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Employment and technological choice of multinational enterprises in developing countries

(A literature review and a case study)

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EMPLOYMENT AND TECHNOLOGICAL CHOICE OF MULTINATIONAL ENTERPRISES

Despite the relatively high rates of growth in most developing countries during the 1950-1974 period, problems of unemployment and labor absorption persisted. Since the oil crisis and world economic restructuring in the 1970s, growth rates have faltered, accentuating further the problem of labor absorption. Growth in job creation has rather consistently been slower than in the urban labor force in most developing countries. Unemployment rates commonly range from 8-15% and disguised unemployment may add as much as 10-15% to these rates.

Firm decisions about their technology clearly influence the amount of employment created. At the microeconomic level, firms must decide upon the balance between labor and machines in the production process, decisions which in turn are influenced by product design and quality, scale of production, availability of raw material inputs, and of course the relative price of factors and inputs. Often decisions about technology are made on the basis of a number of constraints and conditions which have to be satisfied simultaneously to yield the most efficient use of firm resources.

The spread of multinational production creates new institutional relationships which may alter or introduce new constraints into the firm's decision-making process: Product design may be more tightly specified for purposes of differentiation; costs of transferring and deploying technologies extant within the MNE framework may be less than developing alternative technologies and production designs; or worldwide quality rules within MNEs may require particular production specification and thus technology. But it remains an open question whether the multinational character of the enterprise is sufficiently strong to

override local market signals, and second, whether multinationality exerts a consistent bias in the ratio of labor to capital.

Beyond these microeconomic perspectives, several macroeconomic concerns influence the rate of employment creation: the rate of investment and policies designed to create certain types of industry are particularly noteworthy.

This study examines the role of multinationals in shaping technology choice and derivatively employment creation. We are interested in testing rigorously the hypothesis that MNEs do employ less labor per unit of capital than do domestically owned firms--and at the same time unravel the complicated determinants of the choice of technology decisions. First, we summarize principal findings of previous studies, paying particular attention to methodological problems. Second, we present detailed findings for one developing country which has relied heavily on MNEs. Finally, we present some conclusions about the role of the microeconomic decisions of MNEs in the choice of technology as balanced against broader market and policy influence at the macroeconomic level.

Theoretical Considerations and Past Studies

There are several reasons why MNEs might employ less labor per unit of capital. MNEs tend to gravitate toward industries with relatively capital-intensive technique because this is part of the monopolistic advantage they enjoy over domestic firms. This has been well established in the literature and our interest in the industry distribution of ownership is confined to controlling for the bias that it might otherwise introduce into the tests. Industry aside, the parent MNE might still choose a relatively capital-intensive technique because it must compare the fixed cost of developing alternative capital-saving technologies with the projected savings in marginal costs of

production in the developing country; presumably, the fixed costs of innovation and plant design outweigh the present value of the future stream of savings, and so MNEs might opt for using the imported, capital-intensive technique of the home country. This is especially true if local markets are small; on the other hand, this may be offset if the parent organization has operations in other national markets with similar relative factor prices where the new production design could be deployed. Second, MNE managers obtain their technology from the home-country organization and rely heavily upon engineers from the home country. These engineers are interested in maximizing the output per unit of labor (average product) to save labor rather than equating the marginal product of labor with the lower wage rate, biasing their choice in favor of the home technology. In this case, institutional imperfections in the flow of information within the organization--in almost a Galbraithian fashion--are seen as the cause of the distortion. It should be noted that both of these reasons are mitigated if MNEs are producing side-by-side with domestic firms which employ a more labor-intensive technology. It should be easier and less costly for MNEs to adapt locally available labor-intensive technologies than to invest in their creation from scratch.

Three other reasons may be responsible for a more capital-intensive technology on the part of multinationals. First, MNE subsidiaries are linked to international capital markets and have access to their parents' financial resources, and so they may actually face a different set of relative factor prices than domestic firms. That is, subsidiaries may be able to obtain capital at a lower cost than domestic firms. In Brazil, for example, there are a priori reasons to believe this does not hold. The National Development Bank (BNDE), an institution of impressive intermediation capacity, is charged with lending funds

at competitive or even subsidized rates to domestically owned Brazilian firms (Baer and Villela, 1980). Also, legislation constrains multinational parents in lending to their Brazilian subsidiaries to prevent abusive transfer pricing through interest charges to subsidiaries. A second reason is that MNEs' planning may be based upon a longer time horizon than domestic firms, and so they anticipate rises in local wage rates, especially for skilled labor. Finally, MNEs may experience a disadvantage in hiring local supervisors to manage a large labor force because of presumably inferior knowledge of domestic labor markets, and so prefer to substitute capital for labor.

Some authors have argued the opposite. MNEs are seen as more efficient business organizations than domestic firms, and so they are at least as responsive to local factor prices as domestic firms. Moreover, from their global perspective, they have greater opportunity to develop and deploy labor-intensive techniques than domestic firms. Domestic firms must rely on international technology investment in searching for alternative production processes.

Besides these debates about MNEs compared to domestic firms, Morley and Smith (1977b) raise a second ownership issue: the performance of multinational subsidiaries from Western Europe and Japan relative to those of the United States. They argue that since capital has been relatively scarcer in Western Europe and Japan than in the United States, Western European and Japanese technologies should be less capital intensive than their American counterparts. While this is probably less true now than it was in the 1960s, there may be some carry-over into production processes currently employed in Brazil. Morley and Smith's study suggests that we can predict a hierarchy of capital intensity by ownership group: U.S. firms are likely to be the most capital-intensive, Western European and Japanese slightly less so but more than domestic firms.

Again, the argument in support of the null hypothesis is that MNEs are sufficiently flexible and efficient to adapt to different relative prices of factors in the developing country.

The literature on this topic is more voluminous than it is conclusive. Two broad groups of studies can be distinguished:

1. Studies Using General Comparisons. These are studies employing various methodologies. Some do not adequately control for industrial location and products; others do so using detailed micro-engineering comparisons with minimal attempts at generalizations across sectors. Nonetheless, they are useful in providing empirical insight into the complexity of the technological choice decision.

Strassman (1968) studied 22 Mexican and 14 U.S. firms operating in Mexico. Foreign firms tended to be more labor-intensive, using older equipment and more shifts, than local firms. But, among the Mexican firms, capital-intensity was associated with higher efficiency. The author argues they were saving on management resources which were a scarce factor and were therefore adapting well and efficiently. Balasubramanyan (1973) found local Indian firms with foreign technology to be more capital-intensive than foreign firms. Pack (1976) also found foreign firms to use labor-intensive techniques more often than their local counterparts. MNEs in his study frequently used labor more intensively and were willing to use older equipment. For India and Colombia, Lall and Streeten (1977) noted that MNEs are generally less capital-intensive in both capital/output and capital/labor ratios. But since the MNE/non-MNE grouping was not found to have a significant input on choice, while the industry grouping was, they conclude that "Transnationality as such does not have a discernible impact: the industrial category is very significant; and size does not seem to

have a strong and uniform influence."[1] Once industrial location is controlled, there is no difference in technology adopted.

However, numerous other studies have pointed to a different conclusion. Wells (1973), for example, found that foreign firms in Southeast Asia are more capital-intensive. But this is qualified: capital-intensive techniques seem to be more closely associated with firms holding some form of monopolistic advantage and it is usually the foreign firms which enjoy such an advantage. This implies that market structure (market concentration and a firm share of its market) must be considered before drawing conclusions.

Morley and Smith (1977) did find differences in the technologies of foreign and domestic firms. In ten of the twenty industries examined, foreign firms were more capital-intensive. However, size shows no influence in increasing the capital/labor ratio as firms become larger. But again efficiency considerations, as in Strassman (1968), qualify the conclusion: in three industries foreign firms were found to be more efficient than Brazilian firms; in the other industries it was impossible to separate the efficiency efforts of MNEs from their tendency to use more capital-intensive technologies. Agarwal (1976) conducted a study for the Indian manufacturing industry at the three-digit level for 34 industries using the Indian industrial classification. He found that MNEs did exhibit greater capital-intensity, a finding he attributed to different factor and input costs. Solomon and Forsyth (1977) produced evidence for the economy of Ghana, "We find the foreign sector firms . . . to be more capital-intensive overall than the corresponding firms in the indigenous sector."[2] They note that foreign firms are markedly less skill-intensive and infer that relatively intensive use of capital might save on the scarce factor--skill. But this interpretation is not corroborated by other studies. Newfarmer

(1980) studying the electrical industry in Brazil found that foreign firms use more capital-intensive techniques. This is related to their size and operation in concentrated markets, but they are not less skill-intensive as found by Solomon and Forsyth (1977); they are, on the contrary, more skill-intensive.

2. Studies Using Matched Pairs Samples. The only way to circumvent the methods--logical problems inherent in many of the studies cited above-- is to compare MNEs and domestic firms with carefully constituted matched samples or otherwise control for production mix. Mason (1973) in a study for the Philippines and Mexico used 14 pairs of firms matched primarily by product and secondarily by size, "On the basis of the data presented here, we cannot single out the multinational firm as a distinct contributor to the factor proportion problem."3/ He found no discernible difference in factor intensity between the two groups of firms. One obvious weakness of the study is the small size of the sample which uses only fourteen pairs of firms.

In his study of Asian countries, Cohen (1975) also has been unable to reject the hypothesis that there is no difference between MNEs and domestic firms. His methodology, however, raises doubts about the results--the author himself determined whether foreign and domestic firms were producing the same commodity. The only criterion used to determine, for example, whether foreign and domestic firms were producing the same commodity was the author's own judgement.

A series of other studies found no differences once industry and product mix were specified. Wilmore (1976) reached a similar conclusion from a study of firms in Central America. His sample consisted of 33 pairs of firms that were closely matched for size and product mix. The results lend no support to the hypothesis that MNEs are more capital-intensive than local firms. Chung and Lee

(1980) add support to this finding in a study at the factory level in South Korea. Production techniques chosen by MNEs and domestic firms did not differ significantly. Carvalho (1977) analyzed the relative performance of MNEs and local firms in Latin America. His study included information for Brazil, Colombia, Central America (Guatemala 82% of the sample, Costa Rica 9%, El Salvador 7%, and Nicaragua 2%) and Mexico. Carvalho also found that the differences between MNEs and local firms are not statistically significant.

On the other hand, limited evidence exists that MNEs do employ a more capital-intensive technique. Newfarmer (1980) found significant differences in Brazil's electrical industry, with MNEs being more capital-intensive. Finally, Flamm's 1981 study of firms in three Mexican industries, perhaps the most econometrically sophisticated study of all, found differences between foreign and domestic firms in only one of three industries.

This brief review of these studies leads to no clear-cut conclusions about the relative capital-intensity of MNEs. We are inclined to agree with White (1979) who concludes that MNEs are neither "the heroes nor the villains" of appropriate technology. Still, the case is not decided and so we must concur with Lall (1978) who argues for agnosticism: no strong statement can be made due to methodological problems, problems of definition, as well as conflicting evidence. Also we conclude that new studies must pay careful attention to methodology. They should be of a matched pair variety and should control for influences other than ownership. They should sort out from ownership the issues of technical rigidity and market structures.

Technical Rigidities

A conceptually separable issue is whether technologies of production are sufficiently flexible to adapt to markets where relative factor prices are con-

siderably different than at home. Is capital perfectly substitutable for labor? If not, then one technology may dominate others with different factor intensities, either relatively (i.e., for a certain range of relative factor prices) or absolutely (i.e., at all factor prices). It is at least arguable that MNE products encounter more rigidity than simpler domestic products.

Opinion is mixed. Lall (1978) concludes from his review of about 20 studies that technologies are somewhat flexible, although he expresses some doubt about the degree of flexibility once products, income distribution, and tastes are specified. He wrote:

> . . . it does appear that efficient technologies may be fairly "rigid" in a plausible range of economic conditions in LDCs. This rigidity applies especially to MNC technologies (since they tend to predominate in complex, continuous process, capital intensive, and modern industries) . . . (1978:237)

Lall qualified this conclusion by saying that peripheral processes (handling, transport, storage, administration, etc.) may be amenable to substitution of labor for capital. Also, core processes may be adapted through greater machine speeds and more shifts, subcontracting, use of lower quality inputs, and in rapid change in technique and models (1978:238). Lawerence J. White (1976) arived at slightly more sanguine conclusions in his review of more than 50 studies: "There do seem to be plenty of opportunities for more labor-intensive methods to be used." (1976:20) He agrees with Lall that there is a strong link between product type and mix and technical choice, and "there do seem to be opportunities for a more appropriate product mix." Although there is considerable divergence of opinion, Lall and White are joined by an impressive array of other economists who have reviewed parts or all of this voluminous literature, including Baer (1976) and Helleiner (1975). Bruton's 1974 survey is the most optimistic as he proclaims: "Factor substitutability is alive and well

in developing countries." White expressed the majority opinion, however, in saying that "the ranges of choice are far from complete on both the production process and product sides. The economist's smoothly curved production isoquant is rarely present." (1976:20)

The difficulty of arriving at a general conclusion stems from the great variety of production processes across industries. Some industries, such as petroleum refining, exhibit high degrees of technical rigidity; others, such as clothing, exhibit low degrees. Studies of individual processes using engineering data are undoubtedly the best way of establishing the nature of the rigidities. It is usually difficult to test econometrically the effects of technical rigidities using cross-sectional data. However, the present study seeks to generalize across several industries by taking advantage of the engineering "index of technical rigidity," developed by Forsyth, McBain, and Solomon (1980), and discussed at length below.

Market Structures

Market structure also plays a central role in technological choice, a point developed by Wells (1973). His argument was that only the absence of strong market competition would permit the simultaneous existence of different technologies in the market with different cost functions. If firms are compelled to accept a given market price, they can use radically different techniques only so long as (a) the techniques allow the same minimum average total costs or (b) one set of firms (those electing to use the less efficient technique) accept a persistently lower profit margin. Oligopolistic firms in concentrated markets, however, face less stringent discipline from market prices. This theoretically permits both wider margins (allowing room for discretionary technological choice) and greater inefficiency in technological choice, since it permits firms

or groups of firms to price a mark-up over unit costs. Thus, conventional measures for market concentration should have an independent influence on technological choice.

The Case of Brazil: Data and Measures

Brazil offers fertile ground for detailed studies of the choice of technology. It has relied heavily on MNE investment and markets in promoting development. Its industrial and market structures look much like other newly industrializing countries with large internal markets, especially in Latin America.

In 1980 MNEs accounted for about 40% of sales of the largest 4,000 firms. Their share of fixed assets was 26% and employment was 41%. Their share of employment is higher than their fixed assets because of the enormous capital intensity of the state-owned firms. (See Table 1.) Their relative employment share is somewhat lower than Brazilian firms.

Table 1

MNE Share of Sales, Fixed Assets, and Employment: Largest 4,000 Firms, 1980

Sales	MNEs	Brazilian	State	Total
Fixed Assets	26	26	48	100%
Employment	41	47	12	100%
Ratio of Employment to Fixed Asset Share	1.58	1.80	0.25	
Number	666	3,254	82	4,002

Source: Lino Moreira "Multinationals in Brazil and Choice of Technology," Ph.D. Dissertation, University of Notre Dame, 1983.

Data were collected for a sample of Brazilian and multinational firms covering the years 1974 to 1978. Because of gaps in information, exact coverage varies slightly in the number of firms. The whole sample covers 18 major industrial groups (two-digit IBGE industries) and 153 minor industries (four-digit IBGE industries). No state-owned firms were included. All data were converted to constant 1977 cruzeiros and pooled for the analysis. The firm-level data were supplemented with industry-level data obtained from census tabulations and other sources as well as industrial data from the United States. All variables are listed in Appendix A according to their symbols and contain a brief description of each and their manner of computation. In the course of the tests that follow, we present succinct explanations of the variables.

The most difficult aspect of testing for differences among ownership groups is controlling for industries. The Hymer-Kindleberger Caves theory of foreign direct investment[4] predicts that MNE will invest in industries where they have some monopolistic advantage relative to local firms. As noted above, this

suggests that the ownership distribution of assets among industries will be biased, distorting any comparison of the aggregate manufacturing sector and raising the problem of controlling for industrial location. To overcome this obvious problem, we used two procedures in the tests that follow: First, we conducted the tests using the complete sample with controlling for industry distribution using dummy variables for eighteen two-digit industries. Second, we created a sub-sample of "matched" sets of firms in each four-digit sub-industry. This sampling procedure ensured that there was an equal number of observations for Brazilian and foreign companies in each four-digit industry; where possible we tried to include a balance among U.S. and non-U.S. firms among the foreign firms in the sample. This procedure yielded a sample of 172 firms with 258 firm-years distributed over 40 four-digit minor industries and 14 two-digit major industries. Of the 129 MNE firm-years, 53 were U.S.-based and 76 were non-U.S. Consequently in each of the tests below we used two separate samples.5/

The dependent variable used in the analysis is an indicator of labor intensity:

LKR1 = Ratio of total employment to fixed assets.

The ratio is highly correlated with other measures of labor intensity, such as the ratio of production workers to fixed assets, or the ratio of total employment to plant and equipment.

Let us consider the independent variables in four categories: ownership measures, index of technical rigidities, structural measures, and control variables.

Ownership Measures

Firms were classified by the ownership of their controlling group using

Jean Bernet's Guia Interinvest, Visao, and other available information. For our purposes, we defined foreign control as owning 25 per cent or more of total equity; only 37 of 550 firms were minority-owned, the rest being majority or wholly-owned subsidiaries. Foreign firms were subdivided into two categories--U.S. and non-U.S.--based upon the parent controlling the largest outstanding equity share. We thus employ the following variables to denote ownership control:

OWN = A dummy variable indicating domestic or foreign ownership; zero if Brazilian, one if foreign controlled.

This is used in the first set of regressions. A second set examines the hypothesis that U.S. and non-U.S. firms have distinct technological behavior and we use:

US = A dummy variable representing U.S. firms; one if U.S., otherwise zero.

WECJ = A dummy variable representing non-U.S. firms; one if non-U.S. foreign company, otherwise zero.

When both variables are in the same model, the default category (the intercept term), is for Brazilian firms. (All state-owned firms have been excluded from the sample.)

OWN is predicted to carry a negative sign if foreign firms do employ less labor per unit of capital. Likewise, US and WECJ are predicted to have negative coefficients, US more so than WECJ.

Index of Technical Rigidity

To capture the variance accounted for by technical rigidities of production, we relied on the index developed by Forsyth, McBain, and Solomon (1980). The authors examined 181 four-digit industries, and their sub-processes in manufacturing to determine if engineering requirements created absolute or rela-

tive domination of some factor intensities over others. The authors painstakingly scored the disaggregated, sub-processes of each industry according to whether the technologies of production involved any of the following eight "physical barriers to the substitution of labor for capital" (1980:375):

--The use of high- or low-process temperatures;

--The presence of fluids (liquids or gases);

--The application of fluid pressure on materials in process;

--The need for high-speed operation;

--The achieving of close manufacturing tolerances;

--The application of electrical power and of high-load factors;

--The handling of indivisible heavy materials; and

--The presence of special hazards.

Scoring was 0-1 for each barrier to yield a 0 to 8 scale. Thus, the higher is this index of technical rigidity, the more rigid are techniques with respect to the substitution of labor for capital. The index cannot weight the importance of each subprocess, and this may limit its accuracy. Still, it provides a fairly flexible way to incorporate an engineering estimate of technical rigidities into cross-sectional analysis. The measure then is:

ITR = Index of technical rigidity as calculated by the presence of technical barriers to the substitution of labor for capital.

ITR is predicted to be negatively associated with LKR1 since technical rigidities lock the production process into a relatively capital-intensive technique. This measure should capture the variance associated with technical rigidities, and permit more accurate measurement of the effects of ownership and market structure.

Structural Measures

To capture the influence of market power and the ability to engage in mark-up pricing, we use a conventional measure of oligopolistic market structure:

CR4 = Share of the largest four plants in an industry's total value of shipments in 1973.

This measure has somme obvious weakenesses, the principal being that a leading firm may own more than one plant and so it probably understates the level of concentration actually found in a market.)[6] The difficulties of relying on this measure are attenuated in the case of Brazil because multiplant operations are probably less common than in large, geographically-dispersed economies.[7] In addition, four-digit industries classified according to the IBGE classification are slightly broader than they are in the United States, leading to the inclusion of more non-competing sub-products in the definition of the market. Overall, this suggests that CR4 may be a weak proxy for market power. CR4 is predicted to have a negative relation with LKR1.

An additional measure that captures the relative position of the firm within a market is its relative market share. Leading firms in markets with declining costs can absorb slightly higher costs in inefficient technologies and not lose market share. Data were collected for the value of shipments for the leading products of each firm within the sample and these were classified by four-digit IBGE markets. We could then calculate:

RMS = Relative market share of firm (as calculated from product level data of sample of firms).

Two distortions may weaken the effect of this variable: There are undoubtedly some industries where costs are increasing and so industry leaders may have no scope for the luxury of choosing an inefficient technology. Second, this measure is subject to many of the same empirical limitations as that for concentration, particularly the problem of non-competing subproducts, weakening

its overall effect; on the other hand, our sample may have occasionally missed a large producer, overstating the relative market share. As with CR4, the predicted outcomes for RMS is a negative association with the labor-capital ratio.

Control Variables

We include four control variables in the different tests. Firm size, while included here as a control, is to some extent a behavioral variable since firms can choose to establish varying sizes of operations. (It should be noted that size is different from technologically determined economies of scale; when we calculated a proxy for minimum efficient scale, including cost penalties at less than MES, we found the variable had only a .04 positive correlation with SIZE. It is also necessary to control for the level of vertical integration. These variables then are:

SIZE = Size of firm measured in total gross operating revenue.
VERTI = The degree of vertical integration of firms as measured by the ratio of value added to sales.

Both SIZE and VERTI are predicted to have a negative relation with LKRI.

It could also be argued that the reason for a lower rate of labor to capital for multinationals is their reliance on "technologically intensive" production processes. More skilled workers, for example, using more machines can reduce the labor content of a production process while increasing output. Even if firms pay labor the value of its marginal product, the segmentation of the labor market between skilled and unskilled might lead firms to use an ostensibly more capital-intensive production process--but to do so more efficiently. In this case one would predict a negative association between technological intensity and the labor-capital ratio. Our proxy for technological intensity is:

SKENTO = The ratio of skilled workers plus engineers to total employment within the firm.

Other proxies might have been preferable (for example, the level of research and development expenditures, etc.), but these were unavailable. SKENTO is seen as a control variable and predicted to have a negative association with LKRI.8/

Econometric Tests of the Hypotheses

Overview of the Variables

Table 2 presents the means and "t" tests for differences of the seven variables of interest in this paper. MNEs on the average have a significantly lower labor to capital ratio, have higher relative market shares, are much larger, are vertically integrated, and employ a higher share of skilled labor in their labor force.

Table 2

Data Average by Ownership Group

	Brazilian and MNE Compared			US and NON-US Compared		
Matched Sample	Brazilian	MNE	T	US	NON-US	t
LKR1	.015	.011	2.98	.010	.011	-0.71
ITR	2.23	2.12	.47	2.45	1.90	1.65
CR4	.39	.39	.12	.43	.36	1.96
RMS	.07	.14	-4.00	.12	.15	-0.95
SIZE	485,932.00	803,914.00	-3.19	654,743.00	953,770.00	-1.88
VERTI	.57	.61	-2.40	.64	.60	1.74
SKENTO	.178	.191	-0.64	.18	.20	-0.61
Number*	129	129		53	76	

* Firm-Year Observations.

Multiple Regressions: MNEs and Brazilians

This section examines the relationships of ownership, technical rigidity, and market structure considering only the distinction between Brazilian and all other foreign-owned companies (captured in OWN). A subsequent section discriminates between U.S. and non-U.S. multinationals.

Table 3 presents the regression results. OWN is consistently negative as predicted. In all equations it is statistically significant at the 10 per cent level or better. We therefore conclude that, in Brazil at least, multinationals do employ less labor per unit of capital relative to domestic firms, even when controlling for technical market structure, firm size, vertical integration, and industrial location.

Table 3

Labor-Capital Ratio (LKR1) Regressed Upon Ownership Technical Rigidities, and Control Variables (Matched Sample)

	2.1	2.2	2.3	2.4
OWN	-.004	-.004	-.004	-.004
	(-2.593)	(-2.622)	(-2.613)	(-2.517)
ITR	-.002	-.002	-.002	-.002
	(-5.080)	(-5.087)	(-5.125)	(-5.080)
RMS	.002	--	.002	--
	(.266)	--	(.270)	--
CR4	.001	-.002	--	-.002
	(.068)	(-.673)	--	(.662)
SIZE*	-2.331	-2.678	-2.323	-2.772
	(-2.604)	(-2.766)	(-2.637)	(-2.847)
VERTI	-.006	.003	-.006	-.003
	(-1.067)	(.534)	(-1.073)	(-.438)
SKENTO	--	--	--	-.005
	--	--	--	(-.936)
INTERCEPT	.023	.021	.023	.022
	(6.635)	(5.378)	(6.943)	(5.411)
DF	202	222	204	221
F-Ratio	7.44	9.49	9.10	8.05
R^2	.18	.18	.18	.18

*coefficient x 10^{-9}

It should be noted, however, that the models in Table 3 explain only 18% of the observed variance. Most of the variance in technical choice is of course among industries producing quite different products. This suggests the important conclusion that decisions by government planners and by consumers and producers through the market about which industries to establish in Brazil are markedly more important in determining labor absorption than technology choices of firms within particular industries.

By way of illustrating this, we ran the same model using a full and unmatched sample of 550 firms and adding dummy variables for each of 18 two-digit industries. The R^2 of the equation rose to over .50 for all the models, while the OWN variable remained consistently significant and negative. (The performance of the other variables was also the same as in Table 3, though generally stronger.)

Returning to the more precise, matched sampling procedure in Table 3, it can be seen that the index of technical rigidity (ITR) also performs as predicted; more technically rigid industries are associated with more capital intensive production processes. ITR is significant in all equations, usually at better than the one per cent level. Thus, despite the problem of weighting internal production processes, ITR performs rather well and proves to be a useful way to incorporate engineering information into cross-sectional analysis.

The measures for market structure perform less well. CR4 carries the predicted negative sign in all equations in which it appears, but lacks statistical significance. The limitation of the measure as a way of capturing market power may also be responsible for its low statistical significance. The results for RMS are even more disappointing; they are inconsistent with our expectations and lack statistical significance. This leads us to believe that measures of market

power focusing on industrial concentration rather than market share may afford the better vehicle for capturing the influence of market power. It should also be noted that when the models were weighted (to correct for the limited problem of heteroskedasticity described in footnote 7), CR4 and RMS became significant and strongly negative. Thus we find some evidence but not considerable amounts in support of the hypothesis.

In all three procedures SIZE has a strongly negative, significant influence on the labor-capital ratio. This led us to give credence to the importance of small enterprise in employment creation. VERTI, our measure of vertical integration, functions here more as a control than for its explanatory power, which is generally positive.

Technological intensity, as measured in the skilled--total employment ratio (SKENTO), does not seem to have the negative effect predicted. This was true even when other forms of the model were tried as well. This, together with the results of ITR, suggests that the rigidities of the production process, more than the sophistication of production processes per se, explain the low labor to capital ratio.

U.S. and Non-U.S. Behavioral Difference

Subdividing the multinational group into its U.S. and non-U.S. components permits us to examine the Morley-Smith hypothesis that U.S. firms employ less labor relative to their West European, Canadian, Japanese, and other non-U.S. counterparts. (There were three multinationals from outside the industrialized countries in the sample.) For these regressions, OWN is replaced by US and WECJ as the variables representing the various ownership groups. The default category is the Brazilian sample, and US and WECJ represent adjustments to the intercept. Table 4 presents the results. The coefficients for US and WECJ are

Table 4

Labor Capital Ratio (LKR1) Regressed Upon, Brazilian U.S. and Non-U.S. Proxies and Other Variables

US	-.004
	(-2.22)
WECJ	-.003
	(-2.07)
ITR	-.002
	(-4.99)
RMS	-.002
	(.26)
CR4	.0002
	(.082)
SIZE*	-2.36
	(-2.62)
VERT	-.006
	(-1.03)
INTERCEPT	.023
	(6.54)
DF	201
F-Ratio	6.36
R^2	.18

*Coefficient x 10^{-9}

only slightly different from one another but both are statistically significant.

It is possible that if there is any difference within the transnational sector, it is not nearly so great as the difference between the domestic and transnational sectors. The differences between foreign and domestic firms in Table 2 consistently held at .004 are substantially higher than the inconsistent .001 differences between U.S. and non-U.S. firms in Table 4.

By way of summary then, Table 5 shows how many jobs are created with an investment in fixed assets of 1977 Cr$million (approximately US $100,000) corresponding to firm size and to ownership (Brazilian vs. Foreign) in the first part of the table, and concentration and ownership in the second part of the table. In the first part, it is apparent that a small Brazilian firm of Cr$10 million in size that invests Cr$1 million in a plant will, on the average, directly create 18.3 jobs; a large firm of Cr$5 billion in size investing the same amoung will create only 5.02 jobs. Multinationals in each size category will create considerably fewer jobs.

Similarly, we can see in the second part of the table the effects of concentration. While not nearly so dramatic as the effects of size of ownership, the effects nonetheless are strong. An increase in the share of the top four firms from 20 to 80 per cent is associated with declines in the number of jobs produced from 16.5 to about 14.7 per Cr$1 million in fixed assets. It should be remembered that the relationship between market structure and the labor-capital ratio, thought theoretically strong, found only weak statistical significance in our tests, probably because of our measures; the results are sufficiently promising for policymakers to examine market structure as a variable affecting employment policy.

Table 5

Number of Jobs Created with Cr$1 Million Invested in Fixed Assests: By Size, Concentration, and Ownership Category of Investing Firm

Firm Size and Ownership

Size Class of Firm (Cr $1,000)	Brazilian	Foreign
10,000	18.33	14.33
100,000	18.09	14.09
1,000,000	15.69	11.69
2,500,000	11.69	7.69
5,000,000	5.02	1.02

Concentration and Ownership

Four Firm Concentration Ratio	Brazilian	Foreign
10	16.49	12.49
20	16.29	12.29
30	16.09	12.09
40	15.89	11.89
50	15.69	11.69
60	15.49	11.49
70	15.29	11.29
80	15.09	11.09
90	14.89	10.89
100	14.69	10.69

Source: Estimated from equation 2.2, holding other variables constant at their mean.

Smith's earlier findings, though of course other studies have found the opposite.

Fourth, the differences between the multinational sector and the private Brazilian sector are more important than differences between U.S. and non-U.S. firms within the multinational sector. While the coefficients were slightly different in some cases, the signs proved inconsistent and the coefficients smaller, across several models.

Finally, Conceicao Tavares (1978) is probably correct in emphasizing the importance of firm size in the choice of technology. Other things being equal, larger firms do create fewer jobs with the same amoung of capital than do smaller enterprises, be they multinationals or domestic firms.

These findings illustrate the importance of ownership, technical rigidities, and market structure as determinants of the choice of technology. Still, it would be erroneous to make policy suggestions without being aware of a "larger picture." First, employment creation is not the sole objective of policy making. Bear and Herve (1966) pointed out long ago that a more overarching objective is efficient use of both labor and capital to maximize output. Therefore, before any policy lessons could be entertained, it would be necessary to weigh alternative resource use against existing patterns. This implies extending our analysis to consider the relative efficiency of Brazilian and multinational technologies. The same could be said for alternative size and market structures. A second caveat entails the linkage effects of alternative technologies. It may well be that one apparently capital-intensive technology has greater employment creation effects through its upstream or downstream linkages. This cannot be fully assessed without highly disaggregated interindustry analysis that discriminates among competing technologies.

Third, and perhaps most important, our findings at the firm level explain only about 20% of the observed variance in the choice of technology. Clearly most of the variance occurs between industries due to different products, not within industries. This is more than a statistical point: Governmental and market choices to establish particular industries in lieu of others are of far greater importance in influencing the capacity of the economy to absorb labor.

A few positive policies warrant closer examination. First, the decision to establish a particular mix of industries probably has far greater implication for labor absorption than does the decision to promote particular ownership groups within those industries. Only sophisticated governmental planning can actually create the conditions for a country to be able to make such decisions. Second, policies of governments to support domestic enterprise, such as those thorugh the National Development Bank (BNDE) in Brazil, appear to have advantages of greater labor absorption. This is especially true for programs aimed at the same business sector where investments of capital produce relatively large gains in the number of new positions. Likewise, firms in competitively structured industries also show higher potential for job creation relative to oligopolistic industries. These programs gain some justification from the analysis in this paper. The analysis also supports a policy emphasis on fortifying a domestic private sector for increased direct employment creation.

Footnotes

[1] Sanjaya Lall and Paul Streeten, Foreign Investment, Transnationals and Developing Countries, Boulder, Colorado: Westview Press, 1977, p. 110.

[2] R. Solomon and D.J.C. Forsyth, "Substitution of Labor for Capital in the Foreign Sector: Some Further Evidence," Economic Journal, June 1977, 87 (343), p. 288.

[3] R. H. Mason, "Some Observations on the Choice of Technology by Multinational Firms in Developing Countries," Review of Economics and Statistics, August, 1973, 55 (3), p. 354.

[4] This is summarized nicely in Connor (1977), Bergsten, Horst, and Moran (1978), and Newfarmer (1981).

[5] Since the results were quite similar for both tests, we report important differences in the text. For clarity of exposition we report in detail only the tests using the matched sample, which in our view is the preferable procedure.

[6] While this measure understates the level of concentration on average in the market, it does have strong correlations with firm level correlations. For implications of various concentration indices, see Rosenbluth (1955), Blair (1972), and Vanlommel, Brabender and Liebaers (1977).

[7] Connor (1977) created what he termed "minimum concetnration ratios: by merging market share data collected in a survey from U.S. MNCs in 1972 with plant concentration ratios for 1970. Our measure CR4 is positively and significantly correlated with his at .68.

[8] A word should be said on the problem of heteroskedasticity. In tests using firm-level, cross-section data, heteroskedasticity is a common problem usually requiring a weighting procedure to correct for any systematic relationa between the variance of the error term and one or more of the independent variables. We tested for heteroskedasticity by using the Glejser test. This involved regressing the absolute value of the residuals from the original equation on the independent variables. The R2 from this equation was only .115 indicating a relatively low level of correlation between the residual and the independent variables. We did find ITR to be the variable most correlated with residuals. This stands to reason since, by definition, firms with less rigid production functions have more choice in their techniques. If anything, this corroborates the usefulness of ITR. We tried two weighting procedures to overcome this difficutly, one wieghting by the reciprocal of the square root of total assets and the other by the reciprocal of the square root of ITR. Nonetheless, none of our weighting procedures was successful in reducing the per cent of variations explained beyond the original 11.5%; in fact, the weighted models increased the total correlation of the residual by nearly twice as much. So we conclude that the unweighted original data provide the best econometric tests.

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Appendix

CR4 - 4 Plant Concentration Ratio

CR4 is the sum of the output of the four largest plants in an industry divided by the total output of the industry. CR4 is taken from the computations done by Conceicao Tavares (1978).

ITR - Index of Technical Rigidity

Taken from the work of Forsyth, McBain and Solomon (1980). The authors identified industrial processes used in production which are fairly "rigid" (that is, in which labor cannot efficiently be substituted for capital). Eight "rigid" processes were identified and each industry was scored on the basis of how many of these process it used. Thus the more of these eight processes that an industry used, the higher its ITR and the more technically rigid it is. Because of the level of aggregation of the industry, it was infrequently necessary to assign an ITR to a 4-digit industry based on its corresponding 3- or 2- digit industry classification.

LKRI - Labor Capital Ratio

Total number of employees divided by total fixed assets for each firm in the sample.

OWN - A Dummy Variable for Ownership

OWN is set equal to 1 if foreign controlled; 0 otherwise. A firm was considered foreign controlled if at least 25% of a firm's equity is owned by a foreign company. (Source of basic data: Ministry of Finance, Brazil, and Bernet, 1976)

RMS - Firm Relative Market Share

RMS is the share of a firm's output to the total output of specific industries. For each industry that a firm produces in, the ratio of the firm's output to the industry's output is taken. These ratios are then weighted by a product's share in the firm's total output. RMS is the sum of these weighted ratios for each firm. (Source of basic data: Ministry of Finance, Brazil and firm product data)

SIZE - Size of a Firm

Gross operating revenue of the firm for each firm in the sample.

SKENTO - Relative Number of Skilled Workers

Sum of skilled workers and engineers divided by total number of employees.

US - A Dummy Variable for U.S.-owned Firms

US is set equal to 1 if the largest foreign shareholders in a firm previously classified as having an OWN-1, are U.S.-based firms; set to 0 if the major foreign shareholders are non-U.S.-based or if OWN = 0. (Source of basic data: Ministry of Finance, Brazil and Bernet, 1976)

VERTI - Vertical Integration

Gross operating revenue less cost of sales plus the result of the cost of goods sold less cost of raw materials. This sum was divided by gross operating revenue.

WECJ - A Dummy Variable for non-U.S.-owned Firms

WECJ (Western Europe, Canada, Japan and others) is set equal to 1 if the largest foreign shareholders in a firm previously classified as having an OWN = 1 are firms based in Western Europe, Canada or Japan; set to 0 if firms are based in the U.S. or if OWN = 0. (Source of basic data: Ministry of Finance, Brazil and Bernet, 1976)