Volume Title: Explorations in Economic Research, Volume 3, number 3

Volume Author/Editor: NBER

Volume Publisher: NBER

Volume URL: http://www.nber.org/books/sarg76-1

Publication Date: 1976

Chapter Title: Efficiency Frontiers for Industrial Establishments of Different Sizes

Chapter Author: Patricio Meller

Chapter URL: http://www.nber.org/chapters/c9084

Chapter pages in book: (p. 379 - 407)

3

PATRICIO MELLER
National Bureau of Economic Research
and Catholic University of Chile

Efficiency Frontiers for Industrial Establishments of Different Sizes

ABSTRACT: This study measures the technical efficiency levels of Chilean industrial establishments, using Farrell's efficiency frontier approach. Data from the Chilean Manufacturing Census of 1967, disaggregated at the establishment level, permit an extensive intra-industrial analysis and measurement of efficiency levels. First, the relative technical "inefficiency" existing at each industry level is measured; second, the characteristics of efficient and inefficient firms are examined. In measuring efficiency, we find that a high proportion of establishments—about 75 percent—is at a level of efficiency more than 50 percent below that of the most efficient in the particular industry, which suggests that competition is far from perfect among Chilean industries. With respect to the characteristics of the most efficient establishments, neither their size nor their capital-labor ratio or white collar-blue collar worker ratio are different from those of the inefficient group in the same industry.

NOTE: This paper is a revision of Chapter 4 of my Ph.D. dissertation, "Production Functions and Efficiency Frontiers for Industrial Establishments of Different Sizes: The Chilean Case, Year 1967," University of California, Berkeley, January 1975. I am indebted to the members of my dissertation committee, Lovell Jarvis, Alain de Janvry, and Stephen C. Peck: also to my Chilean colleagues, Patricio Barros, Juan E. Coeymans, Mario Corbo, Dominique Hachette, and Sergio Molina. I am especially grateful to Hal Lary and M. Ishaq Nadiri for their many excellent suggestions.

I would also like to thank George Bitros, Robert Lipsey, and Henry Peskin of the National Bureau's staff reading committee, and Richard Bird, Eugene A. Birnbaum, and J. C. La Force of the Directors' reading committee for their careful reading of the manuscript and their many helpful comments. (Of course, I am the only one responsible for any error remaining in the paper.) Thanks also go to Hedy D. Jellinek for editing the text and to H. Irving Forman for drawing the graphs.

Financial support for this article was provided by the Rockefeller Foundation within its fellowship grant for my stay at the National Bureau. The initial version of my study was done while I was a full-time professor at the Instituto de Economía of the Universidad Católica de Santiago, Chile.

[I] INTRODUCTION AND SUMMARY

This paper examines the technical efficiency of different types of establishments in twenty-one Chilean industries, and offers empirical evidence for the coexistence of firms with varying efficiency levels. A separate analysis is made for each industry, relating levels of technical efficiency to establishment size and such other indicators of modern technology as capital-labor ratios and white collar-blue collar ratios.

The study is based on data from the Chilean Industrial Manufacturing Census of 1967, disaggregated at the establishment level (11,468 establishments employing five or more persons). Since the twenty-one industries, at the four-digit ISIC (International Standard Industrial Classification) level, account for 69.9 percent of all industrial establishments, it may be assumed that the results obtained have general validity for Chile's industry.

These results can be summarized as follows.

1. Approximately 75 percent of the industrial establishments have a level of technical efficiency more than 50 percent below that of the most efficient establishments in their particular industry.
2. Large establishments are not necessarily more efficient than smaller ones in the same industry, nor is large size a prerequisite for efficiency. However, there is less dispersion in efficiency among large establishments than among small ones.
3. Establishments using supposedly modern techniques have neither higher nor lower technical efficiency than those with supposedly old-fashioned techniques.

The concept of technical efficiency used in this study is related to Farrell's efficiency frontier approach:[1] a technique of production is technically efficient if it uses a smaller input combination for a given amount of product. This means that the selection of efficient techniques introduces a minimization process to the input combinations, while the production level remains constant for every technique. It differs from the notion of the production function, where a process of maximization employs techniques producing maximum output with a given amount of inputs. While a discrepancy exists from a theoretical point of view between these processes of maximization and minimization, from an empirical point of view there is no such discrepancy—the points selected as efficient by one criterion remain so with the other criteria.[2]

Establishments within each industry are first classified by size; then Farrell's method is applied to measure technical efficiency levels. Technical efficiency zones are obtained for each size grouping of establishments within each industry as well as for the industry as a whole. It is thus possible to measure the wide range of technical efficiency existing in

Chile's industrial sector and to compare the characteristics of efficient and inefficient firms.

The empirical results obtained following Farrell's method demonstrate the coexistence of industrial establishments with different levels of technical efficiency. These findings raise a series of interesting questions for further study. How can the survival of the inefficient firms be explained? Why have the more efficient firms, which often enjoy significant technical advantages, failed to eliminate the relatively inefficient firms from the market? Some answers to these questions are suggested below.

In section II the methodology used in the study is explained from a theoretical and empirical point of view. Section III provides empirical measurements of relative efficiency, both at the industry level and at the establishment-size group level. In section IV the characteristics and relative importance of the efficient establishments are examined, while section V suggests some possible explanations for the survival of the inefficient ones. Finally, section VI offers some qualifications to the empirical findings and summarizes the results of several similar studies in this area.

[II] METHODOLOGY

This section discusses the use of different production techniques by establishments in the same industry, briefly describes Farrell's method, and compares alternative methods of measuring variables with those used here.

1. The Existence of Different Production Techniques

Since this is a cross-sectional study at the intraindustry level, the use of different production techniques by establishments within the same industry at a given point in time should be explained.

According to the neoclassical theory of the firm, an industry is made up of a series of "representative firms" that possess perfect information (they know the production function), operate in a perfectly competitive market in terms of commodities as well as factors, and use the same decision-making rules for combining productive factors (minimization of costs) and selecting production scale (maximization of profits). A logical implication of this theory is that all the firms in the same industry must fulfill a double equality. In a long-run equilibrium situation they must all (1) use the same production technique or combination of productive factors, and (2) operate at the same production level. This would lead one to expect that only one point of the isoquant will be observed, and that the map of isoquants in a cross-section sample will be reduced to this point (assuming that all firms are in a long-run equilibrium situation).[3] However, in most cross-sectional empirical studies such long-run equilibrium has apparently not been attained, and the data from the Chilean Industrial Census of 1967 are no exception. Within each industry, even at a level of four-digit disaggregation, the distribution of observations is much more dispersed than static theory would suggest, both in terms of production technique and in terms of establishment size.

The following reasons might be cited to explain the existence of establishments of different size, using different production techniques within the same industry.[4]

Selection of Techniques and Factor Prices The relative prices of the factors of production play a vital role in the selection of techniques. Firms that exist today began their productive activities in different time periods, and, since relative prices of productive factors have changed over time, these firms have selected different production techniques. When selecting techniques, importance is given not only to the relative prices of the productive factors prevailing at the moment of selection, but also to expectations regarding relative prices. At the same moment in time, different investors may see the future very differently.

The technologies existing at the time the decision to invest was made are different. In addition, at the moment a cross-section sample is taken, firms which have initiated their production in different time periods may, due to wear and tear of the machinery and additional knowledge acquired, use different sets of combinations of factors with the same original production process.

Furthermore, two firms using the same technology but established at different points in time will appear as having different production techniques because their capital equipment was purchased at different prices. The same phenomenon could occur with firms established at the same point in time in an imperfect technology market where, for example, multinational affiliates could obtain different prices than national firms.

Imperfections Various imperfections operating in the real world of business lead firms to arrive at different decisions.

First of all, knowledge of the range of existing production techniques is incomplete and imperfect, and causes some businessmen to make errors.[5] Entrepreneurs know only a portion of the range, and their investment decisions are taken on the basis of this partial information. Moreover, not only do they possess imperfect information regarding the production techniques of their industry, but they also have only an approximate knowledge of the quality of the productive inputs to be used, et cetera.

Entrepreneurial ability, too, differs from firm to firm; the initiative, ability, innovative spirit, and luck of each entrepreneur will lead him to adopt different techniques and production scales.

Finally, the markets faced by firms, in terms of goods and productive factors, are not perfect due to low mobility, varying degrees of accessibility of different markets, and lack of homogeneity of productive factors.

Different Decision-Making Rules Varying administrative and organizational structures among firms lead to the adoption of different decision-making norms. Examples of such norms are maximization of the average income per worker, sales maximization, maximization of the managerial function, et cetera. Each of these criteria leads to equilibrium or disequilibrium situations differing from those that would be predicted by the norm of economic theory (profit maximization).

2. The Farrell Method

The Farrell method consists in obtaining the envelope including the minimum combinations of necessary inputs for producing one unit of product. As Farrell points out, the purpose of this approach is to compare the performance of actual establishments with the best practices observed in reality, instead of taking ideal combinations of inputs as a point of reference.

Farrell's approach has several advantages: (1) it is functional form free; (2) it can handle establishments using heterogeneous technologies and techniques (the type of establishment used in this study); and (3) it is a useful and simple tool for measuring the relative technical efficiency of different techniques.[5]

At the same time, some of the method's limitations should be noted. First of all, the results obtained are of a relative nature; absolute conclusions cannot be inferred. Secondly, there is some indeterminacy in Farrell's method related to the number of degrees of freedom; the number of observations included in the efficiency frontier is very small (two to six points) regardless of the number of observations in the sample. Moreover, the inclusion of one point in the frontier will depend on the type and number of inputs used. In short, the conclusions will depend on the size and composition of the sample and on the type and number of inputs used (in this case only two inputs—labor, L, and capital, K—are used).

To obtain the efficiency frontier for one industry, the requirements of each establishment in terms of capital and labor factors are calculated per unit of value added. These calculations introduce the implicit assumptions that productive processes have the proportionality property (they can be operated at any level) and are subject to constant returns to scale. These assumptions can be partially obviated when the efficiency frontier is separately calculated for each size grouping of establishments. Then the corresponding efficiency frontiers can be compared for each size.

Once we have obtained the productive factor requirements per unit of value added, the corresponding points are located on a graph whose axes are L/Y and K/Y, with each point representing an establishment or one production technique used in that industry.[7] Then the envelope of all points is drawn, on the assumption of additivity and including only those points representing minimum combinations of inputs.[8]

The establishments included on the frontier are considered the most efficient from a technical point of view; all of them are equally "efficient," abstracting from the effect of relative factor prices. They constitute the point of reference for measuring the relative inefficiency of the rest of the establishments in the industry.

Given the way in which the efficiency frontier is constructed, two types of possible biases may occur—the optimistic and the pessimistic bias.[9]

1. Optimistic bias: The efficiency frontier is very sensitive to measurement error in the extreme observations by which it is determined.
2. Pessimistic bias: The position of the efficiency frontier depends solely upon the observations included in the sample, so that a larger number of observations will not contract or move the frontier toward the right; on the contrary, new observations can displace it toward the left or increase its concavity. Moreover, the existence of establishments not working at full capacity may also introduce biases toward underestimating the real efficiency frontier.

Although these two types of biases tend to compensate for each other, the magnitude of each is unknown, and large differences probably occur from one industry to another.

In order to minimize objections to the efficiency frontier on the grounds of optimistic bias, I have calculated three consecutive efficiency frontiers for the industry as a whole, as well as for each size grouping. The first efficiency frontier corresponds to the envelope of all establishments contained in the particular case. The second efficiency frontier is the envelope determined by the rest of the establishments once those located on the first frontier have been eliminated. Finally, the third efficiency frontier is the envelope that results from eliminating the points from both the first and second frontiers.

3. Measurement of Variables

The concept of establishment size could be made operational by using any of these four variables: gross value of production, labor, capital, or value added.[10] Except for the last, however, they have important weaknesses.[11]

In most studies size classification of industrial establishments is performed by taking the number of people employed in each establishment. The advantage of the labor force as an indicator—used in this study, too—has been the greater availability of data. Although data can be obtained on other indicators, using the labor factor facilitates comparisons between industries and countries that must deal with monetary conversion problems. Besides, it is a highly graphic indicator, allowing an immediate conceptualization of establishment size.

To avoid objections to the use of this indicator, the coefficients of correlation between number of people employed and the other possible indicators mentioned above are presented in Table 1. It can be seen that the simple correlation coefficient values obtained are significant at 1 percent (8,021 observations).

Each of the twenty-one industries is divided into five size categories of establishments: 5 to 9 persons employed, 10 to 19, 20 to 49, 50 to 99, and 100 and more. We then proceed to estimate efficiency frontiers in each four-digit industry for the various establishment size groupings and for the industry as a whole.

After a series of experiments with alternative measurements, I have adopted a procedure for measuring the factor input requirements per unit of value added, L/Y and K/Y, similar to the one used by Griliches and Ringstad.[12] Labor requirements are measured by the number of "equivalent" man-days employed by the establishment, and capital requirements, by the flow of capital services obtained by using book values (see footnote 12).

The labor factor could have been measured through the number of man-days (designated by N_I), without using the transformation to equivalent worker that takes into account differences in quality of labor. The simple correlation coefficients between L and N_I for the establishments within the twenty-one industries have values close to 1.0 (see Table 2). This indicates it does not make much difference whether the labor variable

TABLE 1 Coefficients of Correlation between Indicators of Establishment Size

	N	K_M	K_{HP}	K_{KW}	Y	V
N	1.000					
K_M	0.718	1.000				
K_{HP}	0.795	0.831	1.000			
K_{KW}	0.709	0.760	0.725	1.000		
Y	0.653	0.436	0.520	0.575	1.000	
V	0.682	0.501	0.563	0.586	0.892	1.000

NOTE: Note that coefficients of correlation between the number of persons employed (N) and book value of machinery (K_M), number of HP installed (K_{HP}), number of KWH consumed (K_{KW}), value added (Y), and gross value of production (V) are for all establishments of the 21 industries.

TABLE 2 Simple Correlation Coefficients between the Chosen Measurements and Alternative Measurements of Labor and Capital Inputs, by Industry

Type of Industry ISIC Code	LN_1	KK_M	KK_{KW}	KK_{HP}	KK_S
0.969	3111	0.959	0.806	0.597	
0.992	3112	0.983	0.892	0.874	0.996
0.981	3116	0.972	0.622	0.680	0.999
0.984	3117	0.970	0.866	0.837	0.997
0.982	3121	0.949	0.560	0.806	0.996
0.960	3132	0.284	0.152	0.488	0.997
0.996	3211	0.996	0.925	0.865	0.999
0.992	3213	0.994	0.839	0.888	0.998
0.984	3220	0.971	0.864	0.326	0.995
0.981	3231	0.961	0.904	0.887	0.997
0.989	3240	0.985	0.575	0.641	0.997
0.988	3311	0.913	0.675	0.707	0.992
0.985	3320	0.942	0.875	0.875	0.995
0.884	3420	0.992	0.949	0.672	0.999
0.990	3560	0.994	0.927	0.880	0.999
0.984	3693	0.936	0.558	0.926	0.994
0.989	3710	0.989	0.697	0.840	0.994
0.989	3813	0.986	0.887	0.536	0.998
0.983	3819	0.989	0.810	0.867	0.998
0.976	3829	0.992	0.728	0.790	0.999
0.973	3843	0.832	0.864	0.389	0.999
					0.995

NOTE: L = number of equivalent man-days; N_1 = number of man-days; K = flow of capital services (see footnote 12); K_M = book value of machinery; K_{KW} = number of KWH; K_{HP} = number of installed HP; K_S = sum of the book values of machinery, buildings, vehicles, and inventory goods.

is measured by the number of man-days or by the number of equivalent worker-days.

Various alternative measurements (proxy variables) could be used for the capital variable. Among these are two flow variables—the previously defined capital services called K and the number of KWH of consumed electricity K_{KW}. Also, the following stock variables could be used: the number of HP installed corresponding to the machinery related to the production process, K_{HP}; the total book value of the fixed assets plus the stocks of goods and inputs, measured in E°1967, K_S; and, lastly, K_M, the book value of the machinery, measured in E°, estimated to be the most reliable book value provided by the establishments. See Table 2 for a simple correlation between K and the different measurements of the capital factor for each of the twenty-one industries. Most of the correlation coefficients are significant at the 1 percent level (see the appendix for number of observations per industry).

[III] RELATIVE DEGREE OF EFFICIENCY OF INDUSTRIAL ESTABLISHMENTS

The following section provides the empirical values of relative efficiency, first at the industry level and then at the establishment-size level. A comparison is drawn between the efficiency frontiers of different size groups.

1. Efficiency at the Industry Level

Figure 1 presents a picture that is valid for all industries analyzed in this study. Specifically, it illustrates the distribution of the establishments comprising industry 3320 (furniture manufacturing). It contains a drawing of the three efficiency frontiers obtained in the manner described above.[13] Each point on the graph represents a different establishment within the same industry, and all the establishments are producing the same quantity (unit value) of value added. As is effectively shown in Figure 1, it would be ridiculous to speak of a "representative firm."

Table 3, corresponding to the third efficiency frontier, illustrates the surprisingly wide range of relative technical efficiency among most industrial establishments.[14] The results obtained have been condensed at the industry level and are presented for the twenty-one industries in aggregate form.

We see that, at the third efficiency frontier in each industry, 53.1 percent of the industrial establishments have a relative technical efficiency less than one-third—and 74.4 percent, less than one-half—of that achieved by the establishments located on the efficiency frontiers.

TABLE 3 Relative Efficiency of Industrial Establishments for 21 Industries (optimum efficiency coefficient: 1.0)

	Range of Efficiency Coefficients			
	1.00–0.75	0.74–0.50	0.49–0.33	0.32–0.00
Number of establishments	326	577	750	1,875
Relative percentages	(9.2)	(16.4)	(21.3)	(53.1)

NOTE: Using the L/Y–K/Y diagrams, the efficiency coefficient for an establishment is obtained by comparing its distance from the origin with that of a hypothetical establishment on the efficiency frontier which is located on the same ray from the origin.

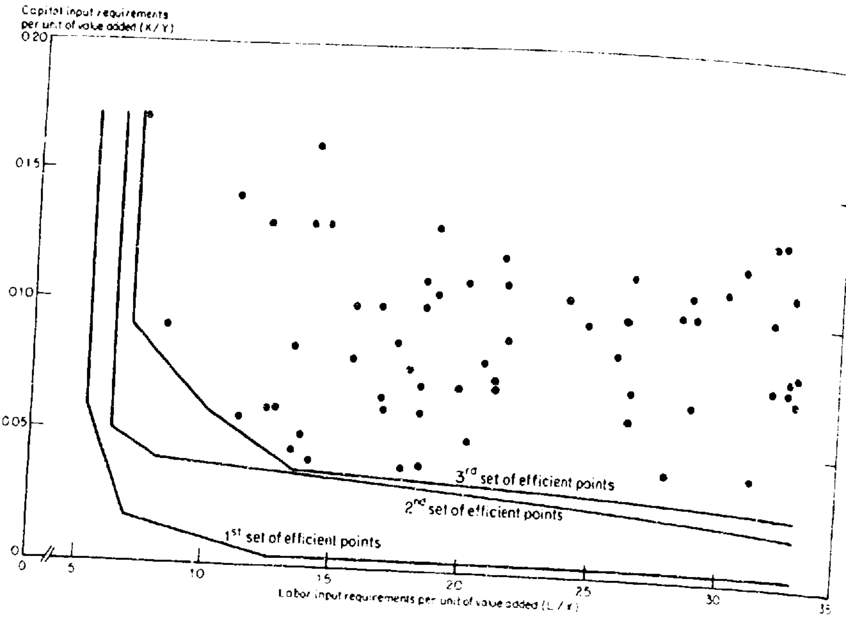


FIGURE 1 Set of Establishments and Efficiency Frontiers for Industry 3320

The degree of general "inefficiency" shows considerable differences across industries. In industries such as 3710 (basic steel and iron industries), only 31.4 percent of the establishments have a relative degree of efficiency less than one-half, while in others, such as 3111 (cattle slaughtering), 95.6 percent of the establishments have a relative efficiency degree under one-half.[15]

Half the industries (11 out of 21) have less than 35 percent of establishments with a relative efficiency degree above .33; furthermore, there are 14 industries in which the percentage of establishments with relative efficiency under 0.5 is 50 percent or more.

These high relative inefficiency levels pose a series of questions. For example, how can one explain the survival of firms whose degree of relative technical inefficiency is lower than .33 of establishments in the same industry? How can the inefficient firms remain competitive in the market faced with the tremendous relative technical advantage of the efficient firms? These questions warrant an extensive study that is beyond the initial aims of this research, but some discussion of these issues is provided below.

The results indicate that a large number of establishments using very inefficient production techniques survive. This suggests that competition is not perfect, either in the commodities market or the factors market.

One of the conclusions of special interest to developing countries is the possibility that an industry can increase production merely by raising the technical efficiency of the less efficient establishments without any increase in the amount of productive factors.

2. Efficiency at the Size-Group Level

Using the third efficiency frontier as a point of reference, the efficiency measurements (obtained for each industry and size group) can be arranged so as to give an idea of the degree of relative technical efficiency by different establishment size.

These efficiency coefficients (see Table 4) have been separately computed *within* the establishment-size grouping of each industry, so that at this stage it is not possible to make comparisons *between* size groups. Note that Table 4 presents a much less dramatic situation than that shown in Table 3.

First, the percentage of establishments with a lower degree of relative technical efficiency within each size group declines considerably as we increase the size. In the smallest size grouping (5 to 9 persons) 67.4 percent of the establishments have an efficiency coefficient under 0.5, while in the largest (100 and more) only 16.2 percent rank that low.

Second, the percentage of establishments with higher degrees of relative efficiency within each size group rises as the size group increases. Thus, in the groups of smaller establishments (5 to 9 and 10 to 19 persons), the

TABLE 4 Relative Efficiency by Establishment Size in 21 Industries (optimum efficiency coefficient: 1.0)

	Number of Establishments			
Size Grouping of Establishments	Efficiency Coefficient 1.00–0.75	Efficiency Coefficient 0.74–0.50	Efficiency Coefficient 0.49–0.33	Efficiency Coefficient 0.32–0.00
5 to 9 persons	171	198	246	515
	(15.1)	(17.5)	(21.8)	(45.6)
10 to 19 persons	176	216	204	259
	(20.6)	(25.3)	(23.9)	(30.3)
20 to 49 persons	209	183	186	144
	(28.9)	(25.3)	(25.8)	(19.9)
50 to 99 persons	84	62	25	20
	(44.0)	(32.5)	(13.1)	(10.5)
100 and more persons	102	73	21	13
	(48.8)	(34.9)	(10.0)	(6.2)

NOTE: The figures in parentheses are the relative percentages of establishments within each size group.

percentage of establishments with efficiency coefficients above 0.75 is 15.1 and 20.6, respectively, while the two largest groups (55 to 99 and 100 and more persons) show percentages of 44.0 and 48.8, respectively.[16]

From these figures I infer that large disparities exist in technical efficiency among the smallest establishments, with some very efficient establishments side by side with a large number of very inefficient ones. As establishment size increases, the disparities of relative technical efficiency decrease in percentage terms (of the number of establishments). Although this general trend persists in the industries examined separately, the variations in the respective percentages are very important.

3. Comparisons between Efficiency Frontiers of Different Size Groups

That larger establishments are more efficient and smaller establishments less so is an assumption repeatedly observed in the literature. It is based on the premise that larger firms use the most modern technology (capital-intensive), taking advantage of economies of scale. Let us see what our investigation shows.

The findings obtained in the previous section suggest that the traditional view is valid in one respect: if a large and a small firm are chosen at random, the probability will be greater that the large firm will be efficient relative to the most efficient in its size class than the smaller firm. However, the frame of reference for measuring relative inefficiency is not the same for each size group. The most adequate measure of the relation between efficiency and size would be a comparison of the efficiency frontiers for each size group. From a theoretical point of view, the different size groups cannot be compared because they have different numbers of observations, i.e., the samples have different degrees of freedom. However, from an empirical point of view, the comparison could be valid because of the large size of the samples.

In order to avoid the inconveniences found when using the first efficiency frontier, I arbitrarily use the second efficiency frontier obtained in each of the five size groups. The relationship between the second efficiency frontiers for these five size groups is depicted in Figure 2.[17] It is worth noting that no definite pattern of behavior emerges. The efficiency frontiers of different size groupings cross each other; although efficiency frontiers of some size groups are clearly more efficient than those of others, the most efficient frontier does not always correspond to the same size group. The same can be said of the most inefficient frontier (which corresponds to that included by the other four frontiers).

These results show that it cannot be established empirically that one size

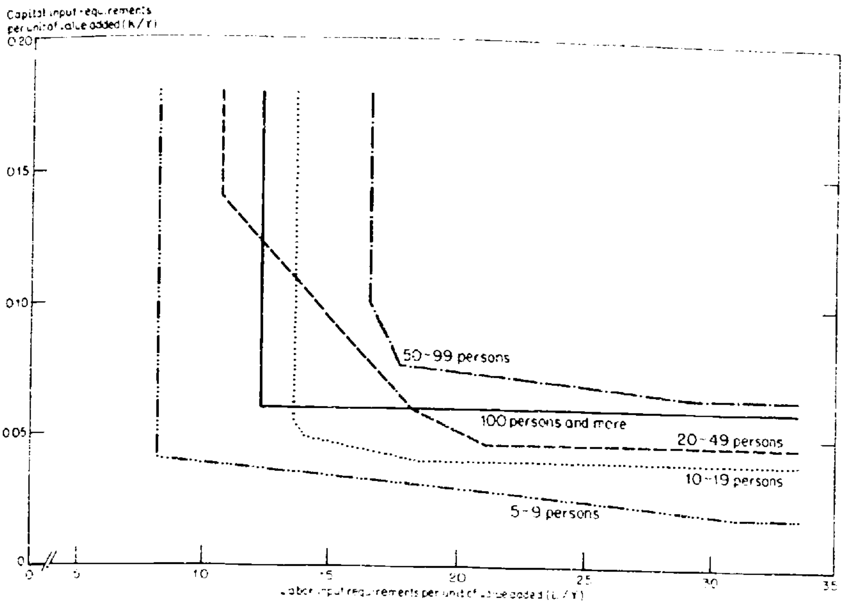


FIGURE 2 Second Efficiency Frontiers by Size Group of Establishments for Industry 3320

group of industrial establishments is more efficient from a technical viewpoint than another size group. In the case of some industries, it is interesting to note that some smaller establishments use more efficient production techniques than larger establishments. These industries are: 3111 (cattle slaughtering), 3116 (mill products), 3132 (wine), and 3320 (furniture). Surprisingly enough, larger establishments are more technically efficient than smaller establishments only in two industries: 3213 (knitting) and 3240 (shoes). What needs to be clarified is whether large establishments are producing the same product as smaller establishments in the same industry.

[IV] SOME CHARACTERISTICS OF EFFICIENT ESTABLISHMENTS

In examining the characteristics of efficient establishments, I consider every establishment as efficient if it has a coefficient of relative technical efficiency equal to or above 0.50, with the second efficiency frontier at the industry level as my point of reference. In addition, establishments located on the first efficiency frontier are also included. The rest of the establishments belong to the inefficient category.

1. Relative Importance of Efficient Establishments at the Industry Level

Table 5 shows what share of an industry's productive factors employed, value added, and gross production value is accounted for by the efficient establishments.

Note that in only 6 industries do the efficient establishments use more than 50 percent of persons employed, in only 9 do they own 50 percent or more of the installed capacity (HP number), and in only 10 of the 21 industries do they consume more than 50 percent of the electricity used. On the other hand, efficient establishments produce more than 50 percent of the value added in 14 industries and more than 50 percent of the gross production value in 12.

TABLE 5 The Efficient Establishments' Share of Input and Output, by Industry (percent)

Type of Industry ISIC Code	Establishments[a]	Employed Persons	Consumed KWH	Installed HP	Value Added	Gross Production Value
3111	2.9	0.5	0.8	0.0	9.8	6.8
3112	32.1	39.2	52.8	51.1	66.8	55.9
3116	28.2	28.5	39.5	29.2	47.4	40.4
3117	15.1	23.6	44.9	33.6	56.0	45.4
3121	12.8	24.4	8.8	23.9	78.2	68.7
3132	6.0	13.2	21.0	15.0	32.9	29.3
3211	24.8	15.6	14.3	15.2	22.1	20.1
3213	42.1	71.8	82.0	76.7	83.8	76.7
3220	7.8	17.2	18.7	12.6	35.1	32.2
3231	52.5	65.3	84.9	78.3	85.6	82.0
3280	35.9	58.8	69.2	63.7	75.8	61.4
3311	22.4	20.4	24.6	28.1	35.5	31.7
3320	24.4	40.6	40.5	40.2	63.0	58.4
3420	51.7	60.8	66.4	68.5	77.4	74.3
3560	54.9	63.6	65.8	45.9	78.2	75.2
3693	50.0	49.3	66.7	69.8	85.8	72.8
3710	43.8	47.8	58.1	57.6	73.1	66.9
3813	27.9	35.2	56.4	51.0	58.6	49.8
3819	43.0	57.8	65.5	50.8	74.5	68.8
3829	28.9	31.2	19.0	17.7	35.4	33.9
3843	29.3	40.2	44.9	23.4	72.1	75.3
Total	22.7	32.7	35.4	34.6	52.9	46.0

[a] The discrepancy with previous results is due to the use of the second efficiency frontier as reference level.

Thus, it can be inferred from Table 5 that efficient establishments produce more than half of the total value added using only a third of available productive factors. Hence, the efficient establishments have an average productivity approximately double that of the inefficient establishments. The situation varies considerably among industries.

In 16 of the 21 industries, the consumed KWH percentages are higher than the installed HP percentages. Thus, efficient establishments make greater use of installed capacity than inefficient establishments.

Finally, for 20 industries the value added percentages exceed those of gross production value. In the next sections, this relationship will be explored more thoroughly.

I have emphasized the overall results in my discussion because some of the figures for individual industries appear to be affected by data omission or other defects in reporting. However, I do not believe that corrections of these defects would change the conclusions for manufacturing as a whole.

2. Comparison between Efficient and Inefficient Establishments

Table 6 compares efficient and inefficient establishments in the twenty-one industries covered in terms of labor productivity, capital-labor ratio, wages, share of labor, ratio of value added to gross product, and ratio of white-collar to blue-collar worker. In reading the results, one should remember that the average values shown are based on the size-of-establishment variable, which makes possible a more exact comparison between efficient and inefficient establishments.

As indicated in Table 6, the average labor productivity values for all efficient establishments are 2.8 times larger than those of the inefficient establishments. In some industries these differences are even larger, and ratios close to four and five are found.

It is interesting to observe that labor-productivity differentials do not go together with capital-labor differentials. In fact, the differences in factor intensity use between efficient and inefficient establishments for the 21 industries is only 10 percent; moreover, only in 12 of the 21 industries is the capital-labor ratio greater for efficient than for inefficient establishments. From these data one may infer that the capital-labor ratio is an inadequate indicator for classifying industrial establishments according to different efficiency levels. Of course, these are overall results at the industry level which indicate the tendency of the parameter across different size groupings.

In each of the twenty-one industries, the average remunerations are higher for efficient than for inefficient establishments. The average remuneration differentials fluctuate between 25 and 143 percent. Overall, the average remuneration differential between efficient and inefficient establishments reaches 65.8 percent.

TABLE 6 Characteristics of Efficient versus Inefficient Establishments, by Industry

Type of Industry ISIC Code	Average Productivity of Labor		Capital-Labor Ratio		Average Wages	
	Effic. E.	Ineffic. E.	Effic. E.	Ineffic. E.	Effic. E.	Ineffic. E.
3111	1.919	0.080	0.027	0.011	6.341	5.433
3112	0.192	0.035	0.023	0.010	11.497	5.639
3116	0.165	0.058	0.015	0.013	8.569	6.956
3117	0.038	0.015	0.003	0.003	5.170	4.104
3121	0.283	0.057	0.007	0.013	11.422	6.937
3132	0.151	0.046	0.048	0.025	4.816	2.164
3211	0.122	0.049	0.020	0.011	7.748	6.723
3213	0.060	0.027	0.009	0.007	5.785	3.858
3220	0.200	0.062	0.006	0.005	10.507	4.331
3231	0.091	0.039	0.010	0.011	9.110	6.002
3240	0.053	0.027	0.004	0.004	5.963	4.289
3311	0.055	0.023	0.010	0.007	4.536	3.263
3320	0.048	0.013	0.004	0.003	5.058	3.957
3420	0.079	0.025	0.011	0.005	11.633	6.822
3560	0.081	0.037	0.007	0.010	6.935	5.569
3693	0.041	0.015	0.006	0.006	6.650	3.677
3710	0.115	0.038	0.015	0.015	10.230	6.339
3313	0.059	0.025	0.005	0.007	7.417	5.200
3319	0.047	0.022	0.004	0.005	6.115	4.235
3329	0.097	0.038	0.006	0.009	9.975	7.794
3343	0.180	0.054	0.013	0.012	9.610	6.325
Total	0.095	0.034	0.011	0.010	7.176	4.327

At the industry level there is no correspondence between average labor productivity and average remuneration of efficient and inefficient establishments. For each of the 21 industries, the relative labor share in the value added is lower in efficient than in inefficient establishments. For 18 industries the relative labor share is above 0.40 in inefficient establishments, but for 15, the relative labor share is under 0.40 in efficient establishments. Relative labor share values in all 21 industries reach 0.33 for efficient establishments and 0.50 for inefficient ones.

The value added-gross production value ratio, Y/V, holds a systematic variation pattern for the 21 industries. It is greater for efficient than for inefficient establishments. For 16 of the 21 industries this Y/V ratio is more than 0.50 in inefficient establishments. For all 21 industries, the Y/V ratio is 0.55 for efficient establishments and 0.40 for inefficient ones. This systematic variation pattern points to the following possible conclusions: efficient establishments might use the raw material necessary for their final products in a more efficient way; or, the efficient establishments could be more

Relative Share of Labor		Value Added-Gross Product Value		White-Collar-Blue-Collar Workers	
Effic. E.	Ineffic. E.	Effic. E.	Ineffic. E.	Effic. E.	Ineffic. E.
0.068	0.504	0.299	0.266	0.180	0.317
0.188	0.423	0.471	0.388	0.339	0.512
0.144	0.360	0.370	0.233	0.407	0.342
0.323	0.554	0.422	0.303	0.262	0.293
0.184	0.404	0.623	0.504	0.652	0.344
0.099	0.352	0.413	0.299	0.318	0.271
0.269	0.454	0.600	0.483	0.178	0.200
0.290	0.036	0.511	0.407	0.235	0.396
0.257	0.670	0.553	0.426	0.239	0.298
0.335	0.413	0.571	0.417	0.209	0.340
0.443	0.533	0.534	0.421	0.236	0.234
0.299	0.570	0.537	0.481	0.203	0.224
0.322	0.652	0.619	0.505	0.264	0.303
0.447	0.613	0.672	0.624	0.464	0.465
0.296	0.414	0.635	0.542	0.209	0.250
0.432	0.652	0.621	0.526	0.206	0.313
0.423	0.475	0.568	0.502	0.255	0.256
0.418	0.606	0.578	0.520	0.336	0.255
0.370	0.490	0.650	0.504	0.240	0.343
0.539	0.674	0.660	0.642	0.271	0.299
0.277	0.402	0.611	0.617	0.244	0.256
0.327	0.503	0.551	0.398	0.271	0.288

NOTE: The capital-labor ratio has been measured on the basis of services of fixed stocks (book values) and number of equivalent workers × days worked. The white-collar category includes all those persons related to the establishment except those in the blue-collar category.

vertically integrated in their productive process than inefficient establishments. This cannot be confirmed without further empirical research.

Finally, the ratio of white-collar to blue-collar workers does not have any effect on the efficiency level of industrial establishments. On the contrary, the ratio is higher in inefficient than in efficient establishments. This result contradicts Fleming, who states that the employment structure is a basic variable explaining productivity differentials among industrial establishments.[18]

In summary, it could be said that neither the size of establishment, nor the capital-labor ratio, nor the employee-worker ratio (variables that could be considered as technical progress indicators) constitute decisive elements for distinguishing between efficient and inefficient establishments (according to the classification made by the Farrell method).[19]

IV SOME REMARKS ON THE COEXISTENCE OF INEFFICIENT AND EFFICIENT ESTABLISHMENTS

According to the traditional theory of the firm, the behavior assumption for decision making is profit maximization. The Darwinian principle of the survival of the fittest supports this assumption. In a competitive market only the strongest firms will survive; these are the profit maximizers.[20] Technologically more efficient firms could eliminate inefficient firms operating competitively.

In the light of the results detailed in the previous section, however, it is indeed time that "economists should develop a theory about firms not disappearing from the market."[21] The aim would be to distinguish between traditional theory, which studies the behavior of a particular firm, and a theory of entry and exit from the market, setting conditions of survival and disappearance of firms from a given market. Such a theory could be used to explain the coexistence of establishments with great discrepancies in their efficiency levels, and to examine the causes preventing the expansion of more efficient firms.

Meanwhile, here are some hypotheses that might explain the coexistence of efficient and inefficient establishments and the low degree of competition this suggests.[22]

1. Price Protection ("Price Umbrella")

In most Chilean industrial sector markets, prices are determined by one or both of the two elements: (1) an oligopolistic structure, in which leading firms fix prices according to a "mark-up" policy at a high enough level to allow the existence of inefficient firms, and (2) a government price fixing agency (e.g. DIRINCO) whose aim is avoiding the bankruptcy of industrial establishments; hence, the cost structure of inefficient firms would determine prices at a level benefiting efficient firms.

2. Imperfections in the Factor and Commodity Markets

Some of these imperfections were pointed out in the discussion of different production techniques. Additional explanations relevant to the survival of inefficient establishments follow. (a) Although the entrepreneurial factor is said to be one of the most scarce resources in underdeveloped countries, the great number of industrial establishments seems to prove the opposite. Undoubtedly, entrepreneurial ability is an important element explaining the great efficiency variations observed among different establishments, but this is difficult to quantify empirically. The existence of many inefficient establishments could be partially explained by the social status of businessmen (or independent workers) in Chile—they are satisfied with very low rates of return.[23] (b) Due to the geographical conditions specific to

Chile, inefficient establishments located in isolated zones could be taking advantage of the low or nonexistent mobility of local productive factors. (c) Certain markets may not be attractive to efficient firms, and thus inefficient firms become the only suppliers to abandoned markets. According to Wellisz, the nonappealing markets would correspond to low-income families consuming low-quality products, produced by inefficient establishments. This same argument could be used for high-income families consuming high-quality products. There is no obvious relationship between the establishment's degree of efficiency and the quality of the product produced. (d) One could argue that inefficient firms might be able to compete with efficient ones if all costs, such as publicity, transportation to isolated zones, et cetera, were taken into consideration. However, this is a questionable argument, given the magnitude of the discrepancy found in efficiency levels between the two types of establishments.

3. Reasons of Efficient Firms for Not Expanding

Some reasons for not expanding could include the following. (a) Expansion costs may be too high; the increase in the share of a specific market may not be great enough to make expansion attractive. Table 5 shows the efficient firm's substantial share of the market as represented by value added. (b) Expansion means employment of a greater number of workers. Whether for union reasons or to avoid the creation of overly large unions, the firm may decide not to expand. (c) Finally, it seems that astute Chilean businessmen (who may be owners of efficient firms) prefer to diversify their investments.[24] The reason for this behavior is "not to put all one's eggs in one basket," an adequate reason for a protected economy with great variations and frequent changes in its rates of protection.

[VI] SOME REMARKS ON THE VALIDITY OF THE EMPIRICAL RESULTS OBTAINED

The main findings of this study point out that most establishments in Chilean industry do not operate in the outer limits of what could be considered the country's production possibility frontier. It seems appropriate under the circumstances to consider possible qualifications to these results, as well as compare them with other empirical findings in the literature.

1. Some Qualifications

The following limitations should be noted in interpreting the findings of this study.

Product Homogeneity Even at the four-digit industry level the product homogeneity objection is valid; establishments could be producing goods which are far from being substitutes for each other. Moreover, they produce a great variety of goods and very different proportions of each type, and also differ considerably in the proportion of value added to the final product. However, dividing the four-digit industries according to establishment size has increased the product homogeneity within each industrial group; and the consistency of the results obtained across all industries and size groups provides support to the main finding: a wide range of technical inefficiency in the Chilean industrial sector.

Use of Only Two Factor Inputs As I pointed out in my discussion of Farrell's method (see p. 383), the results obtained depend upon the type and number of inputs used. In this study, following the traditional production function approach, only two inputs are used: labor and capital. However, I am planning to incorporate additional inputs into my analysis at a later stage of research. The first candidate for this is skills: the labor factor will be explicitly divided into two components, raw and skilled labor. With respect to the capital factor, some measurement of the actual degree of its utilization will be included in the future. Another input item that could be considered is raw materials, in which case the point of reference for the unit isoquant would be gross value of production instead of value added.

Errors of Measurement Industrial establishments differ in the type of inputs used, and the measurements employed in this study cannot capture, among other things, input quality differences. The use of book values to measure the capital services factor (besides the traditional limitations of ignoring differences in capacity utilization, accounting procedures, and depreciation rates) in a persistently inflationary economy like Chile's leads to an underestimation of the capital factor of the older establishments, exaggerating their technical efficiency. Measuring the establishments' input quality differences would affect their relative performance, but it is not clear a priori whether the observed relative technical efficiency differences would increase or diminish.

Short-Term Differences Since this is a cross-sectional study, in a specific year some establishments make profits and some have losses. This affects the way the value added variable is measured, providing an upward bias in the technical efficiency coefficient for the establishments having higher profits. Furthermore, due to the fact that establishments start their operations at different periods, in any one year they reach a different stage in their learning-by-doing process. This introduces a new upward bias in favor of old establishments. For this reason this analysis will also be applied to various other years. This will enable me to observe whether the same number of relatively inefficient establishments is found and whether inefficient establishments reach higher levels of efficiency, stay at the same level of relative inefficiency, or leave the market. In examining establishments located on the efficiency frontier, it will be interesting to find whether those which are relatively the most efficient ones in one year maintained that status in a different year.

2. Comparable Empirical Findings

Evidence supporting the existence of a large proportion of technically inefficient establishments is not new in the economic literature. Most of the empirical results of the studies summarized below agree with those shown in this one.

An ECLA study of the textile industry in Latin America found striking evidence of diversity in (labor) productivity. In the specific case of the Brazilian textile industry, two-thirds of the mills' (labor) productivity was below the industry average. Furthermore, after an econometric analysis of the effects of product-mix and age of machinery, the ECLA study concluded that physical factors did not explain the sharp differences in productivity levels in Brazilian mills.[25]

Leibenstein, in his paper "Allocative Efficiency versus X-Efficiency,"[26] provides a large amount of empirical support for what he calls the existence of X-inefficiency. He explicitly states that "the data suggest that there is a great deal of possible variation in output for similar amounts of capital and labor and for similar techniques." Furthermore, he provides figures showing the possibility of "unit cost reductions at the firm level by making better use of labor and capital of over 50 percent for India and Burma."

The main conclusion of a Dunning and Rowan study is that U.K. firms operating in Britain are less efficient than U.S. firms operating in Britain.[27] Over a time span of four years, the paper finds average efficiency of U.S. firms 20 percent above that of U.K. firms. Furthermore, in some industries like chemicals, U.S. firms had an average efficiency 58 percent higher than U.K. firms.

A study that provides opposite results to those shown above is Richmond's analysis of Norwegian industry. There it is observed that about 80 percent of the establishments in each industry have, in general, a technical efficiency level of higher than 0.75 (where 1.0 is the technical efficiency level of the most efficient establishments).[28] But even this study includes some industries where about 40 percent of the establishments have a technical efficiency level lower than 0.75.

Finally, there are two studies employing Farrell's technique, also used here, that obtain results similar to mine: (1) "Most of the industries considered would have to reflect x-inefficiencies of the order of 50 to 300 percent or more,"[29] and (2) "80 percent of the observations were inefficient."[30]

APPENDIX

Data used in this study are at the four-digit disaggregation industry level of the ISIC classification. Basic data consist in primary information at the industry level for the Chilean Industrial Sector Manufacturing Census of 1967.

The twenty-one industries covered, shown in Table A-1, were selected

TABLE A-1 ISIC Code and Designation of the Twenty-One Industries

ISIC Code	Industry
3111	Slaughtering, preparing and preserving meat
3112	Manufacture of dairy products
3116	Grain mill products
3117	Manufacture of bakery products
3121	Manufacture of food products not elsewhere classified
3132	Wine industries
3211	Spinning, weaving and finishing textiles
3213	Knitting mills
3220	Manufacture of wearing apparel, except footwear
3231	Tanneries and leather finishing
3240	Manufacture of footwear, except rubber or plastic footwear
3311	Sawmills, planing and other wood mills
3320	Manufacture of furniture and fixtures, except primarily of metal
3420	Printing, publishing and allied industries
3560	Manufacture of plastic products
3693	Manufacture of cement, lime and plaster
3710	Iron and steel basic industries
3813	Manufacture of structural metal products
3819	Manufacture of fabricated metal products except machinery and equipment not elsewhere classified
3829	Machinery and equipment except electrical not elsewhere classified
3843	Manufacture of motor vehicles

according to a flexible application of the following criteria. (1) Each chosen industry should have a "sufficient" number of observations to enable a meaningful empirical estimation in the different size groupings of establishments; (2) industries chosen should produce more or less homogeneous products; and (3) there should be at least one industry for each two-digit ISIC classification.

These twenty-one industries comprise 8,021 establishments. Note that for all computations relating to the measurement of technical efficiency a selection was made among these establishments to insure maximum reliability of results. Establishments were excluded on the basis of the following criteria: (1) Number of persons employed per establishment less than 5 (despite the fact that the Industrial Census supposedly covers only establishments employing at least five persons, it actually includes 328 establishments that violate this rule); (2) number of days worked per establishment equal to 0; (3) total number of workers and employees equal to 0; (4) book value of machinery equal to 0; (5) book value of buildings equal to 0; (6) added value less than or equal to 0; and (7) payment to capital factor, obtained as the difference between value added and total labor factor cost, less than or equal to 0. (In most cases 0 does not literally mean zero but reflects the omission of information.)

Establishments that did not meet any one of the previous criteria were excluded from the sample. The number of establishments was drastically reduced from 8,021 to 3,650 (see Table A-2).

The distribution of the sample by establishment size is shown in Table A-3. It should be pointed out that over 80 percent of the eliminated establishments belong to the two smallest size groups (5–9 and 10–19 people employed). In spite of the large number of eliminated observations, the sample still comprises over 30 percent of the total number of establishments for the two smallest size groups and over 70 percent of the total number of establishments for the two largest size groups (50–99 and 100 and more people employed).

TABLE A-2 Number of Establishments Eliminated According to Different Selection Criteria

Type of Industry	Number of People Employed Less than Five	Number of Days Worked Less than One	Number of Workers and Employees Equal to Zero	Buildings Book Value Equal to Zero	Value Added Below or Equal to Zero	Payments to Capital Factories Below or Equal to Zero	Machinery Book Value Equal to Zero	Total Number of Eliminated Establishments
3111	3	0	1	323	0	2	16	324
3112	1	0	1	41	0	0	0	41
3116	3	0	1	27	0	0	1	29
3117	10	0	2	534	0	2	3	536
3121	1	0	0	24	0	0	0	25
3132	43	0	13	342	0	1	0	380
3211	0	0	0	125	0	0	1	125
3213	3	0	0	199	0	0	0	200
3220	5	0	0	483	0	0	0	485
3231	0	0	0	31	0	0	1	31
3240	1	0	1	200	0	2	0	200
3311	244	0	220	960	1	2	1	975
3320	5	0	1	287	0	1	3	288
3420	2	0	1	233	0	1	1	233
3560	1	1	1	66	1	0	0	66
3693	2	0	0	62	0	0	0	63
3710	0	0	0	12	0	0	0	12
3813	1	0	0	111	0	0	0	112
3819	3	0	2	117	0	0	1	117
3829	0	0	0	66	0	0	0	66
3843	0	0	0	63	0	0	0	63
Total	328	1	244	4,306	2	11	28	4,371

NOTE: The figures do not add across to the totals shown in the last column because some establishments are included under more than one heading.

TABLE A-3 Number of Observations Used for Efficiency Frontiers Estimation

Type of Industry	Establishment Size Class: 5–9 Persons	10–19 Persons	20–49 Persons	50–99 Persons	100 and more Persons	Total Industry
3111	78	36	39	16	6	175
3112	11	11	12	8	11	53
3116	29	30	50	20	2	131
3117	210	249	143	15	12	629
3121	9	16	12	4	6	47
3132	357	131	56	6	4	554
3211	22	37	73	36	58	226
3213	36	29	44	20	16	145
3220	60	41	43	20	29	193
3231	9	13	20	11	8	61
3240	30	37	31	20	24	142
3311	124	129	97	33	37	420
3320	79	47	37	10	7	180
3420	48	25	39	14	19	145
3560	6	9	19	7	10	51
3693	21	20	17	5	1	64
3710	7	8	17	4	12	48
3813	19	27	20	8	12	86
3819	45	30	32	8	6	121
3829	22	14	27	21	13	97
3843	15	21	19	12	15	82
Total	1,237	960	847	298	308	3,650

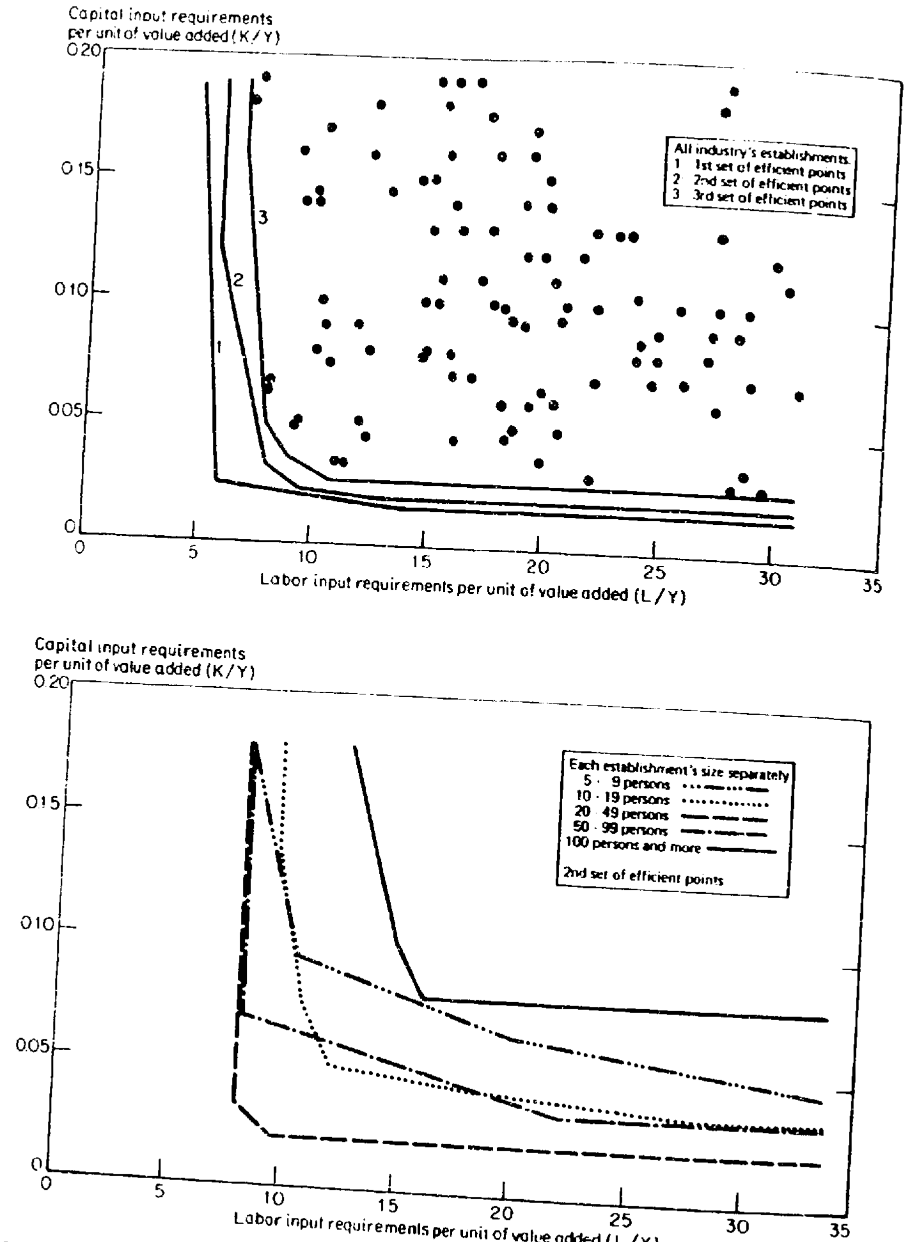
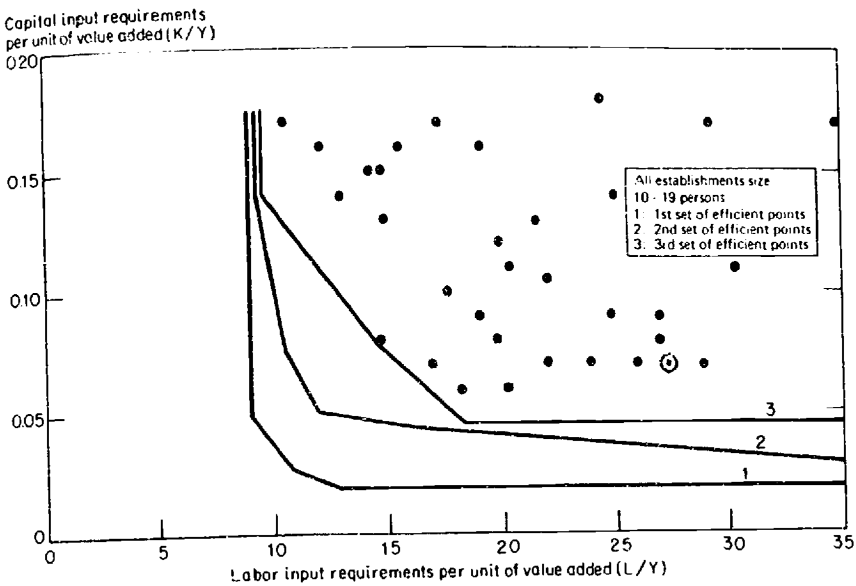


FIGURE A-1 Efficiency Frontiers for Industry 3311



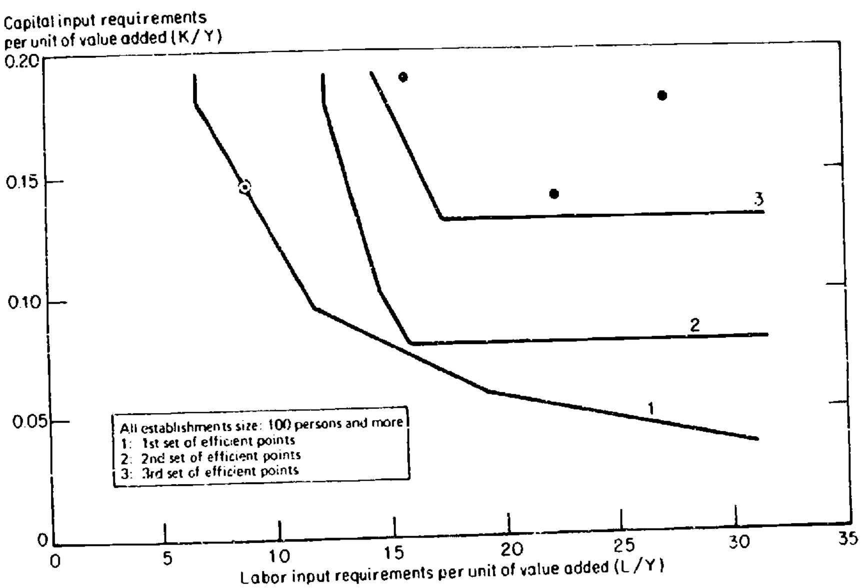


FIGURE A-1 (concluded)

NOTES

1. M. J. Farrell, "The Measurement of Productive Efficiency," *Journal of the Royal Statistical Society*, Series A, Vol. 120, Part 3, 1957.
2. L. Johansen, *Production Functions* (Amsterdam: North-Holland, 1972). On pages 186 through 207, the author provides an excellent review of the theoretical and empirical issues discussed above.
3. R. R. Nelson, T. P. Schultz, and R. L. Slighton, *Structural Change in a Developing Economy* (Princeton: Princeton University Press, 1971). In this volume, the same type of argument is used in relation to the existence of more than one production function for establishments in the same industry.
4. Johansen, *Production Functions*, pp. 28–33; Z. Griliches and V. Ringstad, *Economies of Scale and the Form of the Production Function* (Amsterdam: North-Holland, 1971), pp. 14–15; A. A. Walters, "Production and Cost Functions: An Econometric Survey," *Econometrica*, January 1963, pp. 14 and 38.
5. A. Walters, *An Introduction to Econometrics* (New York: MacMillan, 1968), p. 290.
6. See Farrell's 1957 article for a full explanation of the method. For some theoretical and empirical limitations, see Peter T. Knight, "Problemas de la Comparación Internacional de la Eficiencia Económica al Nivel Microeconómico en Industrias Manufactureras: La Experiencia del Estudio ECIEL de Eficiencia industrial," *Ensayos ECIEL*, No. 1, November 1974.
7. L/Y and K/Y are labor and capital requirements per unit of value added, respectively.
8. Although empirically no production techniques exist in the zone of linear combinations of two efficient production techniques, theoretically we assume the frontier to exist in that zone. (See Johansen, *Production Functions*, pp. 8–9.)
9. Knight, "Problemas," November 1974, pp. 12–13; and J. C. Tandercíar, "Productive Efficiency: A Case Study in the Argentine Agricultural Sector" (Ph.D. dissertation, Agricultural Economics, University of California, Berkeley, 1971), pp. 17–18.
10. A possible alternative would be to use the four variables simultaneously, by combining them through discriminant analysis. The size classification would be achieved via a four-dimensional vector, with most weight assigned to the variable that has the largest variance across establishments. But, if practical conclusions are sought for different establishment sizes, a discrimination size coefficient that mixes different physical units (monetary units, number of workers, horsepower, et cetera) is inconvenient; a simple indicator with precise units is highly preferable.
11. Establishments classified in the same industry cover different stages of the productive process: some cover a large number of productive stages, others only the final stages. The gross value of production could, therefore, indicate similarity of size for establishments that in fact are very different. As to using either labor or capital factors as size indicators—in the former case, the size of establishments using capital-intensive techniques will be underestimated and the size of those using labor-intensive techniques, overestimated, while in the latter case the opposite would result.
12. See their *Economies of Scale*, pp. 22–29.

My variables are measured in the following way:

Y = value added

measured in E° 1967 (1967 escudos).

L = labor factor

measured in number of equivalent man-days, where the number of equivalent workers is

$$L_1 = m_1 + \frac{w_2}{w_1} m_2 + \frac{2w_2}{w_1} m_3$$

m_1, m_2, and m_3 are the number of blue-collar, white-collar workers, and entrepreneurs; and w_1 and w_2 are the average wages received by blue- and white-collar workers.

K – capital factor

measured in E° 1967, computed as a flow according to the following expression:

$$K = 0.10K_M + 0.03K_B + 0.20K_V + 0.10\,(K_M + K_B + K_V + K_I)$$

where K_M, K_B, K_V, and K_I are the book values of machinery, buildings, vehicles and inventory goods. Linear depreciation rates of 0.10, 0.03, and 0.20 have been used for machinery, buildings and vehicles, and a 10 percent real interest rate is used as an alternative cost for nonfinancial capital.

13. See pp. 384–385.
14. The use of the third efficiency frontier as a point of reference is an arbitrary procedure. It is used here in order to argue from a conservative position and to avoid optimistic biases in the location of the industry's efficiency frontier.
15. For these percentages I have taken an arbitrary "efficiency zone" and not an efficiency frontier as point of reference; i.e., I am considering a thick isoquant which covers the northeast area in the positive quadrant, located between the third efficiency frontier and a homothetic isoquant which is 50 percent further from the origin. This procedure obviates the criticism made by A. de Janvry that such percentages depend on the number of establishments of the industry. The efficiency frontier will contain 2 to 6 observations, but an efficiency zone will contain a number of observations depending on the relative degree of efficiency of the industry's establishments.
16. See footnote 15.
17. The graph illustrates the relationships for industry 3320 (furniture), but is representative for all industry.
18. M. C. Fleming, "Inter-Firm Differences in Productivity and Their Relation to Occupational Structure and Size of Firm," *The Manchester School*, March 1970, pp. 223–246.
19. This conclusion could be extended toward that drawn by Gregory and James for Australian industry. They affirm that "vintage models were neither markedly superior nor inferior to nonvintage models." R. G. Gregory and D. W. James, "Do New Factories Embody Best Practice Technology," *Economic Journal*, December 1973, p. 1133.
20. This point was questioned by S. G. Winter in "Economic Natural Selection and the Theory of the Firm," *Yale Economic Essays*, Spring 1964.
21. Winter, 1964, p. 238.
22. J. S. Bain, *Essays on Price Theory and Industrial Organization* (Boston: Little, Brown and Co., 1972), Chapter 9; H. S. Wellisz, "The Coexistence of Large and Small Firms: A Study of the Italian Mechanical Industry," *Quarterly Journal of Economics*, February 1957; J. Bergsman, "Commercial Policy, Allocative Efficiency and X-Efficiency," *Quarterly Journal of Economics*, August 1974.
23. A similar phenomenon has been observed in Italy; see Wellisz, February 1957, p. 122.
24. O. G. Garretón and J. Cisternas, "Algunas Características del Proceso de Toma de Decisiones en la Gran Empresa: La Dinámica de Concentración," Servicio de Cooperación Técnica, Marzo, 1970, mimeo.
25. United Nations, "The Textile Industry in Latin America," ECLA Conf. 23, L.3, October 1963.
26. *American Economic Review*, June 1966, pp. 392–415.
27. J. H. Dunning and D. C. Rowan, "Inter-Firm Efficiency Comparisons: U.S. and U.K. Manufacturing Enterprises in Britain," *Banca Nazionale del Lavoro Quarterly Review*, June 1968, pp. 132–182.
28. J. Richmond, "Estimating the Efficiency of Production," *International Economic Review*, June 1974, pp. 515–521.
29. Howard Pack, "The Employment-Output Trade-off in LDC's—A Microeconomic Approach," *Oxford Economic Papers*, November 1974, p. 393.
30. Benjamin I. Cohen, *Multinational Firms and Asian Exports* (New Haven: Yale University Press, 1975), p. 142.