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In many LDCs foreign-owned firms comprise a large portion of the modern manufacturing sector. These firms transfer technology to their LDC affiliates. Two factors govern the affiliates choice of technology: the firm's operations in the home country and elsewhere, and the underlying economic and political conditions of the host country. This study examines and compares the technologies of 1484 foreign affiliates in developed countries (DCs) and LDCs with more than 200 U.S. based multinational corporations in eleven manufacturing industries. The comparison seeks to determine whether LDC affiliates have more labor-using technologies than DC affiliates and to what extent the observed factor intensity of LDC technology is due to the foreign-owned firm's techniques of production or to what extent it is due to host country conditions. It examines the implications for host governments wishing to increase the rate of labor absorption in the foreign-owned manufacturing sector. In order to make these determinations, the study compares factor intensities and employs production function hypotheses such as the constant elasticity of substitution and other mathematical equations. The empirical results obtained from analyzing the data are discussed and presented in tables. Conclusions from the study are: (1) In six industries, technology differs between DC and LDC affiliates, but not in a more labor-using or a more capital using way. In the other five industries, technology does not differ significantly. (2) Returns to scale appear to be decreasing when total assets are used. (3) There is no evidence that the substitutability between capital and labor is more limited in LDC affiliates than in DC affiliates. This paper recommends further research, especially in the area of joint ventures.

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MULTINATIONAL CORPORATIONS IN LDCs: THE CHOICE OF TECHNOLOGY

William H. Courtney
and
Danny M. Leipziger*

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*Office of Investment Affairs, Bureau of Economic and Business Affairs, U.S. Department of State; and Trade and Payments Division, Bureau for Program and Policy Coordination, Agency for International Development, respectively.

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I. Introduction

Since Eckhaus expounded his fixed proportions or "technological unemployment" hypothesis, numerous authors have asserted that production activities in less developed countries (LDCs) are too capital-intensive.[1] Particularly disappointing in labor-surplus LDCs are low rates of labor absorption in manufacturing, the sector thought by some to be the "engine of growth."[2]

Manufacturing firms in LDCs are accused of adopting a technology appropriate for, and imported from, developed countries (DCs).[3] In many LDCs, foreign-owned firms comprise a significant share of the modern manufacturing sector. Typically, DC parents transfer technology directly to their LDC affiliates, and indirectly to other local firms associated with their affiliates via backward, horizontal and forward linkages. The affiliate's choice of technology is governed by two factors: the parent's operations in the home country and elsewhere, and the underlying economic and political conditions of the host country. Policy-makers in the host country can effectively influence the latter but not the former.

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[1]Though the "technological unemployment" hypothesis has been the most widely discussed aspect of Eckaus' study, he gave equal billing to the role of factor market imperfections in the persistence of unemployment, in the coexistence of both capital-intensive and labor-intensive techniques, and in large differentials between returns in different sectors in LDC economies.

[2]See Fei and Ranis.

[3]In this paper the terms "technology" and "production function" are used interchangeably.

In the manufacturing sector the parent frequently invests abroad to integrate horizontally in order to produce for host country and nearby markets.[4] Although technology in such investments often is not first-line, the parent can save by standardizing technology used by all affiliates, thereby minimizing inventories of spare parts, reducing "learning costs" of its technical personnel, and simplifying administration.[5] To the extent that most production takes place in the high-wage home country or in other developed countries, the firm's optimal "standardized" technology is probably too capital-intensive for LDCs. The parent may also invest abroad to integrate backward, usually for a labor-intensive assembly process uneconomic for home country production. Here the LDC affiliate's technology is more appropriate for LDCs precisely because the parent cannot adapt it to suit factor prices in the high-wage home country.

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[4]See Caves. Caves also asserts that direct foreign investment tends broadly to equalize the rate of return on (equity) capital throughout a given industry, but not between industries in any country. In LDCs, distortions introduced by host government policies tend to weaken the equalization of returns between affiliates in LDCs and DCs, and to inhibit interindustry equalization within an LDC to the extent that government distortions have unequal impacts on different industries.

[5]Baer and Herve' assert that the operative constraint to adapting technology for use in LDCs is the supply of skilled labor; Strassman focuses on the availability of managerial and entrepreneurial talent.

A melange of host government policies and practices encourages capital use: overvalued exchange rates, governmentally supported minimum wage rates for the modern sector which exceed labor's scarcity price, substantial fringe benefits and social security provisions, low taxes on the return to capital, accelerated depreciation, tax and duty exemptions for imported capital equipment, "pioneer subsidies" for new investment in priority sectors, uncontrolled transfer pricing policies, and preferential access by industrial firms to host government loans at artifically low interest rates. Other considerations relevant to LDCs may include: an unstable product demand which encourages excess capacity; the large search, hiring, training, layoff and severance costs associated with short-term labor force adjustment; uncertainty about supplies of inputs, which necessitates larger inventory investments; the problem of having to deal with labor forces belonging to politically powerful labor unions; and the paucity of skilled labor, managerial and entrepreneurial talent.[6]

In this study we estimate and compare production functions of 1484 foreign affiliates in DCs and in LDCs of more

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[6]In light of the unemployment problems and income distribution inequities facing most LDCs, Pack and Todaro (1969) have suggested that LDCs abandon modern technology and imitate older, more labor-using methods, perhaps even producing the capital equipment necessary if it is unavailable in the developed world. Since most older technologies were developed in DCs for labor-saving purposes, we raise the question how old must technology be to be significantly more labor-using. The older it has to be, the higher are the costs of reincarnating it, and the lower the relative costs of developing explicitly labor-using technologies.

than 200 US-based multinational corporations (MNCs) in eleven manufacturing industries. We seek to determine: (a) whether LDC affiliates have more labor-using technologies than DC affiliates, (b) to what extent is the observed factor intensity of LDC affiliates due to the parent's techniques of worldwide production, and to what extent is it due to host country conditions (e.g., relative prices, market distortions), and (c) what are the implications for host governments wishing to increase the rate of labor absorption in the foreign-owned manufacturing sector.

II. Comparing Factor Intensities

Assume that in a given industry: (i) individual affiliates in LDCs and in DCs have identical production functions, but the functions can differ between LDCs and DCs; (ii) LDC affiliates face a lower wage-interest ratio than DC affiliates, and in all cases the affiliates take the ratio as exogenously given; and (iii) the parent uses a standardized, relatively capital-intensive technology in, and

designed for, its DC affiliates. The parent must decide whether to operate its LDC affiliates in a more labor-intensive fashion. The parent can accomplish this objective in two complementary ways: (a) adopt a more labor-using technology (i.e., production function) for use in its LDC affiliates, and (b) within the context of a chosen production, substitute labor for capital, in order to achieve the least-cost capital-labor ratio consistent with the chosen technology. Because the mere substitution of labor for capital can yield rapidly diminishing returns to labor, the lower is the wage-interest ratio in LDCs as compared with DCs, the greater the parent's incentive to adopt a more labor-using technology for its LDC affiliates.

To summarize, the LDC affiliate can realize its optimal capital-labor ratio, and prevent rapidly diminishing returns to labor, by choosing an "optimal mix" between (a) adapting DC technology, thus shifting the isoquant; and (b) substituting labor for capital on the same isoquant.[7]

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[7]Because our data consists of controlled (i.e., majority-owned) foreign affiliates, we implicitly assume that the "optimal mix" is optimal for both the parent and the affiliate. It is possible, however, that the parent and affiliate seek to optimize different objective functions. For instance, the affiliate's manager might prefer transfer prices which improve the affiliate's accounting profit, at the expense of the parent's profit. Adler has hypothesized that objective functions differ because of capital market imperfections. Whatever the reason, if maximization conflicts exist, we may observe a mix of (a) and (b) which reflects a compromise between parent and affiliate goals.

Consider two affiliates in the same industry, an LDC and a DC affiliate, both of which have smooth homothetic production functions, though not necessarily identical.[8] Let (w/r)' and (w/r)" denote the respective wage-interest ratios exogenously given to the DC and the LDC affiliates. Each affiliate has a unique isoquant tangent to (w/r)'. In Figure 1 these isoquants are labeled DC and LDC. Associated with each tangency is a least-cost capital-labor ratio: k_1 for the DC affiliate and k_2 for the LDC affiliate. In other words, given the technology, k_2 would be the LDC affiliate's least cost capital-labor ratio if it faced the same wage-interest ratio as the DC affiliate.

At one point on its surface, the LDC isoquant is also tangent to the isocost line (w/r)", the latter being shifted in a parallel fashion to achieve the tangency. Denote the least-cost capital-labor ratio implied by this tangency as k_3.

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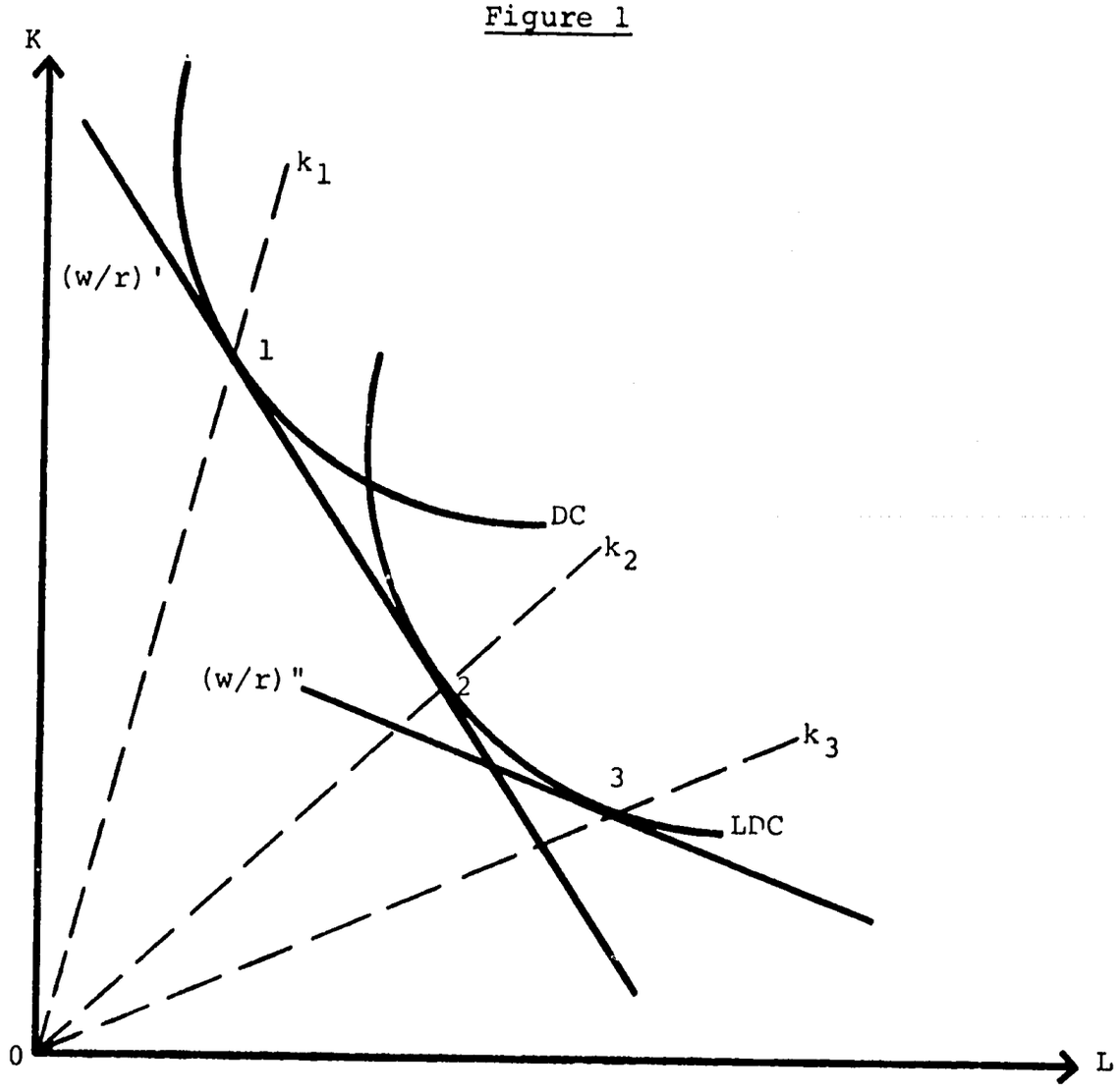
[8]With unchanged technology, the rate of technical substitution between inputs in a homothetic function depends only on the proportion of inputs employed, but not on the returns to scale or level of output. That the production functions of both affiliates are homothetic is necessary and sufficient for the validity of our analysis.

Figure 1



We have drawn Figure 1 such that $k_1 > k_2 > k_3$. By definition, $k_2 > k_3$ if the elasticity of substitution exceeds zero; and the difference between k_2 and k_3 is larger, the greater is the difference between the wage-interest ratios facing the DC and LDC affiliates, and the greater are the substitution possibilities between inputs.

The theory of the firm does not tell us, however, whether k_1 should be greater than, equal to, or less than k_2. Should the wage-interest ratio in LDCs be only slightly lower than in DCs, the parent is likely not to develop a different technology for use in LDC affiliates, and k_1 might equal k_2. If the wage-interest ratio in LDCs is significantly lower than in DCs, the parent would be more likely to adopt a special labor-using technology for use in LDC affiliates, resulting in $k_1 > k_2$.

We would expect that $k_1 < k_2$ only in two perverse cases: if the wage-interest ratio is higher in LDCs than in DCs, or if it is lower in LDCs but other considerations not embodied in the wage-interest ratio predominate.

In summary, simple observation of the labor-intensity of productive operations in the LDC affiliate does not enable one to determine whether the affiliate is applying a more labor-using technology than the DC affiliate utilizes.

We can only judge whether MNCs are successfully adapting their technology by determining whether $k_1 > k_2$; if not, either MNCs are not optimizing, or prevailing conditions in LDCs do not encourage the adoption of a more labor-using technology.

III. Production Function Hypotheses

A. The CES

The constant elasticity of substitution (CES) function is defined as

$$(1) \qquad V = \gamma \left[\delta K^{-\rho} + (1 - \delta) L^{-\rho} \right]^{-\nu/\rho}$$

where V is value added, K is the flow of services from capital, and L is the flow of services from labor. The parameters are: γ, efficiency; δ, distribution; ρ, substitution; and ν, returns to scale. As the elasticity of substitution, $\sigma = 1/(1 + \rho)$, asymptotically approaches unity, the CES asymptotically approaches the Cobb-Douglas function. The CES is characterized by increasing, constant, or decreasing returns to scale as ν is greater than, equal to, or less than unity.

The inherently nonlinear CES can be estimated linearly via a Taylor series expansion around $\sigma = 1/(1 + \rho)$,

$$(2) \qquad \ln V = a_0 + a_1 \ln K + a_2 \ln L + a_3 (\ln K/L)^2 + e_1$$

where $a_0 = \ln\gamma$, $a_1 = \nu\delta$, $a_2 = \nu(1 - \delta)$, and $a_3 = -(1/2)\ \rho\nu\delta\ (1-\delta)$.

If ln K and ln L are exogenous, e_1 is an error term representing random influences and the systematic influences of third and higher-order terms of the expansion.[9] Least squares estimates of equation (2) have well-known simultaneity bias if the inputs are related to the error term, but the absence of data on the price of value added prevents the use of a simultaneous equations procedure.[10]

9/ Kmenta has shown that e_1 approaches a spherical distribution around zero as σ approaches one. Since estimates of equation (2) depend on units of measurement, we redefine the units of measure of input so that their geometric means are equal and the mean of ln k is zero.

10/ Courtney presents a joint equations econometric model of the CES using its marginal productivity conditions (which require data on the price of value-added), thereby avoiding simultaneity bias and permitting tests of specification hypotheses.

From the estimates of equation (2), we can test two hypotheses: that the true function is a Cobb-Douglas,

$$H_1: \quad a_3 = 0,$$

and that the CES function has constant returns to scale,

$$H_2: \quad a_1 + a_2 = 1,$$

under the assumption that δ is not zero or one. Since H_1 is a test against no specific alternative function, its rejection can imply that the CES or some other function is the true function. In what follows the rejection of H_1 is assumed to imply the validity of the CES as the true function.[11]

If H_2 is accepted, we impose it on the model as a linear constraint, and obtain

$$(3) \qquad \ln (V/L) = b_0 + b_1 \ln (K/L) + b_2 [\ln (K/L)]^2 + e_2$$

where $b_1 = \delta$ and $b_2 = a_3$. If e_2 is distributed normally,

---

11/ Even so, the interpretation of a_3 in terms of the CES parameters is unclear because equation (2) is derived from the assumption that $\sigma = 1$.

we can test the hypothesis that the function is a Cobb-Douglas with constant returns to scale,

$$H_3: \ b_2 = 0.$$

As before, rejection of H_3 can imply a wide variety of true production functions, but we assume that it implies the CES.

B. The Cobb-Douglas

The Cobb-Douglas is estimated in single-equation logarithmic form as

$$(4) \qquad \ln V = c_0 + \alpha \ln K + \beta \ln L + e_3$$

where e_3 is an error term.[12] Coefficients α and β are the output elasticities of capital and labor, respectively, and are assumed to be constants whose sum is ν. As with equation (2), we encounter simultaneity bias in estimating equation (4).

12/ Griliches and Ringstad estimate the Cobb-Douglas by regressing ln (V/L) on ln (K/L) and ln L, whose respective coefficients are α and $(\alpha + \beta - 1)$, the latter being insignificant if constant returns to scale obtain. Their formulation can reduce heteroscedasticity, but, if the estimate of α is significant and the estimate of $(\alpha + \beta - 1)$ is not, we are forced to use an insignificant coefficient in the calculation of β. Since our purpose is to calculate k_2 from point estimates of α and β, we prefer to estimate equation (4), whose coefficients' significance does not depend on the estimate of returns to scale. If heteroscedasticity is present, as is probable given varying size of affiliates in our sample, direct estimates of α and β remain unbiased, though their estimated variance is suspect.

The hypothesis of constant returns to scale in the Cobb-Douglas is

$$H_4: \quad \alpha + \beta = 1.$$

C. Calculating k_2

Capital-labor ratios k_1 and k_3 are taken to be the observed means. The ratio k_2 is calculated from the estimated parameters of the production functions and from k_1. Assume that the DC and the LDC affiliates are perfectly competitive, or are imperfectly competitive but have identical and constant price elasticities of output demand. Set equal the least-cost ratios of the DC and the LDC affiliates under the assumption that both affiliates face a common wage-interest ratio, $(w/r)'$, and solve for k_2. To illustrate, let D and L be subscripts referring to the DC and the LDC affiliates, respectively, and suppose both affiliates are characterized by Cobb-Douglas functions and face the same wage-interest ratio, say $(w/r)'$. We equate the least cost capital-labor ratio of the DC affiliate,

$$(\beta_D/\alpha_D) \quad k_1 = (w/r)'$$

with the least cost ratio of the LDC affiliate,

$$(\beta_L/\alpha_L) \quad k_2 = (w/r)',$$

and solve for k_2. Table 1 presents computing formulae for k_2 when affiliates are characterized by the Cobb-Douglas or the CES.

D. Testing for Differences in Productive Technologies

Productive technologies differ between LDC and DC affiliates if, when facing the same wage-interest ratio, their least cost capital-labor ratios differ, i.e., k_1 is different from k_2. The null hypothesis is,

$$H_5: \quad k_1 = k_2.$$

We can test H_5 by applying Chow's F-test of the equality of regression coefficients only when both the DC and the LDC affiliates are characterized by production functions of the same form, e.g., both are Cobb-Douglas or both are CES.

Table 1
Formulae for k_2

LDC Affiliate	DC Affiliate: Cobb-Douglas	DC Affiliate: CES
Cobb-Douglas	$\left[\frac{\alpha_L \quad \beta_D}{\beta_L \quad \alpha_D}\right] k_1$	$\left[\frac{\alpha_L \quad (1-\delta_D)}{\beta_L \quad \delta_D}\right] k_1^{1/\sigma_D}$
CES	$\left[\frac{\delta_L \quad \beta_D}{(1-\delta_L) \quad \alpha_D} k_1\right]^{\sigma_L}$	$\left[\frac{\delta_L \quad (1-\delta_D)}{\delta_D \quad (1-\delta L)}\right]^{\sigma_L} k_1^{\sigma_L/\sigma_D}$

IV. Empirical Results

Our data consists of a 1970 cross-section sample of 1484 U.S. majority-owned manufacturing affiliates, of which 697 are in LDCs and 787 in Europe (EEC of six and the U.K.). There are observations on each affiliate, disaggregated to the two-digit level for eight manufacturing industries; the observations of three of the eight industries are further disaggregated, each into one important three-digit industry and into the remaining observations. In our regressions we use the following data: value added, total assets (a proxy for the flow of capital services), and employment (a proxy for the flow of labor services).[13/]

Estimates of equation (2) reveal that we can accept H_1, the Cobb-Douglas hypothesis, in 19 of the 22 industries in DCs and LDCs.[14/] Of the three industries for which H_1 is rejected, in two the point estimates of δ, computed from significant coefficients, exceed one, and in the other industry the estimate of a_2 is insignificant.

13/ See the Appendix for a description of the data. By special arrangement, the Bureau of Economic Analysis (BEA), U.S. Department of Commerce, performed the regressions. For reasons of business confidentiality, BEA did not release the affiliate observations or the regression residuals.

14/ Table 1 shows estimates for 28 industries, 14 each for LDCs and for DCs. To avoid duplication in summarizing industry estimates, we leave aside the six industries (28, 25, and 36) for which we have more disaggregated estimates. Estimates of equation (2) are not reported but are available from the authors upon request. The three industries for which H_1 is rejected are: in DCs, farming, mining and industrial machinery (352), and transportation (37); in LDCs, and electrical machinery except radio, TV and electronics (36-365).

Our inability to reject the Cobb-Douglas in favor of the CES could stem from several factors, including multicollinearity among the data. If multicollinearity obtains, one unattractive way to lessen its effect is to estimate equation (4). Using the estimates from equation (4), we reject the Cobb-Douglas hypothesis, H_3, in only 3 of 22 industries, the same ones for which we rejected H_1, and the point estimates of δ exceed unity in all three cases.[15/]

We conclude that in 19 industries the second-order term is not significant, and in the other 3 industries the point estimates of δ either exceed unity or depend on insignificant coefficients. For the latter industries, either the data are inconsistent with the CES and Cobb-Douglas, or the invalid theoretical underpinning of equations (2) and (4) has incorrectly given rise to estimates apparently inconsistent with the CES and Cobb-Douglas. Since we cannot clearly rule it out for any industry, we proceed to estimate the Cobb-Douglas.

Estimated parameters of the Cobb-Douglas are reported in Table 2. The F-ratios in Columns 6 and 10 indicate that we cannot reject the constant returns to scale hypothesis, H_4, in 18 of 22 industries.[16/]

15/ We do not test H_2 since the quality of this test is suspect if multicollinearity increases the standard errors of the estimated coefficients of equation (2). This would cause us to accept H_2 in some cases when we should reject it (i.e., a type II error).

16/ Griliches and Ringstad, who accept the Cobb-Douglas in almost all cases for Norwegian manufacturing, report that the Cobb-Douglas appears to exhibit increasing returns to scale.

Table 2

Estimates and Tests of the Cobb-Douglas for Manufacturing Affiliates of U.S.-Based MNCs in DCs and in LDCs, 1970*

		Developed Country Affiliates				Less Developed Country Affiliates				
SIC Code	Industrial Name (No. of observations: DC, LDC)	α	β	$\bar{R}^2$	CRS F-Ratio	α	β	$\bar{R}^2$	CRS F-Ratio	Chow Test F-Ratio
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
20	Food (72,77)	.859 (11.0)[a]	.179 (2.37)[b]	.91	0.83	.601 (7.08)[a]	.397 (5.54)[a]	.81	0	3.29[b]
26	Paper Products (30,30)	.551 (6.58)[a]	.410 (5.03)[a]	.90	0.68	.712 (4.55)[a]	.510 (3.53)[a]	.88	7.53[b]	3.87[b]
28	Chemicals (193,232)	.516 (11.43)[a]	.471 (9.94)[a]	.89	0.26	.510 (10.1)[a]	.555 (11.3)[a]	.82	3.62[c]	15.23[a]
283	Drugs (48,93)	.733 (7.48)[a]	.276 (2.90)[a]	.92	0.41	.543 (5.01)[a]	.633 (6.02)[a]	.86	12.78[a]	9.33[a]
28-283	Chemicals except Drugs (145,139)	.497 (9.81)[a]	.489 (9.01)[a]	.89	0.25	.488 (7.41)[a]	.532 (8.35)[a]	.80	0.16	7.33[a]
32	Stone, clay, glass (36,40)	.371 (1.74)[c]	.626 (3.95)[a]	.90	0	.486 (4.37)[a]	.502 (4.18)[a]	.83	0	.40
33	Metals (64,68)	.446 (5.57)[a]	.493 (6.78)[a]	.84	1.31	.600 (7.08)[a]	.344 (3.77)[a]	.79	0.88	5.55[a]
35	Non-electrical machinery (140,56)	.330 (4.07)[a]	.713 (8.31)[a]	.88	1.76	.591 (6.73)[a]	.505 (6.24)[a]	.88	3.14[c]	2.64[c]
352	Farming, mining and industrial machinery (FMI) (82,33)	.102 (1.08)	.856 (8.78)[a]	.88	1.20	.298 (3.60)[a]	.697 (10.23)[a]	.92	0	2.22
35-352	Non-electrical machinery except FMI (58,23)	.550 (4.26)[a]	.549 (3.96)[a]	.89	3.82[c]	.928 (6.04)[a]	.181 (1.14)	.89	1.83	1.35
36	Electrical machinery (86,95)	.404 (4.29)[a]	.656 (8.07)[a]	.91	2.53[c]	.645 (7.53)[a]	.455 (6.37)[a]	.83	3.64[c]	8.30[a]
365	Radio, TV, Electronic equipment (R.TV.E.) (43,41)	.430 (2.57)[b]	.618 (4.08)[a]	.90	0.80	.680 (7.61)[a]	.397 (4.89)[a]	.86	1.01	6.59[a]
36-365	Electrical machinery except R.TV.E. (43,54)	.419 (3.68)[a]	.657 (6.39)[a]	.92	1.74	.534 (3.34)[a]	.573 (4.24)[a]	.81	1.98	1.96
37	Transportation equipment (34,41)	.208 (1.71)[c]	.855 (7.26)[a]	.95	2.38	.329 (2.05)[b]	.713 (4.11)[a]	.89	0.51	1.31
	Manufacturing Total (787,697)	.547 (20.97)[a]	.475 (18.86)[a]	.89	2.85[c]	.571 (19.43)[a]	.469 (17.02)[a]	.91	5.03[b]	24.73[a]

*Superscripts denote levels of significance: a = 1%, b = 5% and c = 10%. All least squares equations are significant at the 1% level, as given by their F-ratios. Numbers of degrees of freedom for each of the t- and F-tests and the number of observations for each industry, will be supplied by the authors upon request.

In cases where we reject constant returns to scale, equations using net fixed assets as a proxy for capital services are associated with decreasing returns to scale, and equations using total assets sometimes yield increasing returns to scale. Regressions using the two components of total assets--fixed plant and equipment, and working capital--as separate measures of capital services reveal that output elasticities of the former are uniformly lower than those of the latter. This is consistent with Bruton's observation that fixed assets tend to be underutilized in LDCs. The difference in output elasticities could have arisen because import substitution policies encourage excess fixed capacity, especially where the size of the market is limited.

If, as Caves hypothesizes, manufacturing firms invest abroad to integrate horizontally, we would expect an MNC's DC and LDC affiliates to produce similar merchandise. To the extent this is so, it is more probable that production functions would not differ between DC and LDC affiliates, though this does not necessarily follow. It is possible, therefore, that our general inability to reject H_5 indirectly supports Caves' hypothesis.

In column 11 of Table 2 the Chow test F-ratios indicate that production functions do not differ (i.e., H_5 is not rejected) between DC and LDC affiliates in 6 of 11 industries.[17/]

In column 5 of Table 3 we present calculated ratios k_1/k_2, together with superscripts denoting the significance of the Chow tests in Table 2. The ratio k_1/k_2 is significantly greater than unity in three industries (20, 283, and 28-283), and significantly less than unity in three industries (26, 33, and 365). In the remaining five industries (excluding 28, 35, and 36), k_1/k_2 is not significantly different from unity. We conclude that technologies differ between DC and LDC affiliates in a number of industries, but no systematic pattern is evident.

In nine industries, k_2/k_3 exceeds unity, which implies that the chosen production process is run more labor-intensively in the LDC due to a lower wage-interest ratio. In only two industries (20 and 283) is k_2/k_3 less than unity. This is a perverse result since we would expect food (20) and drugs (283) to be relatively labor-intensive activities (as is indicated by k_3), employing unskilled labor at relatively low wage rates.

17/ We cannot exclude the possibility that industries for which H_5 is rejected have DC affiliates which produce different outputs than LDC affiliates. Data at a greater degree of disaggregation could reduce this problem, but it was not available to us for regression purposes.

Table 3

Estimates of k_1, k_2, and k_3

SIC Code	k_1	k_2	k_3	k_1/k_2*	k_2/k_3	k_1/k_3
/1/	/2/	/3/	/4/	/5/	/6/	/7/
20	18.0	5.67	13.9	3.17[b]	0.41	1.29
26	20.9	21.7	20.2	0.96[b]	1.07	1.03
28	33.4	28.0	18.4	1.19[a]	1.52	1.82**
283	26.0	8.40	12.5	3.10[a]	0.67	2.08
28-283	35.8	32.3	21.6	1.11[a]	1.50	1.66**
32	13.3	21.7	16.8	0.61	1.29	0.79
33	16.8	32.4	21.9	0.52[a]	1.48	0.77
35	21.4	54.1	15.7	0.40[c]	3.44	1.36
352	19.0	68.2	14.1	0.28	4.84	1.34
35-352	23.1	111.8	16.9	0.21	6.61	1.37
36	12.0	27.6	10.6	0.44[a]	2.60	1.13
365	11.5	28.3	9.0	0.41[a]	3.14	1.28
36-365	13.8	20.2	11.6	0.68	1.74	1.19
37	14.8	28.1	5.8	0.53	4.84	2.55

* Superscripts denote levels of significance: a=1%, b=5%, and c=10%

** In these industries k_1 is significantly greater than k_2, and k_2 exceeds k_3, therefore k_1 is statistically greater than k_3.

V. Conclusions and Observations

Using comparable data on 1484 affiliates of US-based MNCs in eleven manufacturing industries, we have found that:

i) in six industries technology differs between DC and LDC affiliates, but not systematically in a more labor-using or a more capital-using way; and in the other five industries technology does not differ significantly;

ii) returns to scale appear to be decreasing when fixed assets are used to measure capital and sometimes increasing when total assets is the measure, which suggests that affiliates have excess fixed capacity in LDCs;

iii) there is no evidence that the substitutability between capital and labor is more limited in LDC affiliates than in DC affiliates.[18]

18/ Strassmann concludes that in 60% of the Puerto Rican firms and 50% of the Mexican firms he studied, technologies were imported unaltered from DCs. Pickett, Forsyth and McBain, in a study of Ghanaian and Ethiopian sugar and footwear industries, report that foreign firms tend to choose capital-intensive methods although alternative technologies were available. Wells, in his study of 50 plants in 6 Indonesian industries, also finds that foreign firms are more likely to use a capital-intensive technology.

Contrasting evidence is reported by Pack, who reveals that, in a sample of 3 foreign-owned Kenyan firms, more labor-intensive technologies are used. In a matched study of 14 local firms in 9 Mexican and Philippine industries, Mason finds that the U.S. firms employed more buildings but not more equipment, per worker. Strassman reports that, in Mexico, small U.S. durables manufacturing subsidiaries are more likely to adjust their technology to factor prices. Using a sample of 20 firms in the Brazilian capital goods industry, Leff finds that both foreign and domestic firms relied heavily on second-hand machinery imported from DCs. Cohen, using electricity consumption per worker as a proxy for capital in Southeast Asian MNCs, cannot find a clear pattern of technology choice.

A recent study by the International Labour Organization finds that "it is possible to influence the choice of techniques in favour of labour-intensive methods...though policies have sometimes actually encouraged labour-saving techniques." While it may be "possible", the relevant question for LDC policy-makers is: Is it likely that LDCs can influence the choice of techniques by changing the wage-interest ratio, to the extent that such change is politically realistic?

Our analysis has not answered this question, but it does enable two observations:

a) If LDCs have actively pursued policies designed to encourage the foreign investor to adapt his technology in a labor-using way, these policies have not worked, or at least have not had a systematic effect in a labor-using direction. Therefore, to encourage employment in the foreign-owned manufacturing sector, LDCs must pursue policies designed to lower the wage-interest ratio in order to encourage the substitution of labor for capital.

b) If LDCs have not pursued policies which encourage the adoption of labor-using technology, we can say that in the absence of such policies, the foreign-owned manufacturing sector is not likely to adopt widely this kind of technology. Whether these policies would work is a question that cannot be answered until they are implemented.

With respect to the distribution of income, if the Cobb-Douglas function characterizes the production relationships of the foreign-owned manufacturing sector, a lowering of the wage-interest ratio would not reduce labor's share; rather it would stimulate

increased employment at lower wages. To the extent that more workers would be drawn into the "modern sector" from the "traditional sector," the distribution of income may improve.

Turning to non-factor price influences on the choice of technology, a point often overlooked is the extent to which inappropriate technology results from a non-competitive market structure. In many cases, foreign firms producing for domestic LDC markets are protected from external competition by import-substituting tariffs and government licensing, and from internal competition by patents, capital or skill requirements, or market size. Affiliates earning monopoly profits are less likely to use the more efficient technology, especially if this entails older vintage equipment no longer in use by their parent companies. These affiliates may also be more likely to use capital imported from their parent firm at unrealistic transfer prices to increase internal profits.[19/] Many of the expected welfare gains accruing to the host country from direct foreign investment are based on competitive market assumptions.[20/] It is therefore in the interest of LDCs to consider the potential costs of monopolistic or

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19/ See Streeten.

20/ See Hymer, whose second-best solution restricting foreign direct investment relies on the negative social effects on LDC consumers via increased prices charged by monopolistic foreign affiliates.

oligopolistic market structures in foreign-dominated sectors.[21/]

Foreign affiliates engaged primarily in export manufacturing pose an entirely different set of problems. Exporting firms may either produce a homogeneous good for sale on world markets which must be of a certain quality, or components which must be standardized to match predetermined specifications. In either case, the affiliate may be unwilling to adopt a production technique different from that of the parent.

Foreign affiliates and LDC governments have different objective functions. It is sometimes claimed that foreign investors are simply ignorant of technological alternatives or that they confuse technical efficiency with economic efficiency. To the extent that foreign investors seek technical or financial assistance from their home government or international agencies, efforts should be made to explore alternative, more labor-using technologies.[22/]

21/ Using Argentina data for 1955 - 1961, Katz (pp. 149-154) found that highly concentrated industries received above average flows of private foreign investment. A possible explanation for this pattern is that the average rate of return for the highly concentrated sectors was significantly higher than the rate of return of industries with moderate or low concentration. Katz also believes that laws permitting the introduction of equipment and currency at convenient exchange rates free of import duties, favoring industrial promotion, and providing high protective tariffs or complete import restrictions, stimulated private foreign investment in highly concentrated industries.

22/ More than a dozen DCs offer political and commercial risk guaranty programs to their nationals investing in LDCs. The employment-generating effects of these programs offered by investing countries are, however, mixed. To their advantage, guaranties probably stimulate an increased flow of private investment to LDCs, creating a demand for labor and enhancing the competitiveness of markets, except when LDC governments guarantee the investor protection from imports. Additional investment may be stimulated via backward and forward linkages, and this would also increase the demand for labor. To their disadvantage, by lowering the cost of capital (net of fees the investor pays for guaranties), guaranties encourage more capital-intensive operations, just as host country incentives to use capital do.

VI. Suggestions for Further Research: Joint Ventures

Can LDCs affect factor-intensities in manufacturing by encouraging foreign firms to engage in joint ventures with locally owned firms? If so, what factor price conditions must LDCs create to encourage joint ventures?

Utilizing a Cobb-Douglas function under competitive assumptions, equation (5) shows the least-cost capital intensity of a foreign affiliate with respect to the least-cost capital intensity of a joint venture:

$$\frac{k_f}{k_j} = \frac{\alpha_f}{\alpha_j} \cdot \frac{\beta_j}{\beta_f} \cdot \frac{w_f}{w_j} \cdot \frac{r_j}{r_f}$$

where subscripts f and j denote, respectively, the wholly owned foreign affiliate and the joint venture. Can one make any judgments, either based on parameter estimates or on *a priori* theory, which define the range of this series of ratios?

One might hypothesize that, apart from possible political benefits, foreign investors prefer joint ventures only when they wish: to reduce their contribution of venture capital, to acquire local managerial and entrepreneurial expertise, or to seek access to local markets for factor inputs or sales of final product.[23/] It is known that joint ventures involve less transfer of capital and foreign managerial information.[24/] Furthermore, Reuber has found that technological adaptations are more frequent the higher the degree of local ownership and control,

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23/ See Franko, and Friedman and Beguin.

24/ See Vernon.

and the greater the independence of the affiliate from the parent company. Private participation by locally owned firms introduces local expertise of labor market conditions and may blunt somewhat the foreigner's fear of extensive labor use and labor training programs. Joint ventures might be coupled with introduction of more labor-using equipment of older vintage. These factors lead us to believe that both (α_f/α_j) and (β_j/β_f) are greater than unity.

On the factor price side, Diaz-Alejandro has found that in Colombia foreign firms' wages per worker exceed those of locally owned firms, and it is probable that wages in joint ventures would also be less than those in wholly foreign-owned enterprises, implying $(w_f/w_j)>1$.

The cost of capital is also likely to be higher for joint ventures than for exclusively foreign-owned affiliates. This stems from the fact that a foreign parent not only has internal sources of funds which can be tapped by the affiliate, but also easy access to capital markets in DCs; their debt instruments can be sold in secondary markets as well. The local partner does not usually have access to financing at comparable cost, even with LDC government guaranties. Thus, we would expect (r_j/r_f) to exceed unity.

Under all these conditions the least cost capital-labor ratio for the joint venture would be lower than for the wholly foreign-owned venture. Verification that these conditions, or another set of conditions which also yield $(k_f/k_j) > 1$, would confirm the

existence of an alternative means for LDCs to increase labor absorption in manufacturing.

The final, and most interesting, task would be to evaluate the LDCs' two options for increasing employment-generation in the foreign-owned manufacturing sector: (a) lowering the wage-interest ratio to stimulate substitution of labor for capital and the utilization of labor-using technology, and (b) encouraging foreign firms to form joint ventures with locally-owned firms. Knowledge of the costs and benefits to LDCs of pursuing each of these policies would be of immense interest.

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Appendix: Data

Data for 1966 and 1970 on the financial and economic activities of 298 U.S. MNCs and their 5237 majority-owned foreign affiliates were published in November 1972 by the Bureau of Economic Analysis (BEA), U.S. Department of Commerce.[1] All the 1970 data were collected in a special voluntary survey conducted by BEA in late 1971. BEA requested data from 455 U.S. enterprises, and 298, or two-thirds, responded. The sectoral distribution of U.S. reporters is: manufacturing, 75%; petroleum, 11%; other industries, 14%. Of the 5,237 foreign affiliates, 3,752 were in manufacturing when classified on the basis of the U.S. reporter's industry, whereas 2,479 are in manufacturing when classified by industry of the affiliate. The 1970 net worth of the foreign affiliates included in the Special Survey was $42.6 billion.

U.S. reporters were asked to supply data on their majority-owned foreign affiliates, both primary and secondary. A primary affiliate is one that is owned directly by the U.S. parent or its domestic affiliates, and a secondary affiliate is one that is owned indirectly through primary foreign affiliates. U.S. reporters were allowed to consolidate the reports of two or more foreign affiliates if they were in the same country and industry.

For the purposes of the Special Survey, majority-owned foreign affiliates are foreign corporations (i.e., subsidiaries) in which a single U.S. reporter and its U.S. and foreign affiliates own at least 50% of the voting stock, and unincorporated foreign affiliates (i.e., branches) in which an equivalent ownership interest is held. To be eligible for the tax deferral on foreign source earnings, most foreign affiliates in manufacturing are organized abroad as subsidiaries. U.S. reporters were exempted from filing reports on those foreign affiliates having a sum of total assets and total revenue less than one million dollars.

BEA did not attempt to eliminate duplication of assets between primary and secondary affiliates, thus they are overstated to an unknown extent.

Definitions of variables used in our regressions are:[2]

a) Value-added - represents the sum of depreciation, depletion and related charges (line 8), taxes other than income taxes (line 11), net income before taxes (line 14),

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[1]See U.S. Department of Commerce.

[2]See U.S. Department of Commerce. Line numbers refer to pages 31, 33, and 41.

and payroll costs of employees (line 24). It does not include interest costs.

b) Capital - Total assets (line 1).

c) Labor - Number of employees (line 23).

d) Rate of return to capital - Net income after taxes (line 16) divided by total assets (line 1).

e) Wage rate - Payroll costs of employees (line 24) divided by number of employees (line 23).

No data on output prices were available.

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