ECONOMIC GROWTH CENTER

YALE UNIVERSITY

Box 1987, Yale Station
New Haven, Connecticut

CENTER DISCUSSION PAPER NO. 293

PRODUCTIVITY, MECHANIZATION AND SKILLS:

A TEST OF THE HIRSCHMAN-LEWIS HYPOTHESIS FOR LATIN AMERICAN INDUSTRY

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July 1978

Content

July, 1978

Preliminary. Only for comments.

Productivity, Mechanization and Skills: A test of the Hirschman-Lewis hypothesis for Latin American industry.

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INTRODUCTION

In his seminal work The Strategy of Economic Development, Hirschman, (1961), proposed a hypothesis which, not unlike other ideas of his, was paradoxical and has given rise to numerous comments and attempts at proof or refutation. According to it, in LICs (less industrialized countries) the differences in labor productivity with respect to ICs (industrialized countries), would be smaller in industries which, although capital intensive, being "process-centered" or "machine-paced", are not so dependent on the quality of labor. In his words:

> "....The criteria developed here do point toward certain highly capital-intensive pursuits as particularly well suited for underdeveloped countries. The list includes thus far: large scale ventures, activities that must be maintained in top working order, that must observe high quality standards for their output, machine paced operations, and process-centered industries. .... If we are correct, labor productivity differentials between an underdeveloped and an industrial country should be much larger in certain industries (e.g. metal fabricating) than in certain others (e.g. cement) even when essentially similar techniques are used in both countries."
>
> (p. 152)

Although Hirschman alludes in the text to multiple criteria and it is very difficult to try to assimilate his analysis to only one indicator

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The viewpoints expressed do not necessarily represent the official position of the Bank. Preliminary results contained in this paper were presented in seminars held at the Inter-American Development Bank, Washington, D.C. and the Instituto Di Tella, Buenos Aires. I am grateful to Carlos F. Diaz Alejandro for his comments.

or variable, in the discussion of his hypothesis, emphasis has generally been placed on the role of factor intensity. That is to say, on the possible existence of a Leontief-type paradox since confirmation of the hypothesis would imply that the LICs could develop a comparative advantage in capital-intensive manufactures. As pointed out by Hirschman himself, it is very difficult to define industries which are "process-centered" or "machine-paced"--in opposition to those being "product-centered" or "operator-paced". "Process-centered"is not synonymous with capital-intensive, while "product-centered" can not be considered as equivalent to labor-intensive. Besides, industries generally include a combination of processes and activities, some more capital-intensive than others, etc.

One of the principal implications of Hirschman's analysis seems to be that in those activities which could be transplanted to LICs with a minimum of distortion due to local conditions, where the machines or processes determine the rate of output or yield, and where human intervention is minimal or not critical, there exists a built-in compensation for the lack of labor skills, the poor organization of work, the more rudimentary methods of programming and control of production, etc.

Starting directly from relative factor endowments and focussing in particular on the availability of labor skills, Lewis, (1965), reached similar conclusions although with a different formulation:

> "High capital intensity is appropriate when it embodies greatly superior technology, without demanding very high skills. ...Now there is no a priori reason for developed countries to have a comparative efficiency advantage in capital intensive industries, and one can easily construct cases where the comparative advantage remains with the underdeveloped country, even when the relatively higher cost of capital is taken into account."
>
> (p. 13)

> .."The right answer will favor capital intensity in the countries which are short of capital if capital can be used without skill."
>
> (p. 16)

The hypothesis and trade theory

In fact, as Lewis has observed, the prescription of comparative advantage resulting from the Hecksher-Ohlin theorem is based on assuming that the ICs and the LICs produce with the same technology, (i.e. production function), however, if industrial production functions utilized in both groups of countries are different, a Ricardian, or modified Heckscher-Ohlin type of analysis must be applied (Lewis, p. 16; Bhagwati (1964)). In a Ricardian world, producing with different, but let us assume, homothetic production functions and the same technique, implies the same relative prices and factor proportions. In this case,both labor per unit of output and capital per unit of output would be greater in the LIC (and the productivities smaller) and consequently, average labor productivity could be used as an indicator of total factor productivity. Under Heckscher-Ohlin-Samuelson, assuming the same production function and different factor endowment, thus different prices, both countries will employ different factor proportions, and the lower capital per unit of output of the LIC will be accompanied by a higher labor per unit of output ratio, equivalent to lower labor productivity. In this case,a measure of labor productivity would not be representative of total factor productivity since very low labor productivity may be accompanied with very high capital productivity and the result be equal technical efficiency. Allowing for different production functions and different factor endowments, whether we are able to make a clear characterization of total factor productivity by means of labor productivity will depend on the particular case. In the special case, when capital per unit of output is the same, (due, for example, to rigidity in the core process), the difference in productivity could be measured by the difference in labor productivity, but, this could not be generalized, as in the Hirschman hypothesis. In the Ricardian model, same technique can only mean same factor proportions, technology being of course different for ICs and LICs. In the Heckscher-Ohlin-Samuelson model, technology is the same by definition, and techniques (i.e., factor proportions)are different also by definition. In the mixed model, we may have different techniques and different production functions and no a priori generalization seems warranted.

Previous work testing the hypothesis

Various attempts have been made to verify Hirschman's hypothesis. Most of these studies consisted of labor productivity comparisons at the industrial branch level between an IC and a LIC. In most cases, the independent variable was a measure of capital intensity, although some studies included additional variables. The results obtained so far are mixed although it is fair to say that a majority of the studies find some support for Hirschman's hypothesis in its various formulations. In Table 1, we provide a brief comparative summary of the studies undertaken by Diaz-Alejandro (1965), Bacha (1966), Clague (1967, 1970), Healey (1968) and Gouverneur (1970), including some of the key characteristics of each study and their results. A review of some of these studies is also given in Bhalla (1976).

Table 1

Summary of tests of the Hirschman hypothesis

Author and year	Countries compared	Dependent variable(s)	Independent Variables	Method	Industries	**Results**
Diaz-Alejandro (1965)	Argentina-United States	Value added per operative	Labor intensity measured by proportion of salaries in value added. Establishment size measured by the average number of operatives per establishment in Argentina. Relative size; Argentina/USA, measured by the ratio of the average numbers of operatives per establishment in both countries.	Multiple linear correlation	63 manufacturing industries	Generally favorable to the hypothesis that relative labor productivity will be greater in more capital intensive industries but with qualifications of the results.
Bacha (1966)	Mexico-United States	Value added per operative Value added per unit of fixed capital	Capital intensity measured by the value of fixed capital per-worker in Mexico.	Simple linear regression	45 manufacturing industries	Mixed. Theory of comparative advantage based on factor proportions still has explanatory value and it is possible that no paradox exists.

Table 1, continued

Author and year	Countries compared	Dependent variable(s)	Independent Variables	Method	Industries	Results
Clague (1967)	Perú - United States	Average relative productivity Average relative efficiency	Capital intensity Economies of scale	CES production function	11 manufacturing industries	Favorable to the hypothesis that relative efficiency increases with the capital intensity of Peru's and USA's industries.
Healey (1968)	India - United Kingdom	Average productivity measured as value added per operative	Capital intensity measured by the book value of fixed capital per operative in India. Size, measured by the average number of operatives per establishment. Mechanization measured by the electric energy consumed per operative.	Multiple linear regression	110 manufacturing industries	Slightly favorable to the hypothesis-capital intensity has an effect in determining the level of relative productivity, but there seems to be a technological "gap".
Clague (1970)	Peru - United States	Relative efficiency.	Latitudes: i) Manual dexterity ii) Quality iii) Work schedules iv) Maintenance	Two factor productivity with correction for labor quality	11 manufacturing industries.	Confirms that with greater latitude there is less efficiency.
Gouverneur (1970)	Congo - Belgium	Average productivity, in physical units of output per operative.	A distinction is made between product-centered and process-centered industries and between machine-paced and man-paced operations.	Direct comparison, cross-section and time-series.	Plants in two industries: shipbuilding and flour milling	Partially confirms the hypothesis. Mechanization rather than process-centered industries or machine-paced operations determines higher levels of labor productivity in LICs.

METHOD, DATA AND RESULTS

In trying to test the hypothesis we face not only problems of definition of the independent variables--which should explain the productivity differentials, but also in specifying the appropriate dependent variable(s). Hirschman refers to differences in labor productivity and we must assume that average productivity is meant, i.e. either value added or output per employee or per hour worked.[1/] However, labor productivity reflects the accumulation and utilization of capital and other factors of production. In fact, to have an adequate measure of total productivity would require the inclusion of all factors of production since taking only one, even if it is labor, is arbitrary.[2/] Furthermore, although Hirschman refers to labor productivity differentials, to shift the discussion to unit costs and comparative advantage, as done by both Lewis (loc. cit.) and Hirschman (ibid., foot. 26, p. 152), would require, inter-alia, that the analysis be cast in terms of relative productivities. Fortunately, it can be easily shown, that the measures of relative (with respect to ICs) productivity utilized are equivalent to measures of domestic relative productivity, i.e, between industries of the same country.[3/]

In principle, several methods could be utilized to test the Hirschman-Lewis hypothesis. We could use a test involving a continuous type of association of the dependent and independent variable(s) for all the industries, or we could just test the significance of the range of a measure of relative productivity. Below we present the various statistical tests conducted, first making a brief reference to the data utilized and its sources.

The seven countries selected: Argentina, Brazil, Chile, Colombia, Mexico, Perú and Venezuela, are responsible for about 90% of manufacturing output in Latin America (Inter-American Development Bank, 1974). These are also the countries with a more highly developed industrial structure, i.e. higher industrial value-added per capita, and more diversified product mix. This probably makes for a more severe test than if we were to include smaller countries which tend to be more specialized and are yet at a lower level of industrial development.

The data utilized were United Nations industrial statistics at the 3 and 4 digit levels of aggregation in the International Standard Industrial Classification. It included information on: number of employees, value added, salaries paid, and for some countries, electricity consumed and hours worked. In the case of one country we had to use gross product per capita instead of value-added per capita since the former information was not available.

All the data was for the year 1972, the latest for which comparable data were available for the various countries. During that year, an industrial census took place in many countries and the data collected were made available to the United Nations Statistical Office. It is also before the severe shock caused by the increases in prices of oil and other raw materials which took place in 1973-74, and may have introduced distortions in the data for some countries. For lack of more recent data, 1963 data was utilized in one case.

The United States of America was the IC selected as a standard of productivity comparison. There are several reasons for this choice: its importance as a market, supplier, and as a source of technology for the region; the availability of data, and its status as a leader among ICs.

Does industry choice matter?

Although we do not know if the basic properties required of the underlying statistical distribution are met, and of course we are not using a probabilistic sample, it might be worthwhile to apply ANOVA in an initial attempt to untangle the sources of variability in the relative productivity of the various industries in the countries selected. While it is obvious that we are not conducting a controlled scientific experiment, it could be thought as if "nature" had conducted it in the past. The basic question to be answered is then whether the observed differences in relative productivity are generally due to i) causes assignable to the nature of the industries (this would include the Hirschman-Lewis hypothesis as a special case(s)), or ii) whether they are, for the most part, assignable to the countries, i.e., resulting from the level of economic development and, particularly,industrialization they have achieved, or iii) whether there exists a significant interaction between both causes, if for example, the level of productivity achieved in a certain industry were not independent from the level of industrial development achieved in the particular country.

To conduct this test we took as dependent variable the value of the relative productivities for each industry and country. *A priori*, we would have expected that the more developed economically (and industrially), the country, the greater would be the *average* relative productivity of its industry. Of course, the value of this measure of central tendency could be affected by distortions due to overvalued rates of exchange and other forms of trade protection which would tend to inflate the value added locally (Balassa et al., 1971). Furthermore, it could perhaps be argued that as a result of import-substitution industrialization policies and the promotion of direct foreign investment, the level of effective protection of the various industries within a given country might vary in some systematic manner. We have so far done nothing to take this possible source of bias into account.

It could also be argued that, ceteris-paribus, the more developed economically the country the lower would be the variance of its relative productivity. This we would expect because of greater integration and better functioning of markets and higher factor mobility.

Another type of country-effect may result from the fact that due to market requirements and indivisibilities, some products, in certain industries, will only be developed in the countries that are relatively more advanced (industrially). This could give raise to lack of homogeneity in the product-mix of the industries considered, and could also affect the average level of productivity for a given industry since certain productions have a higher average level of labor productivity than others. This would tend to cause country-industry interaction effects.

Of course, this type of test, if at all valid, could not be used to prove the Hirschman hypothesis, but it could contribute to a refutation if the variance attributable to industry were nil or very low.

The results of the analysis of variance are shown in Table 2. The data used is a subset of the total including 8 comparable industries for the 7 countries.[4/] They indicate that approximately 39% of the total variance could be attributed to differences between industries. The F test of the analysis of variance with country as the source of variation was clearly significant at the 0.05 probability level, since $\hat{F} = 3.58$, while $F_{0.95}$ is equal to

Table 2

Analysis of variance of relative labor productivity in

Latin American manufacturing industries - selected countries.

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	$\hat{F}$	$F_{0.95}$
Country	0.4302	6	0.0717	3.58	2.27
Industry	0.3828	7	0.0547	2.73	2.18
Interaction	0.2889	42	0.0069	0.34	1.61 [a]
Total	1.1019	55	0.0200		

[a] Critical $F_{0.95}$ is for $n_1 = 40$, $n_2 = 55$.

2.27 (for $n_1 = 6$, $n_2 = 55$ degrees of freedom). The corresponding values for industry as the source of variation were $\hat{F} = 2.73$ and $F_{0.95} = 2.18$ (for $n_1 = 7$ and $n_2 = 55$ degrees of freedom), also clearly significant at the 0.05 probability level. The interaction effects do not seem to constitute a significant source of variation, since $\hat{F} = 0.34$, while $F_{0.95} = 1.61$ (for $n_1 = 40$ and $n_2 = 55$ degrees of freedom).

Thus, the results are not conclusive. While the Hirschman hypothesis cannot be rejected, since industry seems to be responsible for about 35% of the observed variation in relative labor productivity; country is responsible for an even larger proportion, 39%, of the observed variation, and a sizable residual is left unexplained.

Is the dispersion in relative productivity significant?

One possible way of testing the hypothesis would be to look, not at the relative productivity values for all the industries but to focus only on the extremes of the range of variability and see if the hypothesis is verified for the highest values,(i.e., those closer to the average labor productivity in the United States.) Thus, we could start by asking the question: Are the observed differences in productivity statistically significant for the extreme values, or could they just be explained as random dispersion around the mean?[5/]

In Table 3 we show for all countries, the mean relative productivity, the standard deviation, coefficient of variation and the range, and in Table 4, the lowest and highest relative labor productivity industries for the various countries, as well as those at 1 and 2 standard deviations above the mean, are shown.[6/]

Table 3

Mean, standard deviation, coefficient of variation and range of relative labor productivity in manufacturing industries - selected Latin American countries.

Country (number of industries)	Mean Relative Productivity[a]	Standard Deviation	Coefficient of variation	Range
Argentina (n=23)	0.355	0.083	0.234	0.234 - 0.522
Brazil (n=18)	0.296	0.053	0.179	0.219 - 0.409
Chile (n=36)	0.374	0.144	0.385	0.133 - 0.811
Colombia (n=36)	0.217	0.089	0.410	0.118 - 0.465
Mexico (n=20)	0.384	0.152	0.396	0.152 - 0.746
Peru (n=21)	0.419	0.151	0.360	0.227 - 0.811
Venezuela (n=26)	0.514	0.146	0.284	0.220 - 0.873

Source: Table I, Appendix.

[a]Unweighted

Table 4

Manufacturing industries with lowest and highest relative labor productivity and those one and two standard deviations above the mean - selected Latin American countries.

Country	Lowest productivity value	Industry ISIC	Highest productivity value	Industry ISIC	1 Standard deviation above mean Industry ISIC	2 Standard deviations above mean Industry ISIC
Argentina	0.234	Transport Equip. 384	0.522	**Rubber products** 355	Textiles 321 Spinning & weaving 3211 Apparel 322 **Leather** 323	Rubber products 355
Brazil	0.219	Wood products 331	0.409	Rubber products 355	Leather & leather prod. 323 **Plastics** 356	Rubber products 355
Chile	0.133	Tobacco 314	0.811	**Leather and leather products** 323	Apparel 322 Footwear 324 Plastics 356 Radio, T.V. 3832 Motor Vehicles 3843	Leather & leather prod. 323
Colombia	0.118	Furniture 332	0.465	Spinning & weaving 3211	Tobacco 314 Textiles 321 Pulp & paper 3411 Synthetic resins 3513	Beverages 313 Spinning & weaving 3211
Mexico	0.152	Petroleum & coal prod. 354	0.746	Rubber products 355	Non metallic prod. 369	Tobacco 314 Rubber products 355
Peru	0.227	Industrial chem. 351	0.811	**Non-ferrous metals** 372	Beverages 313 Rubber products 355	Non ferrous metals 372
Venezuela	0.220	Professional goods 385	0.873	Petroleum refineries 353	Tobacco 314 Paper & paper prod. 341	Petroleum refineries 353

To test whether these extreme values (both, highest and lowest) of labor productivity were statistically significant we performed a t test for the various countries. The results are summarized in Table 5. The null hypothesis that the observed dispersion is consistent with random variations around the mean was rejected in all cases at the 0.01 probability level, both for the lowest and highest values of relative productivity, since all the t estimates were clearly greater than the critical $t_{0.99}$, taking into account the number of degrees of freedom.[7/]

Mechanization and skills.

While the above analysis shows the statistical significance of the dispersion of values of relative labor productivity observed in the various industries of the selected countries, it does nothing to ascribe any causality or to indicate possible sources for the observed variation. To relate to the Hirschman and Lewis hypothesis, we selected two indicators of the criteria suggested by them in their formulations: mechanization,and labor skills. Governeur (1970) stressed mechanization as the main determinant of high labor productivity in LICs. The degree of mechanization we measured by the electricity consumed per hour of work. Labor skills of the various industries were assessed by the average level of salaries per employee.[8/] Both measures refer to the values of U.S. manufacturing industries, our standard of comparison.[9/] We deal first with these variables in a discrete manner, afterwards looking for continuous type of associations.

Table 5

t test of the extreme values (lowest and highest) of relative labor productivity in manufacturing industries for selected Latin American countries.

Country	Mean[a]	Standard Deviation	Degrees of freedom	$\hat{t}$ Lowest	$\hat{t}$ Highest	$t_{.99}$
Argentina	0.355	0.083	22	6.99	-96.49	2.51
Brazil	0.296	0.053	17	6.16	-9.04	2.57
Chile	0.374	0.144	35	10.04	-18.21	2.46
Colombia	0.217	0.089	35	6.67	-16.72	2.46
Mexico	0.384	0.152	19	6.82	-10.65	2.54
Perú	0.419	0.151	20	5.83	-11.90	2.53
Venezuela	0.514	0.146	25	10.27	-12.54	2.48

[a] unweighted average.

1. A Classificatory test

As a first approximation we divided the industries at the mean value level for the mechanization measure (electricity consumed per hour worked), and for the skills measure (average wage), into High and Low Mechanization industries and High and Low Skills industries. This led to four groups: High Mechanization-High Skills, High Mechanization-Low Skills, Low Mechanization-Low Skills and Low Mechanization-High Skills. We then broke down the highest productivity and lowest productivity industries into these four categories. The results are indicated in Table 6 and summarized in Table 7. The two groups, of high productivity and low productivity industries, are generally mutually exclusive. The intersection of the two includes only one industry. The summary table shows:

i) For the high productivity industries, the highest frequency groups are I and IV which are both High Skills groups, one with High Mechanization, the other with Low Mechanization.

ii) For the low productivity industries, the highest frequency group is III, which is both, Low Mechanization and Low Skills.

iii) Following just the mechanization criterion, the high productivity industries include 4 (out of 9) High Mechanization industries. While for the low productivity group, only 2 out of 7 are High Mechanization industries.

iv) The "ideal" Hirschman-Lewis industry, i.e., one with High Mechanization but Low Skills is represented by only one case out of 9, among the high productivity industries, and also by one case, out of 7, among the low productivity industries.

Table 6

Highest and Lowest Relative Productivity Industries Classified According to Degree of Mechanization and Skills.

ISIC	Industry	Mechanization	Skills	Group
	High Productivity			
355[a]	Rubber	L	H	IV
323	Leather	L	L	III
3211	Spinning & weaving	H	L	II
372	Non ferrous metals	H	H	I
353	Petroleum	H	H	I
313[b]	Beverages	H	H	I
314[b]	Tobacco	L	L	III
	Low Productivity			
384	Transport equipment	L	H	IV
331	Wood	L	L	III
314	Tobacco	L	L	III
332	Furniture	L	L	III
354	Petroleum & coal products	H	H	I
351	Industrial chemicals	H	L	II
385	Professional goods	L	H	IV

Source: Table 4

a/ Highest labor productivity in 3 countries.

b/ Industries at two standard deviations above the mean labor productivity.

Table 7

Highest and Lowest Productivity Industries Classified According to Degree of Mechanization and Skills - Summary Table.

Group		Highest Productivity Industries	Lowest Productivity Industries
I	HM/HS	3	1
II	HM/LS	1	1
III	LM/LS	2	3
IV	LM/HS	3	2

Source: Table 6.

While these results are somewhat suggestive, they are not statistically significant, i.e., there are no significant differences among the High Productivity industries and the Low Productivity industries as far as the distribution among the four groups according to Mechanization and Skills, since Chi square tests fail to reject the null hypothesis that frequencies for the four groups do not differ, at the 0.05 probability level, for both industry groupings.[10] Furthermore, they seem to provide very little support for the Hirschman-Lewis hypothesis.

2. Linear regression test.

The independent variables utilized for the linear regression test were the logarithm of energy consumed per hour worked and the average level of salaries paid per person employed, following the formulations of Hirschman and Lewis respectively. For each country, we regressed, using least squares estimates, the average labor productivity in the various industries relative to the average labor productivity for the same industry in the United States, with each of the indicators mentioned above.

Confirmation of the hypothesis in its Hirschman version would have required a positive and significant correlation between the level of relative productivity and mechanization (i.e., electricity consumed). In the Lewis version, we expected a significant negative correlation between skills (i.e., average salary), and relative productivity.

The results are shown in Tables 8 and 9, and we summarize them below for each independent variable and for all countries.

Table 8

Results of linear **regression** of average relative labor productivity with mechanization for the manufacturing industries of selected Latin American countries.

Country	Number of Indust.	Coefficient (Standard error)	t	R^2 a/	$\hat{F}_{(n_1,n_2)}$	$F_{0.95}$
Argentina	23	-0.008 (0.029)	-0.270	0.003	(1,21):0.073	4.32
Brazil	18	0.004 (0.029)	0.131	0.001	(1,16):0.017	4.49
Chile	36	-0.075 (0.042)	-1.769	0.084	(1,34):3.128	4.13
Colombia	36	0.036 (0.027)	1.331	0.049	(1,34):1.770	4.13
Mexico	20	-0.002 (0.095)	-0.023	0.000	(1,18):0.539	4.41
Peru	21	0.094 (0.064)	1.460	0.101	(1,19):2.130	4.38
Venezuela	26	0.025 (0.062)	0.402	0.007	(1,24):0.160	4.26

a/ unadjusted

Table 9

Results of linear **regression** of average relative labor productivity with skills indicator for the manufacturing industries of selected Latin American countries.

Country	Number of Indust.	Coefficient (Standard error)	t	R^2 a/	$\hat{F}_{(n_1,n_2)}$	$F_{0.95}$
Argentina	23	-0.00020 (0.00008)	-2.397	0.214	(1,21):5.744	4.32
Brazil	18	-0.00005 (0.00008)	-0.732	0.032	(1,16):0.535	4.49
Chile	36	-0.00034 (0.00012)	-2.777	0.185	(1,34):7.712	4.13
Colombia	36	-0.00000 (0.00000)	-0.490	0.007	(1,34):0.244	4.13
Mexico	20	-0.00009 (0.00029)	-0.316	0.005	(1,18):0.100	4.41
Peru	21	0.00001 (0.00002)	0.633	0.021	(1.19):0.400	4.38
Venezuela	26	0.00000 (0.00000)	0.300	0.004	(1,24):0.091	4.26

a/ unadjusted

For the correlation with the mechanization variable, the sign of the coefficient was as expected, i.e. positive, in 4 of the 7 cases but the correlation was not significant in all cases as indicated by the value of the R^2 and the F test at the 0.05 probability level.

For the correlation with the skills variable, the sign of the coefficient was as expected in 5 of the 7 cases, but the correlation was significative only in 2 of the 7 cases. In those cases the t values for the estimates of the coefficients were slightly greater than 2 and while the critical Fs were greater than $F_{.95}$, the Rs^2 were relatively small and the portions of the variance explained by the independent variable were 21% in one case (Argentina), and 18% in the other (Chile).

On the basis of these correlation results the Hirschman version of the hypothesis is clearly rejected while the results for the Lewis formulation tend in the same direction.

SUMMARY AND DISCUSSION OF THE RESULTS

The present study tried to test the Hirschman hypothesis for Latin American industry, using for that purpose, data for 7 of the most industrialized countries of the region. Degree of mechanization, instead of capital intensity, was used as an explanatory variable of differences in relative productivity. An attempt was also made to introduce, for the first time in such studies, a proxy measure for labor skills, to include consideration of this variable considered by A. Lewis to be critical in accounting for differences in labor productivity.

The results were less than conclusive and a summary of the main findings follows:

i) While industry choice seems to matter, since it is responsible for an important share of the observed variation in relative labor productivity; country, as a variable, seems to be responsible for an even larger proportion of the observed variation and a sizable residual is left unexplained.

ii) The observed range in relative labor productivity, as between the lowest and highest productivity industries, is statistically significant for all countries and cannot be explained away as random dispersion around a measure of central tendency.

iii) Classifying the industries according to Mechanization and Skills leads to inconclusive results, but suggestively, and against the hypothesis, for the high productivity industries, the highest frequency groupings are both High Skills groups while the "ideal" Hirschman-Lewis industry, i.e., one with High Mechanization and Low Skills, is represented with the lowest frequency, just one case, in the High Productivity group.

iv) Correlation of relative productivity with Mechanization is statistically not significant, and correlation with Skills is significant in two out of seven cases.

These results must be taken with caution, among other reasons, because variables left out of the analysis may play an important role in determining relative labor productivity. We indicated the possible influence of undervalued exchange rates and tariff protection, which may also be related to direct foreign investment in a systematic manner. Differences in plant size may also be relevant and have not been accounted for in this paper because of lack of establishment data. Further research is indicated to explore the role of industry and plant size differences. Problems remain also with regard to homogeneity of product mix, and ideally, one should try to deal in physical units with similar products produced in different countries. There is however always a trade-off between disaggregation and the possibility of relevant generalization.

Finally, it would be interesting to verify the extent to which Latin American countries have realized their potential comparative advantage in the industries with highest relative productivity. Further research is necessary, but there seem to be indications of successful export performance for example for: rubber products (including tires), in the case of Argentina, Brazil and Mexico; leather products in Chile; and spinning and weaving in Colombia - all industries at 2 standard deviations above the mean relative productivity. (See Table 4).

Footnotes

1/ Needless to say, marginal labor productivity will generally be different from average labor productivity. Clearly also, for equilibrium, it is the ratio of marginal products of the factors that must be equal to the ratio of their prices.

2/ The obvious limitation to taking all factors into account is that the division of the total product by the contribution of all factors (in commensurate units), will always be equal to unity and all changes in the ratio would be zero (Brown, 1966, p. 98). Clearly, any measure of productivity should include in the numerator only "usable" output, i.e., the quantity of output measuring up to the preestablished standards of quality or performance.

3/ Consider only two countries and two industries. According to the Hirschman hypothesis:

$$P_{mI} - P_{mL} < P_{oI} - P_{oL} \qquad (1)$$

where:

P_{mI} = Labor productivity in machine-paced industry in IC.

P_{mL} - Labor productivity in machine-paced industry in LIC.

P_{oI} - Labor productivity in operator-paced industry in IC.

P_{oL} - Labor productivity in operator-paced industry in LIC.

We rewrite (1) as follows:

$$P_{mI} - P_{oI} < P_{mL} - P_{oL} \qquad (2)$$

Since by assumption $P_{oI} > P_{oL}$ we can divide the left side of inequality (2) by P_{oI} and the right side by P_{oL} and get:

(footnotes cont.)

$$\frac{P_{mI} - P_{oI}}{P_{oI}} < \frac{P_{mL} - P_{oL}}{P_{oL}}$$

From which it follows:

$$\frac{P_{mI}}{P_{oI}} < \frac{P_{mL}}{P_{oL}}$$

This derived inequality is now in terms of relative productivities for each country, i.e., in the form generally used in international trade theory analysis.

4/ For the basic data, see Table I in the Appendix.

5/ Since the (weighted) means for the whole of the manufacturing sector would in general have a different value than the unweighted mean we used, it could be argued that these results should be checked by using the weighted means in the t test. The relative productivities for the manufacturing sector were computed as shown in the table.

Relative Productivity Manufacturing

		New t	Critical t .99
Argentina	0.215		
Brazil	0.355	-4.32	2.51
Chile	0.447	-15.17	2.46
Colombia	0.232	-15.71	2.46
Mexico	0.397	-10.27	2.54
Perú	0.395		
Venezuela	0.618	-8.91	2.48

Compared with the unweighted values, these means are larger for all countries but Argentina and Perú. Consequently, we performed the t tests only

(footnotes cont.)

with the new values for Brazil, Chile, Colombia, Mexico and Venezuela and for the highest productivity values. The results were the same, i.e., the null hypothesis was also rejected at the 0.01 probability level.

6/ Without much knowledge about the underlying distribution, the selection of 1 or 2 standard deviations around the mean as cut off points for the measure of dispersion may seem arbitrary. However, we know on the one hand that if the distribution happens to be normal, 1 standard deviation around the mean would include 68% of all the measurements and 2 standard deviations around the mean would include 95% of all measurements, which would imply that at the upper end we are dealing with the top 2.5%. But even if we knew nothing about the distribution's shape, Chebyshev's theorem guarantees that at least 75% of the measurements will fall within 2 standard deviations of the mean irrespective of the distribution. Thus, measurements at 2 standard deviations and above, correspond to the top 12.5% of all the measurements.

7/ In fact, this question has already been answered affirmatively through the results of the analysis of variance. But this time we did it in a different way.

8/ For some justification of the particular measures of mechanization and skills used see Teitel (1978, 1976).

9/ It could be, and has been argued, that the measures of factor intensity used should be those of the country in question, and not those of the country used as a productivity standard. I do not plan to argue this point which is really related to the broader question of equality of

(footnotes cont.)

technique and technology as between ICs and LICs, but only to note: i) Clague (1967) used both measures in his Peru-US study and found no differences. ii) In my own work, I found statistically uniform rankings for mechanization (used as a proxy for factor intensity), (Teitel, 1978), and also for average wages, (used as a proxy for skills),(Teitel, 1976) in the manufacturing industries across ICs and LICs. Thus, it seems safe to assume that if a monotonic relationship exists between relative productivity and the ranking by degree of mechanization or skills for one country, it will also exist for all others.

10/ The resulting Chi squares were: 1.222 for the High Productivity group, and 1.563 for the Low productivity group, while the critical Chi square for n = 3 is 7.8 at the 0.05 probability level.

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Appendix

Table I

Average Labor Productivity as a Proportion of US Productivity in Manufacturing Industries - Selected Latin American Countries - 1972

ISIC	Industry	Argentina 1/	Brazil	Chile	Colombia	Mexico	Perú	Venezuela 2/
311/2	Food	0.330	0.247	0.373	0.199	0.248	0.408	0.385
313	Beverages	0.323	0.229	0.379	0.464	0.503	0.591	0.588
314	Tobacco	0.301	0.272	0.133	0.393	0.699		0.710
321	Textiles	0.439	0.338	0.452	0.352	0.307	0.551	0.556
3211	Spinning, weaving, etc.	0.441		0.464	0.465			
322	Apparel	0.509	0.285	0.578	0.180		0.479	0.607
323	Leather and leather products	0.474	0.398	0.811	0.244		0.408	0.487
324	Footwear	0.423		0.616	0.168		0.285	0.450
331	Wood products	0.272	0.219	0.237	0.133	0.311	0.242	0.257
332	Furniture and fixtures	0.296	0.269	0.344	0.118		0.290	0.650
341	Paper and paper products	0.365	0.261	0.466	0.280	0.370	0.444	0.661
3411	Pulp and paper	0.372		0.382	0.326			
342	Printing and publishing	0.259	0.273	0.429	0.172		0.334	0.422
351	Industrial chemicals	0.262	0.335	0.264	0.202	0.344	0.227	
3511	Basic chem. excl. fertilizers			0.226	0.144			
3513	Synthetic resins			0.324	0.316	0.377		
352	Other chemicals		0.279	0.224	0.158	0.212		
3522	Drugs and medicines		0.262	0.198	0.152			
353	Petroleum refineries			0.363				0.873
354	Petroleum and coal products			0.212	0.138	0.152		0.381
355	Rubber products	0.522	0.409	0.457	0.253	0.746	0.610	0.653
356	Plastic products		0.350	0.576	0.191		0.441	0.487
361	Pottery, china, etc.			0.460	0.139		0.454	0.656
362	Glass and glass products			0.262	0.219	0.265	0.224	0.575
369	Non metallic products			0.232	0.173	0.564		0.412
371	Iron and steel	0.380		0.360	0.197	0.407	0.521	0.489
372	Non-ferrous metals	0.386			0.173	0.476	0.811	0.342
381	Metal products	0.386		0.335	0.146	0.265	0.321	0.405
382	Machinery	0.302	0.290	0.235	0.168	0.437	0.305	0.536
3825	Office, computing, etc.			0.323	0.277			
383	Electrical machinery	0.341	0.320	0.502	0.200	0.358	0.552	0.596
3832	Radio, television, etc.			0.537	0.217	0.315		
384	Transport equipment	0.234	0.285	0.315	0.177		0.303	0.454
3841	Shipbuilding and repair	0.268		0.245	0.193			
3843	Motor vehicles	0.287		0.532	0.198	0.329		
385	Professional goods			0.254	0.119			0.220
390	Other industries			0.362	0.157			0.522

Source: United Nations, Yearbook of Industrial Statistics, 1974 Edition., Vol. I, New York, 1976; for Argentina: United Nations, The Growth of Modern Industry, 1971 Edition, Vol. I, New York, 1973. Rate of foreign exchange for conversion to US dollars from: International Monetary Fund, International Financial Statistics.

Notes: 1/ for 1963.
2/ Gross output data instead of value-added data.