals to make only sluggish adaptations…"

The probability of being an exporter is somewhat related to operating with higher than usual capital intensity, especially in the Chemical industry. However, the most consistent determinant of being an exporter is the scale of operations. Larger scale is strongly associated with higher likelihood of being an exporter, across all industries and within almost all industry groups. The causation could run the other way. The ability of an affiliate to export might warrant a larger scale of production.

Appendix Table 1

List of Detailed Manufacturing Industries

Manufacturing

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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