$$\sigma = 1/(1+\rho - \{\rho m/s_k\}),$$

where ρ is the substitution parameter in the CES function, $m = g/(1-b)$, and s_k the share of capital from total output. As Nerlove-Bruno have shown,

$$b = 1/(1+\rho)$$

and

$$g = \rho m/(1+\rho).$$

In the usual cases of $\rho \gtreqless 0$ and $m \gtreqless 0$, it can be shown from the above relations that

$$\sigma \gtreqless b$$

according as

$$g \gtreqless 0.$$

In the more usual case of $g > 0$ (Hildebrand-Liu's findings), the true elasticity of substitution is underestimated by b.

Griliches (1967b)[10] has suggested an alternative interpretation of the Hildebrand-Liu regressions which is mainly statistical. It is suggested that the Hildebrand-Liu equations basically represent an identification problem involving a system of equations,

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[10]Zvi Griliches (1967b) in Brown, ed. (1967), pp. 126-7.

$$\ln Q/L = a \ln (K/L) + u$$

$$\ln Q/L = b \ln W + v.$$

The combined regression (2.9a) with significant b and g coefficients is consistent with the basic CES estimating regression (2.8). Paraphrasing Griliches, since K/L is rarely measured without error and W is related systematically to the effects of K/L, W may serve as a proxy for K/L and its coefficient may turn significant in the regression (2.9). The relative variances of v, the error in the marginal conditions, and error of measurement in capital determine the final results.

There is a symmetric way of estimating a CES function. Given all the conditions of equilibrium about factor pricing and the assumptions of constant returns to scale, there is no reason why the production function from the regression cannot be estimated as

$$\ln Q/K = \ln A' + b' \ln R + e'$$

where Q/K is output per unit of capital, R rentals per year per unit of capital, A' the regression constant and e' the error term. Indeed, Dhrymes (1965) has performed symmetric estimations of this type. In view of the problems inherent in the estimation of capital[11] and in the concept of "capital" as a homogeneous input, this procedure has a basic disadvantage compared to the use of average annual wages as the independent variable.

Pitfalls or Criticisms of Production Function Studies

While empirical production function research has grown from the early 1920's, the catalogue of defects or criticisms have also increased but only very gently. The first reactions were registered before the resurgence of interest in production function estimates, i.e., prior to the mid 1950's. There are definitely many unbelievers, who have made up their minds about the futility of the production function concept, especially for empirical purposes, for instance, Joan Robinson. P.A. Samuelson (1962) has coped with the question appropriately.

The reader is referred to the excellent summary of these criticisms of production function research in Hildebrand and

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[11] "The quality of the data on capital has been recognized by most authors to be extraordinarily poor. In the U.S.A. the compilers of the census of manufactures thought that the capital data were so unreliable that they ceased publication after the first world war. The main reason was that the firms returned the book value of assets, and this figure is not usually closely related to the market value." Walters (1963), p. 29.

Liu (1965). The criticisms or limitations were directed largely to the production functions attempted by these authors. But in view of the general similarity of data sources, the criticisms to the Hildebrand-Liu study apply just as well to this one. Let me list those mentioned by Hildebrand and Liu that have immediate relevance to this study:

1) nonhomogeneity data in 2-digit aggregates
2) aggregation not in most desirable theoretical way
3) measures of capital-book values used, not actual capital in existence
4) important variables missing, e.g., entrepreneurship
5) supply elasticities for the factors not considered
6) no adjustments for quality of labor made

In addition, as pointed out already, the estimation technique used is simple least squares.

Of course, the most important query with respect to this study concerns the interpretation of the cross-section production function. There is a long history of debate on the merits or interpretations of the cross-sectional production function. Bronfenbrenner and Douglas (1939) have satisfactorily answered most of these criticisms. With the development of the literature, it is now almost taken for granted that cross-section empirical production functions can tell a useful story. For instance, in the recent review of the literature on production functions by Nerlove (1967), the estimates of production, whether by cross-section or time series, were naturally surveyed without touching on the old question of how to interpret cross-sectional production functions. That old worry is now apparently buried.

Chapter 3. DATA: CONCEPTS AND CLASSIFICATION

One severe data limitation of the published *Survey of Manufactures* for the estimation of empirical production functions is that, as already shown in Sicat (1963), not enough observations could be generated which will allow reasonable statistical estimation. Indeed this major restriction allowed only the estimation of aggregative production functions for the manufacturing sector which were reported in that paper. For any single year under consideration only a limited number of 3- or 4-digit observations were available for a 2-digit ISIC industry. Let me quote from the earlier study:

> "... Because the manufacturing sector is not as varied as one would find in a developed economy, many of these two-digit industries cannot be disaggregated at the 3- or 4-digit levels of classifications that will yield at least 10 samples. The only exception to this rule is the food manufacturing industry. Thus, the present state of the data will not allow an estimation of industry-by-industry production functions unless an unrestricted pooling of the cross-section data for all the years available for a given industry is made."[1]

The only other acceptable way of getting 2-digit industry production functions was via a pooling of the year to year data per observations under each 2-digit industry group published in the *Survey of Manufactures*, which was in fact attempted then. But because of the relative uneasiness the

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[1] G.P. Sicat (1963), p. 110.

author felt concerning the release of empirical results based on rather shaky data foundation, the prudent thing to do was withhold reporting these results. Now that there is an occasion to compare estimates based on cruder data with those which are based on a more detailed cross-section, it is interesting to examine any such differences. This is done in Chapter 6 of this study.

For this study to become possible, it was necessary to get a tabulation of the individual responses in the 1960 Survey of Manufactures. It is unfortunate that the individual data cards for all the surveys of 1956 to 1959 are no longer available to scholars because they have already been destroyed. Because of this, the ambitious work that was earlier planned was scaled down to operations involving only the 1960 survey. This survey, incidentally, was not the basis of the earlier study because, as the subtitle shows, the said study concerned cross-section estimates for the years 1956 to 1959. Since the above four year data turned out to be homogeneous and their production functions representable by one in which all the cross-sections for the years concerned were pooled,[2] it may be surmised that the 1960 survey, if pooled with the previous

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[2] Ibid., p. 117.

surveys, would not contribute to data heterogeneity. Therefore, it may be conjectured further that the results of empirical industry production functions computed from the 1960 survey would approximate empirically fitted functions from pooled cross-sections.

For purposes of obtaining more observations per 2-digit industry group for the production functions output and inputs, two classifications were used. The first classification was based on the size of fixed assets of the respondent establishments. The second was based on the employment size of the respondent establishments.

Size of Fixed Assets. The size of fixed assets was first used as a possible classifying variable in grouping the observations. For this, the Survey of Manufactures classification of establishments by fixed assets was used. This classification is given in Table 3.1. The number of observations yielded by such a classification were not very satisfactory since they give, at most, only ten observations. But such a classification was helpful in summing up the earlier trials involving the computations of the production functions. These trials prepared the ground for the later regressions involving estimates of production functions using employment sizes as the classifying variable.

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Table 3.1. SURVEY OF MANUFACTURES CLASSIFICATION OF ESTABLISHMENTS BY FIXED ASSETS

Size of Fixed Assets (₱)	BCS Code
Under ₱1,000	0
1,000 - 4,900	1
5,000 - 9,900	2
10,000 - 24,900	3
25,000 - 49,000	4
50,000 - 99,900	5
100,000 - 249,900	6
250,000 - 499,000	7
500,000 - 999,000	8
1,000,000 - and over	9

Employment Size. For purposes of obtaining more observations per industry group other than those provided by the first classification, the employment sizes of the respondent establishments was utilized. The Survey of Manufactures had 14 classes for classifying respondents. But the first two classes are for those respondents with less than 9 workers.[3] For purposes of this study, such responses were

[3]For an explanation of this phenomenon, see G.P. Sicat and A.S. Maminta (1966).

rejected. The classification introduced for the present study allows a widening of establishment observations with larger employment. The difference in the classifications are set forth in Table 3.2.

To what extent this reclassification affects the sampling structure is a question that ought to be answered. The Survey of Manufactures uses employment size as its principal classificatory variable in the sampling framework to separate the small establishments from the large ones, that is, to separate smaller establishments from those having 20 and more workers. Once this sample frame had been set up, establishments belonging to different industry groups were then sampled on the basis of the total number of establishments listed in each specific group. The basic establishment response mechanism is more a consequence of the individual industry group samples than that of specific employment size. Moreover, the establishments represented among those having 20 workers or more is close to being a complete enumeration of the larger establishments. Thus, the reclassification of the respondent establishments into employment sizes which are somewhat more extensive than the Survey of Manufactures classes does not hurt the response pattern in any way.

The chief advantage of the new classification is that it allows us to discriminate against different large

Table 3.2. EMPLOYMENT SIZES OF RESPONDENT ESTABLISHMENTS IN THE 1960 SURVEY OF MANUFACTURES

No. of Employees	Sicat Class Code	BCS Class Code
Under 5	Rejected	0
5 - 19	Rejected	1
10 - 19	1	2
20 - 29	2	3
30 - 39	3	4
40 - 49	4	5
50 - 59	5	6
60 - 79	6	7
80 - 99	7	8
100 - 149	8	9
150 - 199	9	9
200 - 249	10	10
250 - 299	11	10
300 - 399	12	11
400 - 499	13	11
500 - 799	14	12
800 - 999	15	12
1,000 - 1,299	15	13
1,300 - 2,499	16	13
2,500 - over	17	14

BCS = Bureau of the Census and Statistics establishments having the range of 100 workers to 1,000 workers. It also led us to reject establishments which apparently do not belong to organized manufacturing activities, those involving 5 to 9 workers.

Concepts of Outputs and Inputs

We have stressed that all the data were classified by 2-digit (ISIC) levels. These represent 18 industry groups. The establishments in the petroleum refining industry (ISIC 32) and those in the miscellaneous manufactures (ISIC 39) were not tabulated by the Census Bureau in order to maintain the secrecy of identity of the large petroleum oil refining companies.[4]

Output. Two measures of output were used: (1) gross sales, or value of products sold, and (2) value added by manufacturing. We shall summarize these definitions[5] as follows:

> Gross sales - value of shipment including products sold, those shipped on consignment whether sold or not at the end of the year and those transferred from the plant to wholesale branches, central warehouses, retail stores, or other establishments of the company.

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[4] The Surveys of Manufactures always report ISIC 32 under ISIC 39, for this reason.

[5] See any Survey of Manufactures for the definitions. The surveys began in 1956.

Value added by manufacturing - A measure of value created in manufacturing, calculated by subtracting the cost of materials, supplies, containers, fuels consumed, electric energy purchased and contract work from the value of manufacturing receipts. This concept is a gross measure, since the depreciation of capital goods are not deducted.

Thus in both measures, output is represented not by physical units but by value. Since all observations are cross-sectional, these value measures are not affected by any price level adjustments. That is, the price structure among all the outputs of manufacturing remained the same.

Inputs. The data used as production inputs or proxies for them consist of labor, capital, and wage payments.

Labor employment - Average number of workers employed during the year, calculated from data reported for four payroll periods (ending nearest the 15th of February, May, August, and November). The employment measure includes working owners and unpaid family workers, production and non-production workers in the establishments.

The decision to use total employment figures (including those classified as non-production related workers, in other words those in blue-collar positions) is analogous to the problem of capital measurement and of aggregation. Since production and non-production workers represent presumably nonhomogeneous inputs, they should not be added together. But how heterogeneous are they? Moreover, although there may be variations in the proportions of production workers within one industry group, especially when specific establishment groups are observed, this variation will not be too wide to jeopardize the results. In any case, Table 3.3. shows the proportion of production related workers to total reported employment per 2-digit industry group for establishments with at least 20 workers. The data were taken from the 1960 survey and the 1961 Census of Manufactures. Although there are some industry groups with high (e.g., tobacco) and low proportions (e.g., beverages), on the whole, the proportions are not far too different from the range 75 to 80.

> Fixed assets - Book value of depreciable assets as of January 1. Fixed assets includes land, buildings, machinery, transport equipment and tools which have durability of more than one year.

Estimates of capital are subject to a lot of errors. For instance, book value of capital may be based on acquisition costs. With changes in the price of capital goods due to price movements, book values can underestimate the "true" value of capital. Some of our students in the University of the Philippines have directed their attention to the recomputation of capital values in Philippine manufacturing.[6] On the whole

[6] See Romeo Bautista (1965) and Eloisa Franco (1966).

Table 3.3. RATIO OF PRODUCTION & RELATED WORKERS TO TOTAL REPORTED EMPLOYMENT PER INDUSTRY GROUP IN ESTABLISHMENTS WITH 20 OR MORE WORKERS 1960 and 1961

		In Per Cent 1960 Survey	1961 Census
20	Food, manufactured	77	75
21	Beverages	43	46
22	Tobacco	91	90
23	Textiles	89	88
24	Footwear & apparel	80	83
25	Wood & cork	82	83
26	Furniture & fixtures	81	80
27	Paper products	77	80
28	Printed materials	68	74
29	Leather products	84	85
30	Rubber products	79	77
31	Chemical products	59	61
32	Petroleum & coal	a	71
33	Non-metallic mineral, except petroleum and coal	78	82
34	Basic metal	79	79
35	Metal products	82	80
36	Non-electric machinery	73	72
37	Electric machinery	71	78
38	Transport equipment	70	76
39	Miscellaneous manufactures	71	75
	Total Manufacturing	77	75

Sources: (1) Annual Survey of Manufactures: 1960, BCS

(2) 1961 Census of Manufacturing, BCS

a - combined with industry group 39.

however, these estimates are still unsatisfactory. But in view of the lack of any figures, we use the capital book values collected in the surveys. A possible escape from measures of capital is to fit production functions that do not require capital directly as an input in the estimation process. The Johansen production function, which is based on a Cobb-Douglas production function, does away with the capital measure through an imaginative use of factor pricing equilibrium conditions.[7] The CES production function does this likewise.

Annual Payroll or Wages. There are two concepts utilized here.

(1) total payroll to all workers. This item includes salaries, wages, overtime pay, comissions, dismissal pay, bonuses, vacation and sick leave pay and other remuneration paid to employees on the payroll of the establishment during the entire year, prior to all deductions such as withholding taxes, union dues, etc.

(2) payroll to production related workers. This is defined as all items in (1) accruing to "production related workers."

Although employment is aggregated in the treatment of labor as an input to the production process, it was decided to capture the variation of production workers wages and of total wage payments in the estimation of the CES production function.

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[7] J.G. Williamson & G.P. Sicat (1968).

Chapter 4. COBB-DOUGLAS INDUSTRY PRODUCTION FUNCTIONS

Different estimates of the Cobb-Douglas production function for 18 two-digit ISIC aggregation will be presented here. In order to set the analysis in proper sequence, the earlier attempts at utilizing the 1960 Survey of Manufactures for estimates of the Cobb-Douglas production functions will be reviewed. This will be followed by a review of the estimates using data classified by employment size. An analysis of the estimates of factor shares will be made towards the end.

Preliminary Estimates of Production Functions

The estimates that will be reported in this subsection are based on grouping of certain industries by the fixed asset sizes of the establishments.

Estimates Without Restriction to Sum of α_L and α_K. The first estimates were directly based on the unrestricted production functions fitted by a multiple regression given by (2.6), or

$$\ln Q = \ln A + \alpha_K' \ln K + \alpha_L' \ln L + u$$

in which α_K and α_L are estimated directly. This allowed the possibility of testing the nature of the returns to scale for certain manufacturing production functions.

The results of tests of unrestricted Cobb-Douglas production functions were, to say the least, disappointing. In most regressions, the capital input had large errors. Almost all the variation of output (whether fitted as gross sales or value added) was accounted for by the labor input. Only six of the 18 2-digit industries had significant estimates of both capital and labor coefficients. Only furniture and fixtures (ISIC 26) apparently had rather a sum less than one for the two input elasticities, suggesting possible decreasing returns. The rest had coefficients which appeared close to one. Table 4.1 shows the summary of these estimates. All of the regressions had explained variation (R^2) at least as high as 90 per cent, with most having 95 per cent and above. Only two of these industries are exceptions, but the lowest of these is still quite high, 84 per cent for paper products (ISIC 27) in the value added regressions.

In view of the apparent intercollinearity between the two independent variables, capital and labor, the need to use an alternative estimation technique became apparent. This was to restrict the sum of the elasticities to one, so that Cobb-Douglas production functions of constant returns to scale had to be adopted.

Table 4.1. SUMMARY OF ESTIMATES OF UNRESTRICTED COBB-DOUGLAS PRODUCTION FUNCTIONS, BASED ON GROSS SALES AND VALUE ADDED

ISIC Code	Industry	Based on Gross Sales			Based on Value Added		
		α_K	α_L	$\alpha_K+\alpha_L$	α_K	α_L	$\alpha_K+\alpha_L$
20	Manufactured Food	n.s.	0.985		n.s.	1.322	
			(0.270)			(0.393)	
21	Beverages	n.s.	1.149		n.s.	1.448	
			(0.429)			(0.407)	
22	Tobacco	n.s.	1.239		n.s.	1.319	
			(0.162)			(0.157)	
23	Textiles	n.s.	2.012		0.321	0.466	
			(0.568)		(0.193)	(0.282)	
24	Footwear & apparel	n.s.	1.163		0.107	0.708	
			(0.196)		(0.040)	(0.138)	
25	Wood & cork	n.s.	1.648		n.s.	1.100	
			(0.167)			(0.065)	
26	Furniture & fixtures	0.162	0.348	0.510	0.250	0.286	0.536
		(0.039)	(0.116)		(0.038)	(0.115)	
27	Paper products	0.135	1.069	1.204	n.s.	1.102	
		(0.111)	(0.248)			(0.606)	
28	Printing	0.431	0.271	0.702	n.s.	0.286	
		(0.047)	(0.085)			(0.078)	
29	Leather products	0.353	0.450	0.803	0.193	0.836	1.029
		(0.047)	(0.188)			(0.161)	
30	Rubber products	n.s.	1.361		1.500	*	
			(0.712)				
31	Chemical products	n.s.	0.828		n.s.	0.976	
			(0.379)			(0.347)	
33	Non-metallic mineral	n.s.	1.767		n.s.	1.608	
			(0.184)			(0.202)	
34	Basic metal	0.197	0.777	0.974	0.308	0.673	1.081
		(0.070)	(0.130)		(0.092)	(0.172)	
35	Metal products	0.455	0.382	0.837	0.280	0.758	1.038
		(0.143)	(0.270)		(0.096)	(0.183)	
36	Machinery, non-electric	n.s.	1.958		n.s.	2.453	
			(0.432)			(0.593)	
37	Electrical machinery	n.s.	1.070		n.s.	1.194	
			(0.302)			(0.292)	
38	Transportation	n.s.	0.989		n.s.	1.355	
			(0.353)			(0.408)	

n.s. - not significant

Standard errors of coefficients in parentheses.

<u>Restricted Elasticities</u>. The estimation of $Q = A K^{\alpha_K} L^{1-\alpha_K}$ for all industries was then attempted. These regressions are more easily estimated, since the independent variables are reduced by half as much. As pointed out, these production functions are estimated by the regressions (2.7), or (without any subscript notation)

$$\ln Q/L = \ln A + \alpha_K \ln K/L + u.$$

This is a regression of the logarithms of output per man and capital per man in each industry.

The preliminary results of 2-digit estimates from establishments grouped by fixed asset size are shown in Table 4.2. Most of these estimates have relatively smaller explained variance (R^2) compared to the estimates reported for the unrestricted regressions.[1] But despite this, the estimated coefficients for capital are statistically different from zero at least at the 5 per cent level. Only four industry groups gave consistently poor estimates, both for the value added and for gross sales proxies for output. These are textiles (ISIC 23), footwear & apparel (ISIC 24), rubber products (ISIC 30), and non-metallic mineral products (ISIC 33). Electric machinery

[1] These are not reported in this study.

Table 4.2. PRELIMINARY COBB-DOUGLAS PRODUCTION FUNCTIONS CAPITAL SHARES, COMPARED FOR PRODUCTION FUNCTIONS BASED ON GROSS SALES AND VALUE ADDED

ISIC Code	Industry	α_K^* Based on Gross Sales	α_K Based on Value Added	$\alpha_K - \alpha_K^*$	Ratio of Constant V/G
20	Manufactured Food	0.164 (0.050)	0.220 (0.081)	0.056	0.256
21	Beverages	0.356 (0.133)	0.461 (0.157)	0.105	0.322
22	Tobacco	0.237 (0.080)	0.232 (0.087)	-0.005	0.286
23	Textiles	n.s.	n.s.		n.s.
24	Footwear & apparel	n.s.	n.s.		n.s.
25	Wood and cork	0.184 (0.070)	0.129 (0.049)	-0.055	0.282
26	Furniture and fixtures	n.s. (0.072)	0.164 (0.069)		n.s.
27	Paper products	0.258 (0.069)	0.303 (0.153)	0.045	0.254
28	Printed & published materials	0.250 (0.090)	0.247 (0.087)	-0.003	0.363
29	Leather products	0.318 (0.040)	0.199 (0.031)	-0.119	0.254
30	Rubber products	n.s.	n.s.		n.s.
31	Chemical products	0.177 (0.094)	0.296 (0.091)	0.119	0.369
33	Non-metallic mineral	n.s.	n.s.		n.s.
34	Basic metal	0.187 (0.058)	0.300 (0.076)	0.113	0.286
35	Metal products	0.327 (0.089)	0.311 (0.056)	-0.016	0.300
36	Machinery, non-electric	0.268 (0.195)	0.316 (0.277)	0.048	0.312
37	Electrical machinery	n.s.	0.140 (0.104)		n.s
38	Transportation	0.226 (0.088)	n.s.		n.s

n.s. - not significant

Standard errors of coefficients in parentheses.

Ratio of constants is ratio of estimated intercepts for value added to gross sales regressions.

(ISIC 37) and transport equipment (ISIC 38) yielded insignificant coefficients.

It will be fruitful at this point to digress on the difference between the estimates of the production function based on the two different variables representing output. Most studies of production functions, in the absence of any truly physical measures for output use either value added or gross sales as the measure of output. To understand more fully the last two columns of Table 4.2, it is desirable to clarify this point.

Digression: Measures of Output and the Cobb-Douglas Production Function. Let us assume that value added or gross sales may represent output interchangeably. Then if the production function is Cobb-Douglas for any industry i, it may be represented either as

$$V = A\,K^{\alpha_K}\,L^{1-\alpha_K}\,v \qquad (4.1)$$

or

$$G = B\,K^{\alpha_K^*}\,L^{1-\alpha_K^*}\,u, \qquad (4.2)$$

where (aside from the two inputs), V is value-added, G gross sales, A and B constants, α_K and α_K^* output elasticities of capital, v and u random error terms.