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ELASTICITIES OF SUBSTITUTION IN DEVELOPING COUNTRIES AND IN TURKEY

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I. INTRODUCTION

The importance of factor substitution in production from the viewpoints of growth, income distribution, employment and international trade, has stimulated the empirical estimation of the elasticity of substitution between capital and labor in developing as well as developed countries. In developing economies where labor is generally the more abundant factor of production, such attempts were mainly concerned with throwing some light upon the employment potential of the manufacturing sectors with the aim of forecasting the effectiveness of economic policies oriented toward employment promotion by influencing the choice of technique. In this paper an attempt is made,

- firstly, to analyze and evaluate briefly the estimates of elasticities of substitution obtained in relation to some developing countries as well as the models used in their estimation, and

- secondly, to present our estimates of the elasticity of substitution and returns to scale related to Turkish manufacturing and to evaluate the findings in the light of results obtained in other developing countries and previously in Turkey.

II. ANALYSIS AND EVALUATION OF SUBSTITUTION ELASTICITIES IN DEVELOPING ECONOMIES OTHER THAN TURKEY

In this section a survey of the estimates of elasticities will be presented along with a discussion of the models used in the estimation process. This approach where the models are also explored, has been preferred since it enables a more meaningful camparison and evaluation of the estimates obtained by different procedures.

A) Estimates based on the direct method

Elasticity of substitution between capital and labor which is a characteristic of the existing technology is given by,

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$$\sigma = \frac{d\,(K/L)\,/\,(K/L)}{d\,(w/r)\,/\,(w/r)} \qquad (I)$$

where K/L and w/r are the capital - labor and wage - interest ratios, and measures the responsiveness of the K/L ratio to changes in factor prices. By expressing (I) in logarithmic form a linear regression model can be obtained where $\sigma = b$ is the substitution parameter to be estimated :

$$\log (K/L) = \log a + b \log (w/r) \qquad (II)$$

This model which permits the direct estimation of b assumes capital and labor to be homogeneous, technical change to be neutral and factor pricing to be according to marginal principles. But the need for capital data has rendered the model especially inconvenient for application to developing countries where capital data are either unavailable or their reliability is questionable. Despite this drawback the model has been applied to developing countries. Clague (1) for example, using the model, has estimated common elasticities of substitution for the manufacturing sectors of Peru and the U.S., but the rather low elasticity values obtained (.50 on the average) were attributed to the highly restrictive assumptions used in forming the capital series. On the other hand, application of the same model to cross - sectional 1965 data for Mexico (2) has revealed higher elasticity values (between .63 and 1.23) for the two - digit industry categories (3) constituting the manufacturing sector.

B) Estimates based on the simple CES model

Since the elasticity of substitution is one of the characteristics of the existing technology of production, most of the attempts were directed toward estimating it as a parameter of specific aggregate production functions. Since the Cobb - Douglas

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(1) C.K. Clague, "Capital - Labor Substitution in Manfactureng in Under developed Countries", Econometrica, vol. 37, 1969, pp. 528—537.

(2) H. Bruton, "The Elasticty of Substitution in Developing Countries, Research Memorandum Paper, no. 45, Williams College, Massachusetts : 1972.

(3) According to the international (ISIC) classification the manufacturing industry is divided into subsectors where subdivisions increase with the number of digits. The system has been changed by the United Nations in 1968 and the State Statistical Institute of Turkey has begun classifying the manufacturing indistry according to the new system in 1973 where category definitions have been altered.

production function assumes the elasticity of substitution to be equal to one, it could not be used for this purpose and the Constant Elasticity of Substitution (CES) production function was developed where elasticity could take on any value between zero and infinity but remained constant along any isoquant. As first developed by Arrow, Chenery, Minhas and Solow (ACMS) the function assumed constant returns to sacle and was of the following form,

$$Y = \gamma \left[\kappa K^{-\rho} + (1-\kappa) L^{-\rho}\right]^{-1/\rho} \qquad \text{(III)}$$

where Y is output, γ and κ are the efficiency and capital intensity parameters and p is the substitution parameter with $\sigma = 1/1 + p$. Because the parameters of (III) cannot be estimated directly by logarithmic transformation, an indirect method based on the side relation between labor productivity, Y/L (taken as a proxy for capital intensity) and wages, w,

$$Y/L = a\, w^{b} \qquad \text{(IV)}$$

was devised by ACMS (4). Under the assumptions of profit maximization and factor pricing according to marginal products, the CES function can be derived from this relationship (5). By expressing (IV) in logarithmic form the following regression model can be obtained,

$$\log (Y/L) = \log a + b \log w \qquad \text{(V)}$$

where b corresponds to the elasticity of substitution assuming neutral technical progress, full capacity output and adjustment without time lags. This model has provided an additional impetus for the investigation of substitution possibilities in developing economies since it is simple and does not require the use of capital data.

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(4) *K.J. Arrow, H.B. Chenery, B. S. Minhas and R.M.Solow, "Capital - Labor Substitution and Economic Efficiency",* **The Review of Economics and Statistics,** *vol. 43, 1961, pp. 225—250. The CES function has also been developed by M. Brown and J.S. de Cani, "Technological Change and the Distribution of Income";* **International Economic Review,** *vol. 4, 1963, pp. 289—309.*

(5) *For the derivation of the CES function from this relationship see A.C.M.S.* **op. cit.** *pp. 228—230.*

An important application of the ACMS model to developing countries on a cross - country basis is that of Daniels [6]. Using data from eight developing countries, Argentina, Chile, El Salvador, Korea, Paraguay, Peru, Portugal and Spain, and converting the data to U.S. dollars, Daniels has estimated common elasticities of substitution which range between .38 and 1.80 for the various subsectors of the manufacturing industry. The elasticity values of this study are in general slightly higher than those obtained for Mexico by the direct method of equation (II). When the ACMS model was applied to Mexican manufacturing on a cross - regional basis, the estimates turned out to be close to 1.00 and ranged between .64 and 1.33 for the two digit industry categories. On the other hand, the use of the same model at the four digit industry level where industry categories were defined more narrowly, has yielded lower estimates of elasticity [7] for the same study. Since broadly defined industry categories may also include factor substitution due to product diversification, this result is consistent with theoretical expections.

Further evidence concerning variable elasticities of substitution in developing economies was provided by empirical analyses related to the manufacturing sectors of Brazil and Argentina. In a study by Tyler [8] where the ACMS model and cross - regional data for 1959 were used, elasticities between .44 and 2.67 were estimated for the two digit industries of the Brazilian manufacturing sector. For Brazilian manufacturing at the aggregate level the same study has revealed a substitution parameter of 1.00. In the case of Argentina as well, the results of the ACMS model have pointed to the existence of considerable substitution possibilities between capital and labor. In the cross - regional study by Katz [9] estimates between .46 and 2.02 for the year 1946 and between .47 and 1.73 for 1954 were found in relation to the subsectors of Argentine manufacturing industry. The similarities between these findings and the findings of the studies mentioned earlier can easily be observed.

C) Estimates based on modified CES models

In the studies referred to above, the simple ACMS model of equation (V) has been used without any modification. More complicated CES models however have also been used in analyses related to developing economies. The results obtained and the regression models utilized in some of these studies are briefly discussed in this section.

(6) *M. Daniels, "Differences in Efficiency Among Industries in Developing Countries"*, American Economic Review, *vol. 59, 1969, pp. 159—171.*

(7) *H. Bruton*, op. cit. *pp. 18—20.*

(8) *W. Tyler, "Labor Absorption with Import Substituting Industrialization: An Examination of Elasticities of Substitutionin the Brazilian Manufacturing Sector"*, Oxford Economic Papers, *vol. 26, 1974, pp. 93—103.*

(9) *J. M. Katz*, Production Functions, Foreign Investment and Growth, *North Holland Publishing Co., Amsterdam: 1969. Tables 3.1 and 3.2 pp. 47—48.*

If observations are based on yearly differences of $\ln (Y/L)$ and $\ln (w)$ the following variant of the ACMS model can be obtained :

$$\Delta \ln (Y/L) = \alpha_1 X_1 + b \Delta \ln (w) \qquad \text{(VI)}$$

Using the above model and interpreting the parameter b as the elasticity of substitution, Abed [(10)] was able to obtain a value of 1.076 for the Egyptian industrial sector as a whole, thus providing additional evidence from a developing economy related to the substitution potential between capital and labor. The distinguishing aspect of this analysis is the combining or 'pooling' of cross - regional and time series data. However, since the research was primarily undertaken for the estimation of labor demand equations, b values for the subsectors arenot available.By the use of percentage instead of absolute changes in equation (VI) Harris and Todaro have developed another model in which the b parameter could be interpreted as the elasticity of demand for labor when output is held constant [(11)]. This paramameter which also reflects substitution possibilities, has been estimated to be not significantly different from 1 for the manufacturing, commercial and service sectors of another developing country, namely Kenya.

One of the assumptions of the simple ACMS model, that of immediate adjustment by firms and industries to factor price changes, has been eliminated by Griliches in the following variant of the simple model [(12)].

$$\log \quad (Y/L)_t = \log a + \sigma(1-\lambda) \log w_t + \lambda \log (Y/L)_{t-1} \qquad \text{(VII)}$$

In this model where time lags are taken into account, average productivity (Y/L) of period t is determined by the average productivity of the preceeding period (t - 1) and the wage rate of period t. The possibility of obtaining λdirectly through linear regression analysis also enables the calculation of σ which constitutes part of the

(10) *G.Abed, "Labor Absorption in Industry : An Analysis with Reference to Egypt",* Oxford Economic Papers, *vol. 27, 1975, pp. 400—417.*

(11) *See : J.R. Harris and M.P. Todaro, "Wages, Industrial Employment and Labor Productivity : The Kenyan Experience",* Eastern Africa Economic Review, *vol. 1, 1969, pp. 29—46.*

(12) *For further details see : Z. Griliches, 'Production Functions in Manufacturing : Some Preliminary Results", M. Brown ed.,* The Theory and Empirical Analysis of Production, *Studies in Income and Wealth vol. 31, NBER, New York : 1967, pp. 275—322.*

coefficient of log w_t. Applying this model, Behrman [(13)] has calculated long term substitution elasticities for various sectors of the Chilean economy. This study which is based on time series data has revealed estimates of elasticity that are relatively low for agriculture (. 31), services (. 09), public utilities (. 03) and mining (. 51) but not significantly different from one for the government (. 89) and the manufacturing (. 76) sectors.

Another modified CES model developed by Griliches tries to account for autocorrelation [(14)]. An important drawback of time series analyses is the possibility that observations in a time series may not be independent from each other. Assuming the presence of some dependency of autocorrelation, Griliches accounts for this in the following model :

$$\log (Y/L)_t = \log a + \sigma \log w_t + \rho \log (Y/L)_{t-1} - \sigma \rho \log w_{t-1} \qquad \text{(VIII)}$$

This model unlike the earlier one, does not consider lags but aims to account for autocorrelation by incorporating it into the model. If regression results reveal the cofficient of log w_{t-1} to be approximately equal to the product of σ and ρ , obtained as the coefficient of the second and third terms, the fit of the model will also have been confirmed. This model has been applied by Bruton on a cross - country basis using United Nations data which include a large number of developing countries. The use of 1965 and 1966 data converted to U.S. dollars has revelaled elasticity estimates varying between . 57 and 1.75 for the two digit categories of the manufacturing sector (except for fabricated metals (. 021) [(15)].

An important assumption of the CES production function as given by equation (III), and of the models discussed above was constant returns or a scale parameter equalling 1. To overcome this restrictive assumption, the validity of which has often been questioned, the CES production function has later been modified to include a scale parameter, v, which could take on any value between zero and infinity;

$$Y = [\kappa K^{-\rho} + (1-\kappa) L^{-\rho}]^{-V/\rho} \qquad \text{(IX)}$$

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(13) *J.R. Behrman, "Sectoral Elasticities of Substitution Between Capital and Labor in a Developing Economy : Time Series Analysis in the Case of Post - War Chile",* Econometrica, *vol. 40, 1972, pp. 311—326.*

(14) *See : Z. Griliches,* op. cit., *pp. 290—322.*

(15) *H. Bruton,* op. cit., *p. 18.*

and based on this version Ferguson and Paroush have independently developed the following indirect regression model (16).

$$\log Y = \log a + b \log w + c \log L \qquad (X)$$

where the substitution and scale parameters are given by $\sigma = b/c$ and $v = c-b/1-b$ respectively. A slightly modified version of (X) has been applied to the manufacturing sector of Argentina. In this study time series data for the 1954–1961 period were used and elasticity values ranging between .05 and .49 have been estimated for the individual subsectors. These estimates, although relatively low, are not in general considerably different from other time series analyses conducted in developed and developing countries. The scale parameter values of the same study, ranging between .77 and 1.60 (except for tobacco (2.20))provide evidence in favor of relatively constant returns in Argentine manufacturing, a result which is also in line with the estimates obtained in the U.S. and the U.K. (17) through the use of the same model.

The regression models considered above have all assumed the presence of perfect competition where wages are equal to marginal products and where elasticities of demand for labor (E_{wL}), and for the product (E_{py}) are infinite. When imperfections are introduced, then wages will be equal to marginal revenue product as follows,

$$w = \frac{\partial Y}{\partial L} \times \frac{(1+E_{py})}{(1+E_{wL})} \qquad (XI)$$

but the second term on the right will not be equal to one. Using this relationship Feldstein and Katz have independently developed the following model based on the CES function with variable returns to scale (18),

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(16) *For further details concerning this model see : C.E. Ferguson, "Substitution, Technical Progress and Returns to Scale",* American Economic Review, *vol. 55, 1965, pp. 296–305, and, J. Paroush, "The h–Homogeneous Production Function with Constant Elasticity of Substitution : A Note",* Econometrica, *vol. 34, 1966, pp. 225–227.*

(17) *For the estimates related to Argentina see : J.M. Katz,* op. cit., *and for the estimates related to the U.S. and the U.K. see : C.E. Ferguson,* op. cit., *pp. 298–302, and R.J. Dixon and A.P. Thirlwall,* Growth and Unemployment in the United Kingdom, *MacMillan Press Ltd. London : 1975, pp. 234–235.*

(18) *For the derivation of this model see : M. Feldstein, "Alternative Methods of Estimating a CES Production Function for Britain",* Economica, *vol. 34, 1967, pp. 384–394. and J. Katz,* op. cit., *pp. 70–73.*

$$\log \quad Y/L = \sigma \log \left[v(1-\kappa)^{\gamma^{-\rho/v}} \right]^{-1} + \sigma \log w + (1-\sigma) \log P$$

$$+ \sigma \log \left[\frac{1+E_{wL}}{1+E_{py}} \right] + \frac{(1-\sigma)(v-1)}{v} \log Y \qquad (XII)$$

where the term $(1 - \sigma) \log P$ tries to eliminate the bias which may arise as a result of a positive relationship between the price level and wages. Since this model needs information on elasticities, an indirect way of incorporating imperfections into the model has been devised by Katz. Assuming $v = 1$ and no relationship between wages and the price level, the last and the third terms drop out. If market conditions are assumed to remain constant, when data related to period t is substracted from data of $t + 1$, the fourth term also drops out and the following simplified model based on first differences is obtained,

$$\log (Y/L)_{t+1} - \log (Y/L)_t = a + \sigma [\log w_{t+1} - \log w_t] \qquad (XIII)$$

A cross - regional application of this model to Argentine date based on the differences between 1954 and 1946 has yielded elasticity values between . 17 and 1.17 [19] which although slightly lower, are not significantly different from those obtained by the ACMS model for the same country.

2) Evaluation of Results

A closer examination of the findings related to the studies discussed above permits us to isolate certain common aspects. Since these aspects are related to both the substitution possibilities in the manufacturing sectors of developing economies and the methods utilized in the empirical analyses, this seçtion of our study is devoted to a brief discussion of these common characteristics.

– The first common characteristic that can be identified is the existence of a large number of industries with elasticity values close to or greater than 1 in the studies based on cross - sectional data. Furthermore, the elasticity values related to developing countries are in general somewhat higher than those

(19) İbid, *p*. 77.

obtained in developed countries using similar methods [20]. Since in cross-section studies observations from different regions are used, the greater interregional differences in wage rates observed in developing economies may account for this result by reflecting better the equilibrium points on the production function.

– The second striking aspect of these studies is that particular subsectors of the manufacturing industry generally yield lower whereas certain other industries yield relatively higher elasticity values and that this pattern does not vary greatly from one country or study to another. This tendency is apparent in Table I which we have prepared by using the elasticity values for Argentina, Brazil, Mexico and the cross - country study of Daniels covering eight developing economies. Also, to avoid any bias that may arise from methodology, only studies using the simple ACMS method on a cross - sectional basis have been included. The values in the table are higher for paper, tobacco, chemicals and stone - clay categories, but comparatively lower for leather, textiles and vehicles.

Table I

A Cross - Country Comparison of Elasticity Values For Some Industry Categories

	Vehicles	Chemicals	Stone - Clay	Food	Paper
Brezil	.73	.87	1.07	.80	1.56
Mexico	.93	.97	1.09	.80	1.33
Argentina	.46	.90	1.19	1.35	1.49
Cross - country	.47	1.09	1.11	.75	1.34

	Printing	Textiles	Wood	Fabricated Metals	Tobacco	Leather
Brazil	1.01	.44	.90	––	1.43	.66
Mexico	.75	.73	.76	.92	––	.64
Argentina	.87	––	.93	.87	1.76	.87
Cross - country	.82	1.01	.86	.97	1.49	.53

(20) *For some cross - sectional estimates related to the U.S. and the U.K., see A.C.M.S.* op. cit. *pp. 225 — 250, C.E. Ferguson, "Cross - Section Production Functions and the Elasticity of Substitution in American Manufacturing Industry",* Review of Economics and Statistics, *vol. 45, 1963, pp. 305 — 313, and R. J. Dixon and A.P. Thirlwall,* op. cit. *pp. 236—237.*

– Another significant finding of the studies in developing countries is the lower elasticity values yielded by time series analyses. Values ranging between . 05 and . 49 for Argentina and between . 03 and . 89 for Chile are evidences favoring this argument. This tendency which is also apparent in studies related to developed economies was explained by the assertion that time series and cross - section approaches could be measuring different concepts. Although time series analyses aim to measure long run or ex - ante substitution potential, ex - post situations cannot be eliminated and because ex - post substitution possibilities are limited this tends to lower the estimates. Whereas in cross - section analyses more persistent factor prices and factor combinations can be reflected (21).

– The final point which deserves attention is the fact that utilization of different models have not led to appreciable differences in the results obtained. As mentioned earlier the direct and the ACMS model have yielded similar results in the case of Mexico, and the findings of the ACMS model and the model which takes market imperfections into account are closely resembling for Argentina. Furthermore despite the different models used, the results of the cross - country studies of Daniels and Bruton point in the same direction with elasticity values ranging between . 38 and 1.80 for the former and between . 57 and 1.75 for the latter study. Similarities between specific industry categories can also be detected from Table II.

TABLE II

Elasticity Values for Some Industry Categories
Obtained on a Cross - Country Basis

Cross - Country Study	Tobacco	Clothing	Publishing Printing	Rubber	Chemicals
By Daniels	1 . 49	. 79	. 82	1 . 31	1 . 09
By Bruton	1 . 17	. 58	. 83	1 . 11	. 91

Having briefly evaluated the findings of some of the research done in other developing countries with respect to substitution elasticities, we now proceed with evidence related to Turkey.

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(21) *For a more detailed discussion of this point see : M. Feldstein,* op. cit. *pp. 384–394 and M. Brown,* Theory and Measurement of Technological Change, *Cambridge University Press. Cambridge, Mass, 1968, p. 130.*

III. ANALYSIS AND EVALUATION OF SUBSTITUTION ELASTICITIES IN TURKEY

The first part of the analysis in this section is devoted to a brief discussion of some estimates of elasticity formerly obtained in relation to the Turkish economy. The section continues with the presentation of our empirical analysis and findings and concludes with an evaluation and interpretation of these findings within the framework of the capital - labor substitution potential of the Turkish manufacturing industry.

1) Survey of Former Estimates of Elasticities of Substitution

Most of the efforts at estimating elasticities of substitution in Turkey, simalar to the research done in other countries, have been directed toward the manufacturing sector [22]. In one of the earlier studies, Töriner has obtained an elasticity value of . 766 for the private and . 68 for the government sectors of the Turkish manufacturing industry. Using the ACMS model and cross - section data at the firm level for 1967, the substitution elasticities for the subsectors were found to be between . 08 and 1.68 with values relatively close to 1.00 for food, chemicals and vehicles [23]. Another study [24] conducted with the purpose of estimating substitution elasticities, has yielded an elasticity value close to 1 for private manufacturing (using 1967 data) but a significantly lower value for government manufacturing (using data for the 1939–1963 period), a result which could be explained by the use of cross - section data for the private but time series data for the public sector. On the other hand the time series estimate of Tütüncü [25] based on data for the 1965–1975 period has turned out to be . 933 for private manufacturing.

In another time series study, which was conducted by the State Planning Office of Turkey, and where the relationship between productivity (ln Y/L) and real wages (ln w/L) in private manufacturing was investigated, the authors were able to obtain b values ranging between 1.00 and 2.00 for the subsectors and equal to 1.62 for the sector as whole [26]. This study is another example from Turkish manufacturing of relatively high elasticity values obtained with time series data, a finding which is in contrast with studies performed outside of Turkey.

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(22) *Since the present study was completed in 1981, the survey covers the research done prior to 1980.*

(23) *In the same study elasticity values of 1.18 and . 695 have also been calculated for the agriculture and mining industries respectively. See : M. Töriner,* İmalât Sanayiinde İnsangücü Faktörü, *Publication of the State Planning Office, Ankara : 1971.*

(24) İbid. *pp. 21 – 22.*

(25) *E. Tütüncü,* İmalât Sanayiinde İşgücü Kullanımı, *Publication of the State Planning Office, Ankara : 1977.*

(26) *See : K. Ebiri, Z. Bozkurt and A. Çulfaz,* Türkiye İmalât Sanayiinde Sermaye ve İşgücü, *Publication of the State Planning Office, Ankara : 1977, p. 105.*

Öztürk, Doğan and Yücel (27) have used a different approach to the classification of industries in their attempt at estimating substitution elasticities for the manufacturing sector. They have calculated elasticity values for the consumption goods (. 72), investment goods (. 64) and intermediate goods (. 73) industries separately. In this study which is based on cross - section data at the firm level for the year 1970, the elasticity value for aggregate manufacturing was estimated to be . 668, and for the two digit categories the values ranged between . 04 and 2.55 with relatively high values for the coal - petroleum, furniture, paper, rubber and food sectors.

The studies referred to above were all applications of the simple ACMS model which assumes constant returns to scale. However, the CES model of equation (X) which takes non - constant returns into account has also been applied to Turkish manufacturing using time series data. Model (X) with a time trend to account for technical change, has been employed by Yıldırım (28) with the primary aim of measuring technical progress. The study has also yielded elasticity estimates that are close to or over 1 for the food, furniture, rubber, paper, leather, wood and apparel industries but relatively low (. 497) for the sector as a whole. The high values for the subsectors, despite the time - series approach, are a striking feature of this analysis. The estimated scale parameters of the same study suggest the presence of relatively constant returns in Turkish manufacturing.

In the research we have briefly outlined above, CES production function models have been employed either using cross - section data at the firm level or time series data at the firm or industry level (29), whereas the majority of cross - section studies outside of Turkey have utilized data on a cross - regional basis. In view of this point and with the intention of adding a new dimension to the studies previously conducted in Turkey, we have undertaken an analysis at the corss - regional level for investigating the substitution possibilities in Turkish manfacturing. The following section presents our empirical analysis.

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(27) *See : E. Öztürk, A. Doğan and E. Yücel,* İmalât Sanayiinin Yapısı ve Verimlilik *Düzeyi, Publication of the National Productivity Center, Ankara : 1975.*

(28) *See : N. Yıldırım,* Neoklasik İktisadın Teknolojik Gelişme Yaklaşımı, *Publiction of the Faculty of Political Science, Ankara : 1973. pp. 204—205.*

(29) *The only study we have encountered which doesn't use the CES models is that by Avralıoğlu. Using a model based on the Variable Elasticity of Substitution Production Function (VES) and using time series data for the 1959—1967 period, an elasticity value of . 65 was obtained for the Chromium mining industry. See : Z. Avralıoğlu,* Üretim Fonksiyonları, *Publication of İTİA, no. 102, Ankara.*

2) Interregional Estimates of Elasticities of Substitution and Their Evaluation

In the first part our empirical analysis the methodology and the data used are examined and the regression results for aggregate manufacturing and the two digit industry categories are presented. The high share of the manufacturing sector (80 %) in total value added generated by the Turkish industry, along with the high export potential of the sector were the main reasons for selecting the manufacturing industry as our subject of investigation. The explanatory part is followed by an interpretation of our findings in the light of studies related to Turkey and other developing countries.

A) Methodology and results

The regression model employed in the analyses of this section is,

$$\log Y = \log a + b \log w + c \log L$$

given earlier by equation (X). In this model where w is the wage rate, L is the unit of labor input and Y is output in terms of value added, $\sigma = b/c$ and $v = c-b/1-b$ indicate the substitution and the scale parameters as mentioned before. This model has been particularly selected as it doesn't require the use of capital data (which is not avilable at the regional level in Turkey) and yet permits the estimation of the scale parameter which is claimed to be significant in manufacturing.

The data used pertain to the 1976 annual survey of firms employing ten or more workers in private manufacturing, compled by the State Statistical Institute of Turkey. The year 1976 which is a 'peak' year for the Turkish economy has been especially chosen to minimize any bias that may result from the presence of excess capacity. The reason for including only the private sector is our belief that the assumptions of the model especially related to the pricing of factors of production are more likely to be valid for the private sector. The cross - sectional observations relate to the aggregates of value added and number of workers for the eight most industrialized provinces of Turkey, namely Adana, Ankara, Bursa, İçel, İstanbul, İzmir, Kocaeli and Zonguldak, because these are the only provinces for which data are available at the disaggregate level. Observations related to average wages have also been calculated on a provincial basis by dividing total wages by the number of employees for each industry. The inclusion of only eight of the sixty - seven provinces in the analysis does not render the data less representative since these eight provinces account for 86.2 % of the total value added generated by the private manufacturing sector covered by the annual surveys.

A cross - regional analysis has been preferred not only for its superiority in comparison with time series analyses as has been emphasized by Feldstein (30) and Bruton (31), but also because of persistent wage differentials among provinces which are presumed to reflect better the equilibrium points on the production function. These interprovincial wage differences are apparent in Table III which we have prepared by using data related to the annual surveys for the years 1972 and 1976. (The numbers in parentheses indicate the ranking of provinces with respect to average wages)

TABLE III

Average Wages in 1972 and 1976 (in TL.)

	Adana	Ankara	Bursa	İçel	İstanbul	İzmir	Kocaeli	Zonguldak
1972	17 600	13 894	21 979	15 012	20 712	14 092	35 108	11 320
	(4)	(7)	(2)	(5)	(3)	(6)	(1)	(8)
1976	42 843	38 976	45 343	51 715	63 725	41 562	81 678	33 256
	(5)	(7)	(4)	(3)	(2)	(6)	(1)	(8)

As can be observed from Table III, the wage rates for Kocaeli, İstanbul and Bursa are high compared with wage rates for Zonguldak, Ankara, İzmir, İçel and Adana. The range of variation in the wage rate was in the order of 3.1 to 1 in 1972 and 2.46 to 1 in 1976. When average wages for the eight regions in 1972 were rank correlated with those of 1976, a spearman correlation coefficient of . 88 was obtained signifying the persistency of the observed pattern.

The results of the ten regression analyses arrived at by fitting equation (X) to our data are presented in Tablo IV. The reason for having n less than eight for some of the regressions is the non - existence of firms employing ten or more workers in that particular industry category. The high $\bar{R}^2$ values adjusted for degrees of freedom and the low standard errors for the coefficients suggest a good statistical fit for the regression equations. Using the Fisher transformation method, the $\bar{R}^2$'s have turned out to be significant at the . 05 level. The elasticity and scale parameters for aggregate manufacturing and the subsectors (calculated by using the estimated co - efficients of Table IV are presented in Table V.

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(30) *M. Feldstein*, op. cit., *pp. 390—394.*

(31) *H. Bruton*, op. cit. *pp. 1—10.*

TABLE IV
(a)
Regression Results for Two - digit Categories (1976)

ISIC Industry	Regression Equation	$\bar{R}^2$	n
31. Food - Berverage - Tobacco	$\log Y = -1.94017 - \underset{(.9784)}{1.48819} \log w + \underset{(.1084)}{1.02419} \log L$	.933	8
32. Textiles - Apparel - Leather	$\log Y = -4.35015 - \underset{(.58505)}{2.13048} \log w + \underset{(.0774)}{.90821} \log L$	.965	7
33. Wood - Wood Products	$\log Y = -1.91356 + \underset{(.6849)}{1.58350} \log w + \underset{(.1571)}{.91160} \log L$	.918	8
34. Pulp - Paper - Printing	$\log Y = -2.60725 + \underset{(.3139)}{1.65749} \log w + \underset{(.0683)}{.98912} \log L$	.980	7
35. Chemicals - Petroleum - Coal - Rubber - Plastics	$\log Y = -.79374 + \underset{(.5083)}{1.43189} \log w + \underset{(.1442)}{.79642} \log L$	.875	7
36. Stone - Clay - Glass	$\log Y = -.420211 + \underset{(.66404)}{1.28933} \log w + \underset{(.1654)}{.84462} \log L$	.856	8
37. Primary Metals	$\log Y = 2.79017 + \underset{(.2902)}{.51934} \log w + \underset{(.0876)}{1.00501} \log L$	.984	7
38. Fabricated Metals - Machinery - Vehicles	$\log Y = -.00630 + \underset{(.3494)}{1.1900} \log w + \underset{(.0752)}{.89880} \log L$	.966	7

(b)

Regression Results for Aggregate Manufacturing

Years	Regression Equation	$\bar{R}^2$	n
1972	$\log Y = -.53918 + \underset{(.5838)}{1.31037} \log w + \underset{(.1512)}{.94679} \log L$	.981	8
1976	$\log Y = -.0062 + \underset{(.2417)}{1.18406} \log w + \underset{(.0551)}{.91216} \log L$	.838	8

As can be observed from Table V, the elasticity values for the two - digit categories range between . 517 and 2.35 with values except the one related to primary metals being over 1. For the two regression analyses undertaken at the agrregate

TABLE V

(a)

Elasticity and Scale Parameters for the Two - digit Categories (1976)

ISIC Industry	Elasticity of substitution $\sigma = \frac{b}{c}$	Returns to scale $v = \frac{c - b}{1 - b}$
31. Food - Beverage - Tobacco	1.4530	.9504
32. Textiles - Apparel - Leather	2.3458	1.0812
33. Wood - Wood Products	1.7370	1.1515
34. Pulp - Paper - Printing	1.6760	1.0165
35. Chemicals - Petroleum - Coal - Rubber - Plastics	1.7979	1.4714
36. Stone - Clay - Glass	1.5265	1.5370
37. Primary Metals	.5168	1.0104
38. Fabricated Metals - Machinery - Vehicles	1.3240	1.5324

(b)

Elasticity and Scale Parameters for Aggregate Manufacturing

Years	Elasticity of Substitution $\sigma = \frac{b}{c}$	Returns to Scale $v = \frac{c - b}{1 - b}$
1972	1.3840	1.1720
1976	1.2981	1.4772

industry level for comparing the 1972 and 1976 parameters, the elasticity values are both above 1 and do not differ appreciably from each other. The scale parameters as Table V indicates are close to 1 being between .95 and 1.537. Since the elasticity and scale parameters are calculated by means of the coefficients of log w and log L, the reliability of the parameters will be effected by the reliability of the estimated coefficients, b and c. One factor which could increase the standard errors of the coefficients and thereby decrease their reliability is the presence of a significant association between log w and log L or: multicollinearity. The test for multicollinearity, made by investigating the significance of the simple correlation coefficient, r, between log w and log L did not reveal the r's to be significant at the .05 level, (except for primary metals) thus further increasing the statistical reliability of the parameters.

B) Evaluation of results

The results of our empirical analysis point in the same direction as the studies made in other developing countries and previously in Turkey and suggest the presence of substitution possibilities between capital and labor in Turkish manufacturing. When compared with the elasticity values of Table I which are estimated for various developing countries by the use of the ACMS model, our estimates are slightly higher. However, the relatively higher values for chemicals, paper - printing and stone - clay categories, but lower values for food and fabricated metals are indications of a similarity of pattern not only with Table I but also with Table II where estimates for the cross - country analyses were presented. The considerably low value of .53 for the primary metals category of Turkish manufacturing can be explained by the highly specialized technological requirements of the industry. The relatively unchanging elasticity values estimated for aggregate manufacturing in Turkey are in line not only with findings for other developing economies, but also with the results related to developed countries. The elasticity value of 1.00[32] for the Brazilian and 1.076 [33] for the Egyptian manufacturing sectors at the aggregate level, an the values of 1.221 for 1963 and 1.439 for 1958 obtained for British [34] aggregate manufacturing may be given as examples of this assertion.

If we compare the elasticity values of Table V with those of previous studies made in Turkey, one striking aspect is the large number of estimates that are close to 1 in both cases. However a general upward tendency can be observed in the case of Table V. The use of a more sophisticated model and cross - regional data emphasizing regional differences may be offered as an expanation for this tendency.

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(32) *W. Tyler*, op.cit. *p. 97.*

(33) *G. Abed*, op. cit. *p. 402.*

(34) *R.J. Dixon and A.P. Thirlwall*, op.cit. *p. 236.*

Despite the similarities pointed out above, differences can also be detected in elasticity values obtained not only with respect to the manufacturing Sectors of different countries but also with respect to the various subsectors of the manufacturing industry. Two main reasons can be advanced to account for these differences. The first is the possible variation in the stage of development reached by the same industries in different countries, a phenomenon which effects industrial structure and thereby the substitution possibilities which are characteristics of the existing technology of production. A second factor which may expain the observed differences is the variation in the approaches or the type of data used in the estimation process. The rather low elasticity values for the Argentine manufacturing sector obtained by model (X) may easily be attributed to the time series data since the cross - section analysis for Argentina based on the ACMS model has revealed elasticity values of close to 1 as mentioned earlier.

The scale parameter estimates, being in the vicinity of 1 for our analysis are evidence favoring constant returns both at the aggregate and the disaggregate levels within Turkish manufacturing. These results are not only similar to scale parameter values obtained by Yıldırım (35) for Turkish manufacturing, but are also in line with the findings of studies related to Argentina, U.K. and the U.S. where the same model was employed.

IV. CONCLUSION AND ECONOMIC IMPLICATIONS

In the former part of our study, after identifying the concept of the elasticity of substitution between capital and labor, we have briefly explored the estimates of elasticities in relation to some developing countries and the econometric models on which these studies were based. The latter part of our study covered the presentation of our own empirical analysis as well as the evaluation of its results in the light of research conducted in other developing economies and previously in Turkey. In this section we shall conclude with a brief consideration of some of the economic implications that can be derived from our study.

With the development of the CES production function models it became possible to measure the elasticity of substitution within an aggregate production function framework. The same development also opened the way for investigating the employment potential of the manufacturing sectors of developing economies where labor is known to be the abundant and capital the scarce factor. As indicated by our survey, elasticity values obtained for a large number of industries of the developing economies are positive and rather high. The results of our own regression analyses also support the research in other developing countries and in Turkey, and point to the presence of technological alternatives for the manufacturing sector as a whole and its subsectors.

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(35) *See : N. Yıldırım*, op. cit., *pp. 204—205.*

The existence of capital - labor substitution possibilities in an economy will have favorable effects on growth and development if this potential can increase the utilization of the relatively more abundant factor of production and thus decrease costs. However, if factor prices do not reflect factor scarcities, as is claimed to be valid for some developing countries where the cost of capital is kept artificially low and that of labor high, this will encourage the choice of those techniques that are not optimal for the economy as a whole and will thus create adverse effects on employment. So far as the estimated elasticity values can be relied upon to reflect existing technological substitution possibilities between capital and labor in production, the use of policy measures influencing the choice of technique through factor - price intervention (tax - subsidy measures) will bu justified and employment will thereby be promoted (36).

Although obtained in economies with widely differing characteristics, important similarities can be observed in such production function parameters as the elasticity of substitution and returns to scale. These similarities point to a common denominator whose nature and economic implications deserve to be investigated in further detail.

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(36) For a detailed discussion of the question of choice of technique and related economic policy measures see : B.A. Köksal, "Teknik Seçiminin ve Teknik Seçimini Yönlendirmenin Gelişmekte Olan Ülkeler ve Türkiye açısından Önemi", Journal of the Faculty of Economics of İstanbul University, vol. 39, 1981, pp. 191 — 216.

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