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TECHNOLOGY, ECONOMIES OF SCALE AND AVERAGE SIZE
OF INDUSTRIAL PLANTS:
SOME FURTHER CROSS-COUNTRY EVIDENCE

by

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TECHNOLOGY, ECONOMIES OF SCALE AND AVERAGE SIZE OF INDUSTRIAL PLANTS: SOME FURTHER CROSS-COUNTRY EVIDENCE[x]

I. The Hypothesis

Sargant Florence pointed out long ago that broad technological factors seemed to underlie inter-industry differences in the typical size of plants.[1] Much attention has been paid in several other recent studies to factors affecting average size of plants in industries and its variations among countries and over time.[2] Their findings establish the important point that what lies at the heart of the matter is the different degrees to which countries are able to realize economies of scale in production.

While the importance of technological economies in the shaping of the industry's scale curve is well recognised in theoretical literature, the empirical studies have, however, paid little explicit attention to this factor as a determinant of plant size differences across countries. This paper examines the hypothesis that average plant size of industries is an increasing function of the level of capital intensity in production. In testing this hypothesis, the capital intensity pattern and average plant size of industries are compared for countries at different levels of economic development. This approach has two advantages. First, the observed differences in the level of capital intensity are likely to be most pronounced when countries at different levels of technological development are considered. Secondly, it throws some light on the question of the relationship of economic development to the size of industrial plant, an issue of considerable interest in itself.

x I gratefully acknowledge the benefits of discussions with Ulrich Hiemenz in the writing of this paper.

1 P.S. Florence (1948).

2 See, for instance, Silberston (1972); Pryor (1972); Scherer (1973); Teitel (1975).

This paper differs in two further respects from other studies. First, the concept of average size (measured by employment) used here takes account of the entire distribution of plants, including the small-sized plants.[1] Use is made of the lognormal distribution model in estimating the average size.[2] Secondly, the scope of the present sample is also broader than has been the case so far; average plant sizes by industries are compared for 23 nations, including many less developed.

II. Some Theory

Economic theory suggests that if perfect competition prevailed, all firms (and assuming a one-to-one relation, all plants) in the industry would face the same average cost curve, would operate at the same level of output, at the same average cost, and would be of identical size. The price determining long run supply curve of the industry is then horizontal, and the conditions of demand determine the number of firms (plants) in the industry. If firms differed in size, it could be due only to short run mistakes of changes in operating conditions. In the real world, however, as is well known, at any moment of time, firms (plants) of different sizes exist together in the industry. The size distribution of plants, when measured by employment, capital assets, horsepower or

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1 The basic data are obtained from industrial censuses providing information on an establishment basis; the term "establishment" denotes a single plant or factory in which manufacturing operations are performed. A plant is thus distinct from a company (or firm), as the latter can operate more than one plant and is involved also in non-manufacturing activities. It is important to note that household industries providing important sources of subsidiary employment in primarily agriculture-oriented developing countries are not included in the scope of our data.

2 See section III for a brief description of this model and the rationale for its use in the present context.

any other measurable characteristics, typically follow a skew pattern; a large number of small plants are to be found at one end of the distribution together with a small number of larger plants at the other.

To understand the prevailing average size, it is, therefore, necessary first of all to identify the forces underlying the size differences among plants within industries. It is useful, at this point, to draw a distinction between the determinants of absolute and relative scale of plants. Included in the former category are the factors determining the shape and the position of the industry's scale curve (i.e. its long run average cost curve). They include, therefore, various forms of static and dynamic economies of scale, internal as well as external.[1] Given the scale curve, the limiting factors to actual size and the number of plants in the industry are the size, growth and geographical dispersal of markets, the dispersal of its sources of supply and the degree of sellers' concentration. Taken together these factors constitute the main determinants of the relative scale of plants. Theory as well as empirical evidence suggest the following relationship to hold. The average plant size is larger in relation to the industry's minimum optimal scale, the larger the size of its market (Pryor, 1972) the greater its degree of localization (Florence, 1956), the lower the "cost of overcoming the environment[2]" (Pryor, 1972), the greater the penalty associated with sacrificing the scale economies (Silberston, 1972) and the higher the degree of sellers' concentration (Scherer, 1973).

In this paper the variable capital intensity is introduced as an additional determinant of the average plant size of industries because, as we already pointed out, it serves to clarify the relationship of size

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1 The various forms of scale economies need not be repeated here, as an excellent treatment of the subject is given in Silberston (1972).

2 By which are meant transportation costs (of bringing produced goods to customers and raw materials from their source) and costs of overcoming trade barriers to the industry's exports.

to economic development, an issue raised but not pursued by Pryor (1972).[1] It seems that technical economies of scale associated with fixed capital provides the primary link between the level of technological development and the average size of plants. The main technological economies of scale arise from specialization and indivisibilities of capital equipment. Intuition as well as theory lead us to expect that the rising level of technology acts in a manner to increase industrial plant size as production methods become increasingly capital intensive to take advantage of technical scale economies. The implication is that in comparing countries at different levels of technology a positive association between the average size of plant and the industry's average capital intensity is to be expected, reflecting the differences in the degrees to which countries are able to realize technical scale economies in the production.

The scale curve applicable to developed countries, at their set of factor prices, is likely to be different in a low income country, at another set of factor prices. The prevailing scale curve of the less developed country's (LDC) industry is likely to be more appropriate for small-scale production, requiring to set up plants involving small capital expenditure, a low capital intensity and obtaining little or no economies of scale.[2] Consideration of factor prices together with the small size of the domestic market are perhaps the primary explanations of the relative numerical superiority of small plants in the plant structure of industries in LDCs as compared to those in developed countries.[3] The simultaneous existence of large-scale plants in LDCs is,

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[1] It is important to note that differences in the level of capital intensity may explain the differences in plant size within the industry, differences in the average size of plants from industry to industry within a country and also the differences in the average size of industrial plants from country to country. The last mentioned aspect is central to this paper, although the second aspect is also examined in section IV.

[2] If technology is such that considerations of minimum optimal size preclude small-scale plants in the industry and the market is small, either or both of two things may result: (1) large plants will operate at suboptimal capacity and (2) with one or two plants catering to the market, an oligopolistic structure will emerge. Both phenomena are commonly encountered in practice.

[3] See Banerji (1975).

however, not thereby precluded. The technological dualism which besets most LDCs is one reason for large plants to coexist with a multitude of smaller plants. Typically, the combination of foreign capital participation and import substituting industrial policy will enable the imposition of modern large-scale plants on a largely technologically backward economy. In exceptional cases, the resulting structure may on balance cause the average size of plants to be large and comparable to that of a developed country's industry. In general, however, we will expect in LDCs the smaller plants to dominate displaying on average lower level of capital intensity than what is to be found in a developed country.

III. The Sample, Methodology and a Comparative Overview

Our basic sample consists of 23 countries shown under Table 1.[1] For each country the average size of plants by industries is derived, in a manner to be discussed shortly, from the entire size distribution of plants (including the very smallest ones) defined by employment. At the outset, two caveats may be noted. Firstly, there are well known shortcomings of the employment measure of size. No further apologies will, however, be provided for its use here than to say that employment is an important indicator of plant capacity, it facilitates international comparison as data on plant distribution by employment are available in most censuses and, finally, there is evidence of a close relationship between size as measured by employment and size as measured by installed energy per worker.[2] The second caveat lies in the adoption of an arbitrary division of industries (at 2-digit International Standard

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[1] It will be noted that the countries are classified as high-income and medium and low-income countries, instead of developed and developing, because of the difficulties associated with placing some countries like Spain and Israel by the latter classification scheme. It may also be noted that the reference year is not uniform for all countries as the choice of sample is dictated by the availability of industrial census data.

[2] See Banerji (1975).

Table 1 Average Rank Orders of Industries by Average Size of Plants[a] And a Comparative Overview of Plant Size Relationships, Letting Average Size of Plants in the USA = 100

Industry Group	Average rank ordering			High-income countries USA = 100			Medium and low-income countries USA = 100			U.S. average plant size[a] (No. of persons)
	All countries in sample	High-income countries	Medium & low-income countries	Range of indices	Mean of indices	Sample Size	Range of indices	Mean of indices	Sample Size	
All Industries				3-100	40.8	9	3-64	10.0	14	127
Tobacco products	1	1	2	28-100	60.0	4	6-53	20.0	7	541
Basic Metals	2	2	1	14-440	184.5	9	24-145	48.3	7	166
Chemicals	3	4	5	48-467	178.7	9	3-464	57.1	14	97
Paper and Pulp Products	4	6	4	16-156	90.1	9	3-65	22.4	13	155
Textiles	5	8	3	3-100	42.3	9	2-76	41.5	14	249
Petroleum	6	3	10	20-520	203.7	9	3-86	27.7	7	148
Electrical Machinery	7	5	9	8-165	70.7	9	2-66	14.6	14	186
Rubber Products	8	10	6	8-215	79.3	9	5-143	48.2	14	87
Non-electrical Machinery	9	9	8	37-304	120.5	9	7-195	52.1	14	51
Transport Equipment	10	7	12	2-298	71.1	9	1-17	5.1	14	271
Non-metallic Mineral Manufactures	11	12	11	15-151	76.8	9	7-149	40.0	14	55
Printing and Publishing	12	18	7	6-100	31.4	9	6-71	19.8	14	90
Beverage	13	11	16	60-119	85.4	5	11-197	41.4	9	37
Leather Products	14	13	13	2-100	24.2	9	2-75	9.0	14	182
Food Processing	15	15	15	5-189	58.5	7	5-228	33.4	13	82
Fabricated Metal	16	16	14	7-253	71.0	9	6-156	28.6	9	54
Diverse Industries	17	19	17	5-117	47.0	9	5-65	17.0	14	79
Apparel	18	14	18	8-308	89.6	9	6-156	28.0	14	48
Furniture	19	17	19	3-123	44.0	7	3-13	3.5	13	126
Wood	20	20	20	22-378	92.7	9	17-244	52.0	14	18
Food, Beverage and Tobacco				6-220	84.8	9	6-162	20.7	13	65
Coefficient of concordance	0.40*	0.52*	0.39*							
Sample size (No. of countries)	23	9	14							

* Significant at 1 percent significance level. [a]Computed from the parameters of fitted lognormal distribution.

Sample: High-income countries: Austria (1964), Australia (1968/69), Canada (1970), France (1966), Germany, F.R. (1970), Japan (1971), Norway (1963), UK (1968), USA (1967). Medium and low-income countries: Brazil (1960, 1970), Cyprus (1967), Ghana (1962), Israel (1965/66), Korea, South (1967), Malaysia, W. (1968), Mauritius (1967/68), Mexico (1965), Peru (1963), Puerto Rico (1963, 1967), Spain (1970), Taiwan (1966), Thailand (1963), Turkey (1964).

Source: Computed from industrial censuses cited in the Appendix.

Industrial Classification level) which conceals a great deal of diversities within any individual group. This method of industry classification is adopted partly for reasons of statistical expediency and partly because it facilitates a comparison of our results with those of other studies.

The size distribution of industrial plants by employment is empirically well described by lognormal distribution. That is to say, the normal distribution can be used to graduate the logarithms of the numerical values of plant size because its distribution is inherently skewed.[1] The average size of plants in the industry can then be derived simply from the estimated parameters of the fitted distribution.[2] This average which is derived with reference to the whole frequency distribution of plants by size of employment in the industry is very different from the concepts of average that are designed to isolate certain plants in terms of their

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[1] From a theoretical point of view, the lognormal model as applied to the distribution of plants in the industry implies that changes in the plant structure are the consequence of a random process in which plants of all sizes have the same chance to grow at a certain rate. No such theoretical foundation to its application to the present case can, however, be claimed because neither an attempt is made to trace the growth process of plants over time, nor are the underlying assumptions of the random process model examined.

[2] The density function of the lognormal distribution is given as:

$$f\,(\log S) = \frac{1}{\sqrt{2\,\pi\,\sigma}}\;\ell^{-(\log S - \mu)\,/\,2\,\sigma^2}$$

where S = size (>0); μ= mean of log S; σ = standard deviation of log S. The distribution of S is completely specified by the parameters μ and σ. The mean, median and the mode of the distribution of S is given by:

$$\text{Mean} = \ell^{\mu + \frac{1}{2}\sigma^2} \qquad \text{Mean} = \ell^{\mu} \qquad \text{Mode} = \ell^{\mu - \sigma^2}$$

In case of grouped frequencies the method of quartiles provides the most straightforward estimate of the relevant parameters. The estimated mean is then given as the weighted average of the three quartiles, the weights being proportional to the heights of normal-curve ordinates erected at these values. Thus,

$$\mu = \frac{\log Q_1 + \log Q_3 + 1.2554 \log Q_2}{3.2554}$$

where Q_1, Q_2 and Q_3 are the expressions for the first, second and the third quartiles of the distribution. The estimate of standard deviation is given by the expression: $\sigma = 0.7413\,(\log Q_3 - \log Q_1)$. For details see, Aitchison and Brown (1957); Davies and Crowder (1933).

relative importance in the industry's total output or employment. The criterion for estimating the latter types of average has varied widely in the literature, depending partly on the problem under consideration.[1] In all cases, however, the smaller plants are conspicuously excluded presumably from considerations of their small contribution to the industry's output volume, regardless of their relative superiority in terms of number. Concentrating on the larger plants only introduces, however, a bias in the estimates of average, and renders international comparison somewhat misleading in view of the observation that smaller plants in low and medium-income countries often tend to be relatively more important value-added or employment-wise than in the more advanced countries.[2] The mean size of plants in the industry as estimated from lognormal model in this paper represents a typical size in the sense that it balances the values (in the frequency distribution of plants) to the right of it with values to the left of it. This mean is thus weighted by the number of plants in different size groups, when size is measured by employment.

The closeness of fit obtained from the fitting of lognormal distribution to our sample countries turns out to be significant in terms of the χ^2-statistic in all cases. The resulting arithmetic mean sizes of industrial plants are found to reveal a great deal of diversity. In Table 1 the plant size relationships are compared for groups of high-income and medium and low-income countries using as benchmark the estimated average size of plants in the United States. In the same table is also provided the rank order of industries by average size of plants;

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[1] For instance, the average plant size measure used by Bain (1966) in his international comparison study was that of the largest 20 plants. Scherer (1973) adopted "Top 50 percent" size index, meaning that the average size of those plants when arranged in descending size order, "account for top 50 percent of an industry's cumulative output of employment". Pryor's (1972) measure was arithmetic average of workers and employees in plants with a labour force of 20 or more, alternatively, "percentage of total labour force employed in establishments with a labour force of 1,000 or more".

[2] See Banerji (1975).

the significance of this ordering will soon be made clear.

When different industries are lumped together, as in the first row of the industry column in Table 1, the average size of the United States plants is seen to be larger than that in the other countries in our sample, regardless of their income level. At the disaggregated industry level, however, the range of variation in the plant size is revealed to be much greater and not infrequently the average size of plants exceeds the benchmark.[1] Looking at the mean values of the indices, which obviously are influenced by the presence of extreme values, the following observations are to be made: (i) in medium and low-income countries the tendency is towards plants of considerably smaller sizes as compared to those in the United States and also in comparison to the mean values of the high-income group; (ii) the average size of plants in the United States tends to be larger than the average of the high-income group (though, not by as much as compared to medium and low-income countries) in all industries except basic metals, chemicals, petroleum and non-eletrical machinery; (iii) there is near parity of average plant sizes between the countries of high-income group and medium and low-income group in the production of textiles.[2]

The comparative overview of plant size relationships thus establishes the important point that with rare exceptions the average size of industrial plants in low and medium-income countries tends to be much smaller than in high-income countries.

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[1] The extreme (high) values, in comparison to the United States, in the high-income countries represent UK (basic metals, chemicals, paper, petroleum, rubber products, transport equipment, non-metallic minerals, and apparel), Germany, F.R. (basic metals, diverse industries), Canada (furniture and wood) and Norway (beverages). The corresponding countries in medium and low-income countries are Mexico (basic metals), Spain (chemicals, non-electrical machinery, non-metallic minerals, food processing, fabricated metals), Puerto Rico (beverages, apparel) and Malaysia (wood). The likely explanations of the average plant size exceeding the US benchmark are many, including relative differences in technology (a point examined in some detail in the next section of this paper), a greater geographical concentration of plants as compared to that in the USA, and in the case of low-income countries, the presence of technological dualism in the economy.

[2] The results change very little if the comparison is in terms of median of indices instead of mean. By this criterion, the United States average plant sizes are larger than in other countries in all industries except chemicals, rubber, basic metals and non-electrical machinery in high-income countries.

Regardless of the absolute differences in the average size of industrial plants to which the evidence presented above points out, the rank orders of industries by size may be expected to show some uniformity across countries. This is to be expected if, as is often hypothesized,[1] the technical factor (i.e. the nature of the product) is the primary determinant of the size of plants in all countries. That is to say, if it can be accepted that technology differs from industry to industry in a uniform manner in all countries, we will find a near parity of the rank order of industries among countries. To find out how far this is the case, the industries in our sample countries were ranked in a descending order of average size and the degree of communality involved was tested for its statistical significance.[2]

The average rank orderings which emerged from the countrywise ranking of industries are shown in the second part of Table 1, for all countries and also separately for the two groups under consideration. Between the two country groups the average rank orderings differ, though not significantly judging from the Spearman rank correlation coefficient of 0.76, which is significant at 1 per cent level. It would seem that in all countries the average tendency is towards largest plants in the production of tobacco, basic metals, chemicals, textiles and paper

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[1] See Florence (1948), p. 26.

[2] The coefficient of concordance, measuring the relationships between the various rankings, is computed according to the Kendall formula:

$$W = \frac{S}{\frac{1}{12} m^2 (n^3-n) - m \sum_T T} \quad ; \qquad T = \frac{1}{12} \sum_t (t^3-t)$$

W = coefficient of concordance; m = number of countries; n = number of industries; S = the sum of squares of deviation of m sums-of-ranks from their mean; T = a correcting factor to take account of ties in the ranking; t = number of ties of a given set. The test of significance is given by the χ^2-statistic

$$\chi^2 = \frac{S}{\frac{1}{12} mn (n+1) - \frac{1}{n-1} \sum T}$$, with (n-1) degrees of freedom.

See Kendall (1955), pp. 94-106.

products and smallest plants in the wood products, furniture and apparel industry.

Judging by the coefficients of concordance, (all of which are significant at 1 per cent level) the similarity in the rank orderings of industries is found to be much closer within the group of high-income countries than among medium and low-income countries of the sample. The former group thus appears to be more homogeneous from the point of view of production conditions than the latter. The technological contrast in the medium and low-income countries is found to be greater presumably because of the wide variation of technological dualism prevailing in their economies.

Comparing our results with those obtained from other studies, the first point to note is that the average rank orders of industries turn out to be very similar regardless of the differences underlying the concept of average plant size and the samples.[1] Secondly, in contrast to conclusions drawn by others, our computations warn against placing too much importance on technological identity of production among countries. On the contrary, technological contrasts, as judged by the coefficients of concordance, appear to be much more extensive within and between the groups of developed and developing countries than seem to be the case when the estimates of average plant size exclude the consideration of small-scale production units.[2]

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[1] For high income countries, the coefficient of concordance between our's and Pryor's (1972) rank orders of industries is 0.88 and between our's and Teitel's (1975) is 0.89 - both of which are significant at 1 per cent level. Similarly, for medium and low-income countries a significant correlation coefficient of 0.84 is obtained between Teitel's and our rank ordering.

[2] The coefficient of concordance according to Pryor's (op.cit.) computation for high-income countries is 0.89 (compared to 0.52 of our's); for a mixed sample of developed and developing countries Teitel (op.cit.) obtains a coefficient of 0.57 (and alternatively 0.62) compared to 0.40 that we obtain from a sample of nearly the same size.

IV. Model Specification and Testing of Hypothesis

Of the general determinants of variations in the industrial average plant size, the relative importance of the following will now be examined using the method of regression analysis: capital intensity, market size and the level of economic development.[1]

Before dealing with intercountry variations, a brief analysis of capital intensity as a determinant of interindustry differences in the average size of plants is presented for eighteen countries for which industrywise data on average capital intensity are obtained (see Table 2).

The regression results reveal capital intensity to be a weak determinant of interindustry average plant size variations except in a few countries (Japan, Israel, Thailand and to a lesser extent Australia and Norway). The sign of the capital intensity coefficient is positive in most cases, though the coefficient itself is statistically significant between 5 and 10 per cent level in only nine out of the eighteen countries under consideration. The implication is that in all countries interindustry differences in the average plant size are the results of many forces affecting the absolute and relative determinants of plant size. Of these capital intensity is one but apparently not the primary influence.

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[1] The size of market is approximated by the variables per capita income (measured in US dollars), and population;the density of population serves to proxy the degree of buyers' concentration. The level of per capita income serves also as an index of development; alternative specifications based on the degree of industrialization (approximated by the share of manufacturing value-added in GDP and the share of manufacturing employment in the total) turned out to be inferior, with some exceptions to be noted, because of their multicollinearity with the per capita income variable. The ideal measure of capital intensity would be the horsepower per worker in industries. This statistic is,unfortunately, only sparsely available for the countries in our sample. Less satisfactory but adequate for our purpose is the measure of capital intensity proxied by value-added per employee. This measure, a flow concept, entails both physical and human capital intensity in the production. A comparative study by Lary (1968) shows that industries tend to be ranked very similarly under alternative measures of capital intensity including value-added per employee. In the present paper, the capital intensity for an industry represents the weighted average of capital intensities at different plant size levels, weights being the number of employees at each plant size. The capital intensity figures are converted into US dollars to facilitate intercountry comparisons.

Table 2 - Results of Regression between Average Plant Size and the Average Level of Capital Intensity Across Industries

	Constant term	Coefficient of capital intensity	R^2
High-income countries			
Austria	- 4.53	0.89 (1.04)	0.06
Australia	-10.75	1.66* (3.35)	0.38
Canada	- 5.30	1.04** (1.92)	0.19
Japan	- 4.23	0.81* (4.08)	0.48
Norway	- 6.33	1.14* (2.94)	0.31
U.K.	8.93	-0.45 (-0.40)	0.01
U.S.A.	- 0.92	0.58 (1.44)	0.10
Medium and low-income countries			
Brazil	- 5.88	1.13** (1.99)	0.19
Cyprus	- 9.18	1.52** (1.78)	0.17
Israel	-10.18	1.51* (4.26)	0.57
Korea, South	6.28	-0.45 (-1.30)	0.08
Malaysia, West	- 2.53	0.75 (1.12)	0.07
Mauritius	- 0.06	0.32 (0.90)	0.06
Peru	- 2.02	0.55** (1.95)	0.18
Puerto Rico	1.71	0.24 (0.60)	0.03
Taiwan	3.92	-0.12 (-0.42)	0.01
Thailand	- 0.28	0.69* (4.08)	0.51
Turkey	- 0.99	0.34 (1.20)	0.07

Note: The estimates are based on double-logarithmic function. One asterisk denotes significant at 5 % level; a double asterisk denotes significant at 10 % level.

Source: Same as in Table 1.

Notwithstanding the implication drawn above with regard to inter-industry differences, the average level of capital intensity turns out to be a significant factor in explaining intercountry differences in the average plant size of industries. In Table 3 the results of the regression are presented in which the capital intensity variable is introduced once on its own and further in combination with other competing variables to see whether it is able to retain its explanatory power in a multiple regression framework.

The relevant results obtained from the regressions can be summarized in the following way:

(1) Of the industries under consideration (the tobacco industry was dropped because of a lack of sufficient degrees of freedom) it is only in six cases that the capital intensity variable, taken in isolation, is not statistically significant even at 0.10 level, although having the expected positive sign (printing and publishing, basic metals, non-electrical machinery, rubber products, petroleum and diverse industries). The relationship between average plant size and capital intensity is statistically significant at 0.05 level in eleven industries (including the average of all industries) and further at 0.10 level in three industries. Taking all industries together, capital intensity alone explains over one-half of inter-country variations in the average size of plants, although the explanatory power of the variable tends to vary from industry to industry. It lies at the specific industry level in the range of one-fifth (textiles) to over three-fifths (furniture) for industries for which a statistically significant result is obtained.

(2) Inclusion of per capita income, population and density in the regressions with the capital intensity variable adds in most cases to the explanatory power of the equations (the relevant exceptions to be noted are furniture, non-electrical machinery and electrical

Table 3: Results of Cross-Country Regressions between Average Plant Size by Industries and Selected Explanatory Variables[1]

	Constant	CI	Y	P	D	R^2
All industries	-6.34	1.11*				0.52
	(-2.92)	(4.15)				
	-7.70	1.12*	0.11	0.24**	0.18	0.64
	(-3.30)	(4.18)	(0.27)	(1.79)	(1.29)	
Food products	-5.57	0.97*				0.39
	(-2.02)	(2.88)				
	-4.88	0.76	0.22	-0.13	0.02	0.44
	(-1.575)	(1.354)	(0.59)	(-0.82)	(0.13)	
Beverages	-3.55	0.74**				0.36
	(-1.10)	(1.965)				
	2.84	-0.68	1.07	-0.34	0.12	0.65
	(0.67)	(-0.76)	(1.58)	(-1.27)	(0.66)	
Textiles	-0.39	0.59**				0.20
	(-0.17)	(2.02)				
	0.58	0.85**	-0.26	-0.34	-0.10	0.36
	(0.21)	(1.74)	(-0.58)	(1.70)	(-0.53)	
Clothing	-4.11	0.90*				0.53
	(-2.62)	(4.25)				
	-5.31	1.13*	-0.19	0.10	0.14	0.58
	(-2.64)	(2.26)	(-0.430)	(0.66)	(0.97)	
Wood products	-2.20	0.58*				0.41
	(-1.65)	(3.35)				
	-1.02	0.82*	-0.02	0.25**	0.03	0.51
	(-0.64)	(2.34)	(-0.05)	(1.90)	(0.223)	
Furniture	-4.97	0.98*				0.63
	(-3.14)	(4.68)				
	-4.21	0.56	0.32	0.12	0.01	0.65
	(-1.57)	(0.69)	(0.50)	(0.69)	(0.76)	
Paper products	-3.17	0.83*				0.49
	(-1.85)	(3.95)				
	-3.06	0.52	0.34	0.10	-0.02	0.53
	(-1.28)	(1.35)	(0.94)	(0.54)	(-0.12)	
Printing & publishing	0.74	0.26				0.13
	(0.55)	(1.52)				
	1.62	-0.14	0.29	0.11	0.04	0.20
	(0.49)	(-0.18)	(0.57)	(0.78)	(0.39)	
Chemicals	-3.91	0.87*				0.35
	(-1.50)	(2.92)				
	0.20	-0.33	0.86*	0.30**		0.57
	(0.07)	(-0.60)	(2.24)	(2.07)		
	0.67	-0.30	0.80**	0.28**	-0.09	0.59
	(0.23)	(-0.52)	(2.00)	(1.90)	(-0.65)	
Petroleum	-6.27	1.05				0.15
	(0.73)	(1.19)				
	0.22	-0.27	0.94			0.56
	(0.03)	(-0.32)	(2.55)			
	4.18	-0.35	0.66	-0.01	-0.37	0.73
	(0.51)	(-0.38)	(1.71)	(-0.02)	(-1.50)	

Continued ....

Table 3: Results of Cross-Country Regressions between Average Plant Size by Industries and Selected Explanatory Variables

- Continued -

	Constant	CI	Y	P	D	R^2
Rubber products	-1.94	0.65				0.12
	(-0.54)	(1.48)				
	-1.59	0.27	0.20	0.37	0.12	0.25
	(-0.32)	(0.35)	(0.40)	(1.37)	(0.50)	
Leather products	-5.90	1.08*				0.49
	(-2.73)	(3.89)				
	-4.72	0.74	0.19	0.13	-0.02	0.52
	(-1.54)	(1.10)	(0.45)	(0.82)	(-0.01)	
Non-metallic mineral manufactures	-2.89	0.72*				0.36
	(-1.47)	(2.98)				
	-4.81	0.86*			0.19	0.45
	(-2.17)	(3.51)			(1.63)	
	-4.16	0.69	0.14	-0.03	0.19	0.46
	(-1.19)	(0.84)	(0.23)	(-0.26)	(1.45)	
Basic metals	2.74	0.25				0.02
	(0.60)	(0.47)				
	6.50	-0.65	0.60	0.03	-0.09	0.13
	(0.86)	(-0.52)	(0.70)	(0.07)	(-0.27)	
Fabricated metals	-3.05	0.70*				0.49
	(-2.14)	(3.89)				
	-3.81	0.80**	-0.13	0.18	0.09	0.59
	(-1.99)	(1.81)	(-0.37)	(1.37)	(0.81)	
Non-electrical machinery	0.92	0.26				0.07
	(0.49)	(1.11)				
	0.21	0.43	-0.14	0.01	0.04	0.08
	(0.073)	(0.65)	(-0.27)	(0.08)	(0.27)	
Electrical machinery	-7.09	1.32*				0.42
	(-2.24)	(3.38)				
	-6.53	1.17*		0.25		0.46
	(-2.06)	(2.87)		(1.14)		
	-7.28	1.21	0.01	0.26	0.08	0.47
	(-1.70)	(1.43)	(0.01)	(1.06)	(0.37)	
Transport equipment	-7.31	1.30*				0.57
	(-3.14)	(4.46)				
	-6.09	1.04*		0.33**		0.64
	(-2.64)	(3.31)		(1.75)		
	-6.49	0.74	0.33	0.40	0.12	0.67
	(-1.72)	(0.89)	(0.59)	(1.58)	(0.65)	
Diverse industries	-0.76	0.41				0.13
	(-0.36)	(1.55)				
	-0.99	0.35		0.28**		0.31
	(-0.51)	(1.42)		(1.94)		
	-2.29	0.62	-0.19	0.30**	0.10	0.34
	(-0.86)	(1.04)	(-0.39)	(1.94)	(0.65)	0.34

[1] The explanatory variables in the equations are:

CI = capital intensity; Y = per capita GDP;
P = population, and D = density of population.

Note: One asterisk denotes significant at 0.05 level; a double asterisk denotes significant at 0.10 level. The t-values are shown in parenthesis.

Source: Based on National Industrial Censuses (see Appendix); United Nations, Yearbook of National Accounts Statistics (various issues); World Bank, World Tables (various issues).

machinery). The computed coefficients of the variables, other than that of capital intensity, are, however, rarely significant in the multiple regressions. The capital intensity variable retains its statistical significance in eight out of the fourteen industry groups (including the group "all industries").[1]

(3) Economic theory postulates a positive relationship between the market size and the average size of industrial plant.[2] Similarly, the suggested relationship between the degree of market concentration and the average plant size is positive, since dispersed markets are likely to be associated with smaller plants.[3] In the multiple regressions, however, neither the market size (proxied by per capita income and population), nor the density variable (taken as an indicator for the geographic dispersal of markets) is statistically significant in most cases. The exceptions are the population variable in the case of "all industries", wood products, transport equipment, chemicals and diverse industries, and per capita income in the case of chemicals.[4] The results appear interesting in the light of the observation that in simple two-variable regressions the relationship between the average plant size and per capita

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1 The so-called beta weights provide a useful device, in multiple regressions, to measure the relative explanatory power of the independent variables in explaining the variations in the dependent variable. By this measure, the capital intensity variable appears first in the order of importance of explanatory power of average size in all industry groups, except beverages, printing and publishing, basic metals, chemicals and petroleum, in which cases per capita income takes the first position and rubber products for which the relative explanatory power of population is the largest.

2 Pryor (1972).

3 Florence (1948).

4 Note that Pryor (1972) obtained a significant positive relationship between market size and average plant size across countries at the aggregative industry level, using as a measure of market size the absolute volume of GNP.

income is statistically significant in all cases, as is the relationship between average plant size and population in the case of total of industries, wood products, fabricated metals, transport equipment, electrical machinery, rubber products, chemicals and diverse industries[1]. In many industries, thus, as compared to other variables, capital intensity emerges as being dominant in explaining intercountry differences in the average size of plants.

(4) Finally, an interesting observation emerging from the regression analyses is that in those industries where capital intensity fails to be a significant variable, the level of industrialization often appears to have a significant explanatory power: beverage, paper products, printing and publishing, basic metals, non-electrical machinery, chemicals and petroleum.[2] The results seem to make intuitive sense, although their theoretical implications are not immediately clear.

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[1] In none of the industries, however, is the density variable statistically significant in simple regression. For reasons of space, the detailed results are omitted from the text and can be obtained from the author.

[2] The best relations obtained from multiple regressions are industrywise:

Beverage:

$$\ell n\ AS = -0.27 - \underset{(-0.73)}{0.20}\ \ell n\ P + \underset{(2.40)}{1.31^{*}}\ \ell n\ ES \qquad R^2 = 0.61$$

Paper:

$$\ell n\ AS = -3.68 - \underset{(-2.11)}{0.25^{*}}\ \ell n\ D + \underset{(5.15)}{2.82^{*}}\ \ell n\ VS \qquad R^2 = 0.68$$

Printing:

$$\ell n\ AS = 1.11 + 0.10\ \ell n\ P + 0.52^{*}\ \ell n\ ES \qquad R^2 = 0.29$$

Basic metals:

$$\ell n\ AS = 4.41 - \underset{(-1.31)}{1.18}\ \ell n\ CI + \underset{(0.52)}{0.17}\ \ell n\ P - \underset{(-1.31)}{0.43}\ \ell n\ D + \underset{(1.84)}{3.25^{**}}\ \ell n\ ES$$

$$R^2 = 0.42$$

continued ...

IV. Conclusions

Our finding provides considerable evidence, albeit with important exceptions, supporting the central hypothesis that was posited, namely, that the level of capital intensity is a crucial determinant of average size of industrial plants across countries. The strong positive association between average plant size and the level of capital intensity observed for many industries highlights its implication concerning the choice of industrial plant size in less developed countries where the factor price relations may favour the use of relatively labour-intensive techniques. The implication with regard to the choice of industry remains, however, unclear because no definite conclusion emerged concerning the relationship between interindustry average plant size variations and the level of capital intensity. This is regardless of the fact that the countries in our sample displayed some degree of uniformity in the way industries tend to rank according to their average size.

Footnote 2 from previous page continued.

Non-electrical machinery:

$$\ell n\ AS = \underset{(-0.22)}{-0.36} - \underset{(-0.62)}{0.14}\ \ell n\ Y + \underset{(2.02)}{1.44^{**}}\ \ell n\ VS \qquad R^2 = 0.25$$

Chemicals:

$$\ell n\ AS = -2.24 - \underset{(-2.47)}{2.27^{*}}\ \ell n\ D + \underset{(4.75)}{2.33^{*}}\ \ell n\ VS \qquad R^2 = 0.66$$

Petroleum:

$$\ell n\ AS = 0.13 - \underset{(-4.16)}{0.44^{*}}\ \ell n\ D + \underset{(4.24)}{1.83^{*}}\ \ell n\ ES \qquad R^2 = 0.87$$

AS = average size; Y = per capita income; D = density; P = population; CI = capital intensity; VS = share of industrial value-added in total value-added; ES = share of industrial employment in total employment; t-values are indicated in parentheses; one asterisk denotes significant at 0.05 level, a double asterisk at 0.10 level. It will be noted that in three cases the density variable is significant but with a sign contrary to what was predicted.

Our results concerning the influence of market size and concentration on the average size of plants do not compare well with those of others, employing a different model and sample.[1] The implication is not that these variables are not important enough in themselves; it is rather that in intercountry comparisons their importance is overshadowed by other variables such as capital intensity. Nevertheless, the contrasting results definitely point towards the need for further research in this field, using in particular broader samples and more sophisticated measures of market size and capital intensity than have been adopted in this paper.

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1 With regard to market size contrast for instance the results obtained by Pryor (1972, p. 561).

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Appendix

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