# *AN ESTIMATION OF TECHNICAL CHANGE AND PRODUCTIVITY USING A TRANSLOG FUNCTION FOR GREEK INDUSTRIAL SECTORS*

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**ABSTRACT**

This paper investigates the way in which technical change implemented and influenced the competitiveness and modernization levels in the Greek manufacturing. We employ an empirical model which analyses the cost structure and technical change in twenty Greek manufacturing sectors with double digit codes (ISIC) for the period 1959-1990. The present methodology update substantially the existing applied literature. In particular, we try to estimate the technical change and decomposed it in three parts: (i) pure technology, (ii) non-neutral technology and (iii) scale augmenting component. Scale economies are also allowed.

**Keywords: technical change, translog-function, productivity, production theory**

## INTRODUCTION

Technical progress (through production functions) plays a crucial role in the theory of economic growth. A production function specifies a long-run relationship between inputs and outputs and technical progress is an essential factor underlying the growth of per capita income. There are a number of ways to approach the estimation of production functions and technical progress. A shift in the production function over time is generally considered to represent technical progress through greater efficiency in combining inputs. These shifts are achieved in a variety of ways, including changes in the coefficients of labor and capital. The characteristics of technical change may be shown by the shifts of the unit isoquant towards the origin over time. A greater saving in one input than in others will result in a bias in technical change. The relative contribution of factors to the production process is measured by the elasticity of substitution. Then, a bias in technical change will be represented by a modification in the position of the isoquant and will lead, for example, to greater labor savings for all techniques. All these specific themes are under inquiry here within an inter-sectoral environment and comparison. Finally, we attempt to infer some policy implications if possible, as well as indicate the leading manufacturing sectors throughout the time period 1959-1990, due to the data restrictions. This paper consists of two parts: the first contains a detailed description of the theoretical model adopted and on estimation technique. The second part shows the estimated results and tests against the underlying microeconomic theory. We have estimated only the period between 1959 to 1990, due to the restrictions on the available data-set and also due to the application of a new adjusted recalculation system, after 1991.

## THE MODEL SPECIFICATION

The aim of this section is to examine the nature of technological progress and factor substitution using the *translog production function* for the annual time-series data in the period 1959-1990 derived from the Greek industrial sectors.

In particular, this section presents an estimate of technical progress and of the contributions of each of the sources of growth (namely: capital, labor and technical progress) without maintaining these assumptions. One of the problems in estimating the rate of technical change and the elasticity of substitution is that of accurately specifying the production function as well as the type of technical progress. There is a big difference though, between the models adopted here and models of *induced* technical change. The sectoral cost functions have to be homogeneous of degree one, monotonic or non-decreasing and concave in input prices. In particular, this section analyses cost structures and technical change in twenty-Greek manufacturing sectors with double digit codes (ISIC). This model contributes substantially and upgrade the methodologies adopted therein. It is possible to distinguish several different aspects of this procedure, for instance:

(i) The model was first proposed by Jorgenson D.W. and Fraumeni B.M. (1983). Their main innovation was that they estimated the rate of technical change along with income share equations as functions of relative input prices. The shares and the rate of technical change are derived from a translog production function.

(ii) The procedure permits the decomposition into the estimated technical change of three components: *pure technology*, which is only the time element times a coefficient; *non-neutral*, shows how the time trend influences the usage of inputs; *scale augmenting* component, which suggests how time affects the economies of scale. The sum of those three give the growth of *multifactor productivity*.

(iii) It relaxes the assumption of constant returns to scale by estimating the initial cost function along with factor shares and the rate of technological change, and so provides the evidence for the existence of *scale economies*.

The methodology is based on a two input (capital and labor) case dual translog cost function (Christensen, Jorgenson and Lau 1971, 1973), on the derived factor shares and on the rate of technical change for all twenty industrial sectors. All these variables are functions of relative prices and time. Implicitly, it is assumed that total cost and the input shares are translog functions of their corresponding prices and time. Technology is in fact endogenous in our sectoral models and is parametrically rather than residually estimated. Applying Jorgenson and Fraumeni's methodology we fitted the models so that they embrace all of these theoretical requirements. Since perfect competition is assumed, the input prices are exogenously determined. The translog cost function can be written

$$ln\overset{v}{c}(w_K,w_L,YT)=\overset{v}{\alpha}_0+\overset{v}{\alpha}_y ln\overset{v}{y}+\frac{1}{2}\overset{v}{\alpha}_{yy}(ln\overset{v}{y})^2+\sum_{i=1}^{n}\overset{v}{\alpha}_i ln\overset{v}{w}_i+\frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\overset{v}{\gamma}_{ij} ln\overset{v}{w}_i ln\overset{v}{w}_j+\sum_{i=1}^{n}\overset{v}{\gamma}_{iy} ln\overset{v}{w}_i ln\overset{v}{y}$$

$$\overset{v}{\gamma}_T T+\frac{1}{2}\overset{v}{\gamma}_{TT}T^2+\sum_{i=1}^{n}\overset{v}{\gamma}_{iT}\, ln\overset{v}{w}_i T+\overset{v}{\gamma}_{yT}\ln y^v T \qquad \textbf{(2.1)}$$

where C= total cost, $W_i$ (i= K,L)=input prices (price of capital and labor), Y= value-added, and T= technical change index.

Since we are using the averages we have to transform the cost function, the share equations and the rate of technical change as, (for simplicity we can drop the superlative index which declares the number of sectors):

$$\overline{lnc}^{v}(\overline{w}_K,\overline{w}_L,\overline{Y},T) = \alpha_0^v - \alpha_y^v\,\overline{lny}^{v} - \frac{1}{2}\alpha_{yy}^v(\overline{lny}^{v})^2 - \sum_{i=1}^{n}\alpha_i^v\,\overline{lnw_i}^{v} - \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\gamma_{ij}^v\,\overline{lnw_i}\;\overline{lnw_j}$$

$$-\sum_{i=1}^{n}\gamma_{iy}^v\,\overline{lnw_i}\;\overline{lny}^{v} - \gamma_T^v T - \frac{1}{2}\gamma_{TT}^v T^2 - \sum_{i=1}^{n}\gamma_{iT}^v\,\overline{lnw_i}\,T - \gamma_{yT}^v\,\overline{lny}^{v}T - \overline{e}_c^{v} \qquad (2.2)$$

where the share equation and the rate of technical change take the form:

$$\overline{S}_i^v(w_K,w_L,Y,T) = \alpha_i^v - \sum_{i=1}^{n}\gamma_{ij}^v\,\overline{lnw_j}^{v} - \gamma_{iy}^v\,\overline{lnY}^{v} - \gamma_{iT}^v T - \overline{e}_i^{v} \qquad (2.3)$$

$$-\overline{S}_T^v(w_K,w_L,Y,T) = \gamma_T^v - \gamma_{TT}^v T - \sum_{i=1}^{n}\gamma_{iT}^v\,\overline{lnw_i}^{v} - \gamma_{yT}^v\,\overline{lnY} - \overline{e}_T^{v} \qquad (2.4)$$

(where:v = 1....,20 and i = K, L), are the average error terms. The share equations have the following form: $S_K$ (share of capital)=($P_K$*$Q_K$)/TC and $S_L$ (share of labor)=($P_L$*$Q_L$)/TC, where $P_{K,L}$L is the price of capital and the price of labor, $Q_{K,L}$ is the capital and labor and TC is the total cost.

The Allen-Uzava partial elasticities of substitution, $\sigma_{ij}$, and price elasticities of input demands, $P_{ij}$, are given by following equations.

$$\sigma_{ij} = (\gamma_{ii} + S_i^2 - S_i)(S_i^2), \quad i = K, L\ i = j \qquad (2.5)$$

and

$$\sigma_{ij} = (\gamma_{ij} + S_iS_j)(S_iS_j), \quad i,j = K, L\ i \neq j$$

Where the own-partial elasticities of substitution, $\sigma_{ii}$, are expected to be negative. On the other hand, the cross-partial elasticities of substitution can be either positive, suggesting substitutability between inputs, or negative, suggesting input complementarity.

$$P_{ij} = \sigma_{ij}S_j,\ i = K, L\ i \neq j \qquad (2.6)$$

and

$$P_{ii} = \sigma_{ii}S_i,\ i = K, L\ i = j$$

Several comments should be made concerning these substitution elasticity estimates. First, parameter estimates and fitted shares should replace the $\gamma$'s and S's when computing estimates of the $\sigma_{ij}$ and $P_{ij}$. This implies that in general the estimated elasticities will vary across observations. Second, since the parameter estimates and fitted shares have variances and covariances, the estimated substitution elasticities also have stochastic distributions. Third, the estimated translog cost function should be checked to ensure that it is monotonically increasing and strictly quasi-concave in input prices, as is required by theory. For monotonicity it is required that the fitted shares all be positive, and for strict quasi-concavity the (n x n) matrix of substitution elasticities must be negative semidefinite at each observation. Moreover, we may calculate the scale elasticities, (which is the percentages change of the total cost after the change one percentage in the output). As has been shown by Giora Hanoch (1975) there are computed as the inverse of costs with respect to output. More specifically, ***scale***=1/$e_{cy}$ where $e_{cy}$= $\partial$lnc/$\partial$lny and where for the translog function.

$$\overline{\varepsilon}_{cy} = a_y - a_{yy}\,\overline{\ln Y} - \Sigma_i^n \gamma_{iy}\,\overline{\ln P_i} - \gamma_{Yt}\,\overline{T} \tag{2.7}$$

A number of additional parameter restrictions can be imposed on the translog cost function, corresponding to further restrictions on the underlying technology model. For the translog cost function to be homothetic it is necessary and sufficient that $\gamma_{iy}=0$ $\forall$ i= 1,...,n. Homogeneity of a constant degree in output occurs if, besides these homotheticity restrictions, we have $\gamma_{yy}= 0$. In this case the degree of homogeneity equals $1/\alpha_y$. Constant returns to scale of the dual production function occurs when, in addition to the above homotheticity and homogeneity restrictions, $\alpha_y=1$.

One potential problem with estimation of scale economies, however, is that the $\alpha_y$ and $\gamma_{YY}$ parameters do not appear in the share equations, and so these parameters cannot be estimated by using only the share equation system (equations 2.2, 2.3, 2.4). To estimate the above model of the average cost functions along with the share of one input and the rate of technical change, we adopted the three stage least squares --with endogenous lag variables-- (i.e. lag shares, lag prices of capital, labor and output). This method requires the usage of instrumental variables. We picked up the lagged variables of capital stock, price of capital, value added, price of output, number of employees and the price of labor. To interpret the estimates of these parameters it is useful to recall that if the production function is increasing in capital and labor inputs then the average value shares are non negative.

There are only few attempts at Greek sectoral analysis such as Kintis (1973, 1978), Lianos (1976), Ioannides and Caramanis (1979) and Panas (1986). All of them tried to investigate the patterns of input substitution as well as to derive a measure for technical change and technological biases. They modelled producers' behaviour using simply the constant elasticity of substitution (CES) and a Cobb-Douglas functional form applied to period 1958-1975. Ioannides and Caramanis employed a translog cost function assuming constant returns to scale fitted to period 1958-1978. Furthermore, they did not take into account possible scale biases which may affect not only sectoral decisions but also policy-makers' orientation.

## DISCUSSION OF THE EMPIRICAL RESULTS

### The Data[1]

The data used for our estimations come from the annual industrial surveys (AIS) and from the statistical yearbooks (SY) of the National Statistical Service of Greece (NSSG). *The data we use refer to large industries* (which correspond to the companies with 20 or more employees). However, there is a restriction on data-set. Some of the series (such as capital-stock and output) are given up to 1990. In particular, after 1990 for the series of output there is a new re-calculation adjusted system using another basis for the large industries, while the series of capital-stock are given by CEPR (Center of Economic Planning and Research) up to 1990 and are not available after that. For these reasons we have estimated the function and the variables up to 1990.

Output is measured as value added in the large enterprises, as reported by AIS and SY. Labor is measured as number of employees. The wage rate and salaries correspond to the total labor cost for the large industry. The price of labor was derived by dividing the total labor cost by the number of employees. The price of capital stock was derived by dividing the value added minus the total labor cost by the capital stock figures. The data on value added and wage rates have been deflated to the constant prices in 1985. The data are available for twenty industrial sectors for 32 years (1959-90). A function of manufacturing sector as a whole estimated using the same data, and each variable is *weighted* by its shares and calculate the averages. The capital-stock derived from the data-set of CEPR (Center of Economic Planning and Research) calculated by Skountzos and Mathaios for the period up to 1990. The capita-stock including residential buildings, non-residential buildings, other construction and works, transport equipment, machinery and other equipment, public sector and private sector. Finally, there are no-available series-data for energy input and for these reasons we are using two input-model for the period 1957-1990.

To solve the equation system we should use the *Zellne's seemingly unrelated estimator* (the so called *ZEF or SUR –seemingly unrelated regression estimator* or otherwise the *minimum chi-square estimator*). The *iterative Zellner efficient estimator* is termed as *IZEF* and yields parameter estimates that are numerically equivalent to those of the maximum likelihood estimator (ML). The ZEF system estimator yields different parameter estimates than those form equation by equation OLS; this happened because the input-output equation contains different regressors and in addition one would expect disturbances across input-output equations to be contemporaneously correlated, implying that the covariance matrix would be non-diagonal. We adopted an alternative estimate using 3SLS; we also employ the instrumental variables estimation techniques (as instrumental variables we are used logarithms of lagged variables of prices of capital and labor, output and time). The steps in estimation of the model are the following: we estimate the total cost as a function of capital and labor inputs and prices. We construct capital and labor shares (using prices, inputs and total cost). Using the Shephard's lemma (for instance, for the cost and labor shares), in order to derive the input demands and to solve parametrically the equations of capital and labor shares. We use instrumental variables (logarithms of lagged variables) and we solve by 3SLS. With these parameters we estimate the two factor cost shares (such as, $S_L$, $S_K$,). We calculate the substitution elasticities from these above parameters using the equations (2.5), (or similarly the equations (2.6) ) for the price elasticities.

The duality property between cost and production functions was first introduced by Shephard (1953). Given a cost function satisfying certain regularity conditions, we can derive a production function which in turn may be used to derive our original cost function. See in Diewert and Wales, (1987). A disturbance term must specified in each of the input-output equations and it is also assumed that the disturbance vector is independently and identical normally distributed with mean vector zero and constant nonsingular covariance matrix W. These disturbance terms could simply reflect optimization errors on the part of industries, (Berndt, 1991). Since the input-demand functions are linear in the parameters and these demand equations have cross-equation symmetry constrains, then the OLS estimation equation by equation appears more attractive. However, we can use the *Zellner's seemingly unrelated estimator* (ZEF which called and *seemingly unrelated regression estimator (SUR) or the minimum ch-square estimator*). The different parameter estimates than those form equation by equation OLS result from the following reasons:(a) the disturbances across the input-output equations are contemporaneously correlated which imply that the disturbance covariance matrix is nondiagonial; (b) each of the input-output equations contains different regressors. For these reasons the

ZEF estimator will provide more efficiently estimates of parameters rather that the OLS.The *Zellner's seemingly unrelated estimator* (ZEF) uses equation by equation OLS to obtain an estimate of the disturbance covariance matrix and then does generalized the least squares. See Berndt, (1991).

A common procedure for reducing collinearity with time series data is to first-difference the data and then to work with the first-differenced data. Logarithmic first-differenced, since $\ln y_t - \ln y_{t-1}$ equals $\ln(y_t / y_{t-1})$, which for small changes can be interpreted as the percentage change in y from period t-1 to period t. this way of computing percentage change is also attractive in that $\ln(y_t / y_{t-1})$, always yields a value between $(y_t - y_{t-1}) / y_{t-1}$ and $(y_t - y_{t-1}) / y_t$. Using the annual data from 1959 to 1990, we have computed the logarithmic first differences, in order to avoid the problem of multicollinearity.

Since the input prices and $\beta_i$ vary over the observations, then the substitution and price elasticities $\sigma_{ij}$, $P_{ij}$ estimates also will differ over the observations. As required by the theory, the fitted values for all input-output equations are positive and the (n x n) matrix of the $\sigma_{ij}$ substitution elasticities is negative and semidefinite at each observation which implies that the estimated cost function is monotonically increasing and strictly quasi-concave in input prices.

## THE EMPIRICAL RESULTS

All the parameters are being presented below in the Table 2.1. This Table provides the empirical estimations for the translog cost function over the period 1959-1990. In particular, the coefficients $\{\alpha_K, \alpha_L\}$ are the average values of the input shares for each sector; we have discarded the superscript v for convenience. The interpretation of the parameters $\{\gamma_T, \alpha_Y\}$ which represent the average of the negative rate of the technical change and the average share of output in the total cost is similar. The parameters $\{\gamma_{KK}, \gamma_{LL}, \gamma_{KL}\}$ imply the share elasticities with respect to input prices and they are constant. The coefficients $\{\gamma_{KT}, \gamma_{LT}, \gamma_{TT}\}$ express the technical change biases and the rate of acceleration of the technical change correspondingly. Our next set of parameters $\{\gamma_{KY}, \gamma_{LY}\}$ provide an indication of the scale biases, given that the underlying function is not homothetic; they show the growth of output influences the input shares. So, a positive number implies that input i is relatively more as output grows. The coefficient $\alpha_{YY}$ shows the rate of outputs' acceleration. The parameter $\gamma_{YT}$ tells us how time affects the growth of output.

The above parameters have been estimated for twenty industrial sectors in Greek manufacturing but in the sector 39 (Miscellaneous manufacturing industry) the rate of technical change is set equal to zero by definition. Several comments should be added, concerning the above results. Let us start with the analysis of the parameters $\{\alpha_K, \alpha_L, \alpha_Y, \gamma_T\}$. The average factor shares are positive as is required by monotonicity for all twenty sectors. Apart from the sectors 28 and 31, $\alpha_Y$ has a positive value and shows the average value share of output in the total cost, whereas the negative rate of technological change is negative in five sectors and positive in nineteen.

The next set of the estimated coefficients we are going to discuss is $\{\gamma_{KK}, \gamma_{LL}, \gamma_{KL}\}$. They imply the substitution patterns between the two factors. The second order parameters, for instance $\gamma_{KK}$, $\gamma_{LL}$ and $\gamma_{KL}$ are defined as the constant share elasticities which are derived by differentiating the factor shares with respect to logarithmic prices. The coefficients $\gamma_{KT}$ and $\gamma_{LT}$ are the biases of technical change and they are given by differentiating the rate of technical change with respect to input prices. If we differentiate again the rate of technical change equation with respect the time then we get $\gamma_{TT}$, which shows the rate of change of the negative of the rate of technical change. We have to note, that because a two factor cost-function is assumed, we do not expect capital and labor to be complements. In that case then, the producers could have been able to increase their output without any cost. In this sense, capital and labor are substitutes as the parameter $\gamma_{KL}$ is negative for seventeen sectors and positive but not significant in two. The rest of them $\gamma_{KK}$, $\gamma_{LL}$ show how the use of an input responds to a shift in its price. By the law of demand, these should have been negative but they are not. Although these differences suggest violations in convexity, this is not so since the values of the own substitution elasticities for nineteen sectors are non-positive for every point within the sample period. This means that capital and labor inputs are price responsive. In the sector 32 we had convexity violations so we imposed it, using the method described above. The cost of this imposition is that we set these parameters equal to zero.

The parameters $\{\gamma_{KY}, \gamma_{LY}\}$ indicate the share elasticities with respect to output. In other words, they show how an input' share would be affected after a change in the level of output. In five sectors 27, 28, 29, 31 and 39 the share of capital increases with an increase of output and in fifteen sectors it decreases. Exactly the opposite is true with labor input. The parameter $\alpha_{YY}$, represents cost flexibility, or, how marginal cost will change with a change in the level of output. In five sectors 26, 27, 28, 29, 33 marginal cost will increase, as the output expands.

The parameters $\{\gamma_{KT}, \gamma_{LT}\}$ suggest the technical change biases. They represent the change of a factor share with respect to time. In all nineteen sectors (not forgetting that for the sector 39 $\gamma_{KT}=\gamma_{LT}=0$) $\gamma_{KT}$ is positive, implying that the usage of capital increases over time. At the same time all the sectors have the tendency to be labor saving, because of the technical change. The coefficient $\gamma_{YT,}$ shows the impact of technical change on the growth of output.

More specifically, in the sectors 26, 27, 28, 29, 33 technical change decreases with sectoral output. The last parameter $\gamma_{TT}$, shows the rate of acceleration of the negative rate of the technical change. In seven 26, 27, 28, 29, 33, 35 and 37 sectors, the acceleration rate is positive which implies that the technical change is decreasing with time whereas in the rest twelve it is increasing.

Table 2.2 provides estimations for mean substitution and price elasticities. We decomposed the multifactor productivity (MFP) or the rate of technical change in three parts, the pure technology; the non-neutral technology; and the scale augmenting technology. In the last column of this table, we furnished Hannoch's measure for scale economies. Finally, Tables 2.3 and 2.4 illustrate the results from the cross-section analysis.

First, the mean own substitution and price elasticities are negative as it is required. That is, the factor demands are price responsive. Furthermore, in twelve sectors 20, 24, 25, 26, 27, 29, 30, 32, 33, 35, 36 and 39 the share of capital is influenced relatively more after a change in the price of labor. In other words, the demand for capital is less inelastic for the above twelve sectors than the labor demand is. Consequently, these industrial Greek sectors are willing for instance to give up comparatively easier some capital inflows in order to substitute with the relatively cheaper labor inputs. *Technological capability and the efficiency of the country* remained at low levels. The transferred of technological inputs *orientated to the traditional sectors*, which correspond to the less intensive research activities. If we take qualitative research characteristics into account, (such as, the quality control), the overall situation of the country is rather worsening than improving. A worth-note characteristic is the extremely low level of innovation activities of the private sector. The major part of research activities derive from funding of public sector. The linkages between *theoretical and productive research* are very loose, which implies an additional barrier for the improvement of technological apparatus of the country. Finally, the administration in national research centres and in universities has proved rather inefficient in passing on research results and innovation activities to the industrial production. The Greek industry was very vulnerable to foreign competition and one of the main causes for this is the weak technological performance and the lack of indigenous produced technologies. In order to change this situation, the Greek industry should utilise the imported technologies more creatively in the future rather than it did in the past.

Second, we provide a measure of the scale economies (Scale). In twelve sectors 23, 24, 25, 27, 28, 29, 31, 34, 35, 36, 38 and 39 we observed increasing returns to scale. This suggests that the sectors have the ability to increase their outputs at a relatively faster rate than to their total costs.

More simply, these twelve sectors function on the left-hand side of the minimum point of the U shaped average cost. So they can still exploit high returns by expanding their production until their marginal cost gets equal with the average cost (under the assumption of perfect competition). In three industries 20, 26, 33, the values of scale economies are very close to unity 0.86, 0.96 and 0.94 respectively, so without making a significant mistake, we can assume constant returns to scale for these sectors. In five industries left 21, 22, 30, 32 and 37, (plus the all manufacturing) we decisively concluded the existence of diseconomies of scale which implies that these industries function in an inefficient way. Their marginal cost is greater than their average cost.

Third, the multifactor productivity (MFP) is positive for only three sectors 28, 30 and 34. This means that in the rest of sixteen sectors, technological change reduces total costs at a rough average of 6% throughout the sample period. In addition, we performed a decomposition of the shadow value of time (MFP) in TCH1, TCH2 and TCH3. In particular, TCH1 is negative in fourteen sectors, which suggests that the pure technology, the technology which is attributed more to the time trend, reduces total costs in fourteen industrial sectors by an average 8%.

The non-neutral part of technical change TCH2, is in fourteen sectors positive. This implies that technology makes the usage of inputs relatively more intense as the years pass by and so the total costs increase on average 0.1%. At last we have the scale augmenting part TCH3. It is positive in fourteen sectors and implies that technology increases sectoral output and total cost by almost 1.5%.

Table 2.5, shows the comparison of elasticities of substitution and technological progress between this study and previous studies for the Greek economy. The index of substitution elasticities in the first column indicates the results from our estimations. The index of substitution elastcities in second column indicates the estimation-results of Panas' paper (1986), covering the period 1958-75 and give estimations for 17-sectors of Greek economy. The index of substitution elastcities in the third column indicates the estimation-results from Kintis' paper (1978), covering the period 1958-1973 and give estimations for 14-sectors of the Greek economy. The index of substitution elastcities in the fourth column indicates the estimation-results from Lianos' paper (1973), covering the period 1958-1969 and give estimations for 18-sectors of the Greek economy. The estimation-result of this study are *closer* to the results of Kintis and Panas. Of course, the methods which are used and the data set are quite different. According to these, the capital input in the case of Greek manufacturing industries grew faster than output and also confirms the existence of *over capitalization*. Consequently, more and more capital-intensive methods are adopted and this implied that capital grew more than is required which can lead to negative capital augmentation.

## CONCLUSIONS

In this paper we have estimated a translog cost function for twenty Greek manufacturing sectors double digit (ISIC). Due to the restrictions of data-set estimations covered the period 1959-1900. We tried to estimate the technical change which decomposed into three parts: (i) pure technology, (ii) non-neutral technology and (iii) scale augmenting component. Scale economies are also allowed. We have tested and rejected the hypothesis of homotheticity, homogeneity and constant returns to scale. Firstly we estimated the parameters of cost-function with share inputs and after the price elasticities and the elasticities of substitution. Furthermore, we decomposed the multifactor productivity (MFP) or the rate of technical change in three parts, the pure technology; the non-neutral technology; and the scale augmenting technology.

On the basis of the previous discussion, the main conclusions and recommendations of this paper can be summarised as follows:

The interpretation of the parameter-coefficients $\{\alpha_K, \alpha_L\}$, $\{\gamma_T, \alpha_Y\}$, $\{\gamma_{KK}, \gamma_{LL}, \gamma_{KL}\}$, $\{\gamma_{KT}, \gamma_{LT}, \gamma_{TT}\}$ and finally $\{\gamma_{KY}, \gamma_{LY}\}$, are the average values of the input shares for each sector; the average of the negative rate of the technical change and the average share of output in the total cost, the share elasticities with respect to input prices which they are constant, the technical change biases and the rate of acceleration of the technical change and finally the scale biases that showing the growth of output influences the input shares, respectively. The coefficients $\gamma_{KT}$ and $\gamma_{LT}$ are the biases of technical change and they are given by differentiating the rate of technical change with respect to input prices. If we differentiate again the rate of technical change equation with respect the time then we get $\gamma_{TT}$, which shows the rate of change of the negative of the rate of technical change.

The above parameters have been estimated for twenty industrial sectors in Greek manufacturing. The parameters $\{\alpha_K, \alpha_L, \alpha_Y, \gamma_T\}$ showing the average factor shares are positive as is required by monotonicity for all twenty sectors which means the producers could have been able to increase their output without any cost. The parameters $\gamma_{KK}$, $\gamma_{LL}$ showing how the use of an input responds to a shift in its pric and according to the law of demand, these should have been negative but they are not. The parameters $\{\gamma_{KY}, \gamma_{LY}\}$ indicating the share elasticities with respect to output and they show how an input' share would be affected after a change in the level of output; in five sectors 27, 28, 29, 31 and 39 the share of capital increases with an increase of output and in fifteen sectors it decreases, while the opposite is true with labor input. Finally, according to the parameter $\gamma_{TT}$, the rate of acceleration of the technical change, showing that in seven 26, 27, 28, 29, 33, 35 and 37 sectors the acceleration rate is positive which implies that the technical change is decreasing with time whereas in the rest twelve it is increasing.

In conclusion, according to our results, the technology is proxied by the use of the time trend for the estimation of *translog cost function* for the sectors of Greek manufacturing. Although time trend functions only as a rough representative of the true underlying determinants of the technological change, it is the best we could do given the lack of satisfactory data set. The results indicate that most of the industrial sectors (except the sectors 23 and 32) are capital using intensive (or labor saving) which can be interpreted in accordance to the previous analysis that the technological inputs (such as the imported capital goods and the transferred technologies) were not appropriate to the local necessities and did not fit the availability of market resources. To see the difficulties that Greek manufacturing has in adjusting itself to new technologies, we may use the measure of scale economies, as a guide. It is evident that the Greek manufacturing to a large extent exhibits increasing returns. Hence, these industries have the potential for further exploitation. If this is the case, they could contribute to Greek economic development.

## APPENDIX A

The cost function approach does not dominate the production function approach; the choice depends on the parameters to be estimated. For example, for reasons much the same as the ones given above the production function approach is preferable when estimates of factor productivity is sought.

The specification of the cost-function does not impose any restriction on technological change and returns to scale. Invoking Shephard's lemma, one obtains the familiar cost shares which together with the above equations, provide the basis for the estimation:

$$\frac{\partial \ln C^v}{\partial T} = -S_T^v(w_k, w_L, Y, T) \tag{1}$$

where

$$S_i^v(w_K, w_L, Y, T) = \alpha_i^v + \sum_{i=1}^{n} \gamma_{ij}^v lnw_j^v + \gamma_{iy}^v lnY^v + \gamma_{iT}^v T \tag{2}$$

The rate of technical change in each sector is given as the negative of the rate of growth of sectoral cost with respect to time, holding input prices constant. Doing this, we can get:

$$\frac{\partial \ln C^v}{\partial T} = -S_T^v(w_k, w_L, Y, T) \tag{3}$$

$$-S_T^v(w_k, w_L, Y, T) = \gamma_T^v + \gamma_{TT}^v T + \sum_{i=1}^{n} \gamma_{iT}^v lnw_i^v + \gamma_{yT}^v lnY \tag{4}$$

or s.t.: $\gamma_{ij} = \gamma_{ji}$, $i \neq j$, $i,j = K,L$, $v = 1,\ldots,20$ is the number of sectors.

$$\Sigma\,\alpha_i = 1\ ;\ \Sigma\,\gamma_{ij} = \Sigma\,\gamma_{ji} = 0 \qquad \Sigma\gamma_{it} = 0;\ \text{and}\ \ \Sigma\,\gamma_{yi} = 0 \tag{5}$$

The restrictions (equations 5) imposed on the cost function), on the cost-shares and on the rate of technological change imply that the share equations satisfy:

$$\Sigma\,\alpha_i = 1\ ;\ \Sigma\,\gamma_{ij} = \Sigma\,\gamma_{ji} = \Sigma\,\gamma_{iy} = \ \Sigma\gamma_{it} = 0$$

The second order parameters, for instance $\gamma_{KK}$, $\gamma_{LL}$ and $\gamma_{KL}$ are defined as the constant share elasticities which are derived by differentiating the factor shares with respect to logarithmic prices. On the other hand, the coefficients $\gamma_{KT}$ and $\gamma_{LT}$ are the biases of technical change and they are given by differentiating the rate of technical change with respect to input prices. If we differentiate again the rate of technical change equation (3) with respect the time then we get $\gamma_{TT}$, which shows the rate of change of the negative of the rate of technical change.

The function C has to be non-decreasing in input prices so the factor shares have to be non-negative throughout the sample period. If we denote as (S) the matrix of shares and (H) the Hessian matrix of the second order terms, then we may represent the matrix of share elasticities, say Q, in the form:

$$Q = (1/C)\, P^{*}H^{*}P - ss' + S$$

where

$$P = \begin{bmatrix} w_K & 0 \\ 0 & w_L \end{bmatrix} \quad S = \begin{bmatrix} S_K & 0 \\ 0 & S_L \end{bmatrix} \quad s = \begin{bmatrix} S_K \\ S_L \end{bmatrix}$$

Now, concavity implies that the cost function has to have a negative semi-definite H matrix. If we rewrite equation (Q), we can get:

$$(1/C)\, P^{*}H^{*}P = Q + ss' - S$$

which is negative semidefinite if and only if H matrix is negative semidefinite. This is very useful outcome because it gives right to represent the unknown parameters using the Cholesky factorization:

$$Q + ss' - S = L^{*}D^{*}L'$$

where L is a unit lower triangular matrix and D is a diagonal matrix with non-positive terms. Applying the above transformation permits us to the share elasticities matrix we guarantee concavity in the sample period.

The idea here is to estimate the rate of technical change along with the share equations but what is the quantity of $S_T$? Although it is unobserved we may circumvent this problem by considering the *translog price index* for the rate of technical change. We may say that the technical change between any two points of time, T and T-1 is given by the subtraction from the growth of total cost the growth of each input price weighted by their corresponding average shares:

$$-\overline{S}_T^v = [( lnc-(T)^v - lnc-(T-1)^v ) - \textstyle\sum_{i=1}^{n} \overline{S}_i^v ( lnw_{i(T)}^v - lnw_{i(T-1)}^v ] \quad (6)$$

where T = time, (i = K, L and v = 1,...,20 the number of sectors).

$$\overline{S}_i^v = \frac{1}{2} [ S_{i(T)}^v + S_{i(T-1)}^v ] \quad (7)$$

Within the same context we may derive the average shares as:

T = time, (i = K, L and v = 1,...,20 the number of sectors).

The above restrictions imply also an adding up condition of the share equation system (2.2) such as:

$$\textstyle\sum_i \overline{S}_i^v = 1$$

$$\overline{e}_c^v = \frac{1}{2} ( e_{c(T)}^v + e_{c(T-1)}^v ) \quad (8)$$

$$\overline{e}_i^v = \frac{1}{2} ( e_{i(T)}^v + e_{i(T-1)}^v ) \quad (9)$$

$$\overline{e}_T^v = \frac{1}{2} ( e_{T(T)}^v + e_{T(T-1)}^v ) \quad (10)$$

This adding up feature of the share equation has several important econometric implications, to which we now turn our attention. First, since the shares always sum to unity and only n-1 of the share equations are linearly independent, for each observation the sum of the disturbances across equations must always equal zero. Second, because the shares sum to unity at each observation, when the symmetry restrictions are not imposed, the residuals across equations will sum to zero at each observation, that is,

$$\bar{e}_K^{\,v} + \bar{e}_L^{\,v} = 0$$

A number of additional parameter restrictions can be imposed on the translog cost function, corresponding to further restrictions on the underlying technology model. For the translog cost function to be homothetic it is necessary and sufficient that

$$\gamma_{iy}=0 \;\forall\; i= 1,...,n.$$

Homogeneity of a constant degree in output occurs if, besides these homotheticity restrictions, we have $\gamma_{yy}= 0$. In this case the degree of homogeneity equals $1/\alpha_y$. Constant returns to scale of the dual production function occurs when, in addition to the above homotheticity and homogeneity restrictions, $\alpha_y=1$. Finally, the translog function reduces to the constant returns to scale Cobb-Douglas function when, in addition to all the above restrictions, each of the $\gamma_{ji}=0$ i, j=1,...,n.

# Appendix B

**Table 2.1**
**Parameter estimations (time-series translog-cost function): Greece (1959-1990)**

| | $\alpha_0$ | $\alpha_Y$ | $\alpha_{YY}$ | $\alpha_K$ | $\alpha_L$ | $\gamma_T$ | $\gamma_{KK}$ | $\gamma_{LL}$ | $\gamma_{TT}$ | $\gamma_{YT}$ | $\gamma_{KY}$ | $\gamma_{KL}$ | $\gamma_{KT}$ | $\gamma_{LY}$ | $\gamma_{LT}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 2.0 | 2.6 | -1.4 | 0.51 | 0.49 | -0.1 | 0.01 | 0.01 | -0.03 | 0.21 | -0.1 | -0.01 | 0.17 | 0.10 | -0.1 |
| | (7.0) | (5.0) | (-1.8) | (6.9) | (6.6) | (-2.8) | (0.4) | (0.4) | (-1.4) | (1.5) | (-2.1) | (-0.4) | (2.6) | (2.1) | (-2.6) |
| 21 | -0.60 | 4.59 | -2.28 | 0.80 | 0.20 | -0.42 | 0.017 | 0.017 | -0.05 | 0.34 | -0.06 | -0.01 | 0.013 | 0.062 | -0.01 |
| | (-1.3) | (4.4) | (-1.2) | (8.4) | (2.1) | (-2.2) | (0.8) | (0.8) | (-0.8) | (0.9) | (-1.6) | (-0.8) | (2.3) | (1.6) | (-2.35) |
| 22 | 0.63 | 1.98 | -0.5 | 0.40 | 0.60 | -0.05 | -0.03 | 0.090 | -0.02 | 0.094 | -0.10 | 0.03 | 0.015 | -0.03 | -0.086 |
| | (0.5) | (1.5) | (-0.7) | (2.6) | (4.0) | (-0.3) | (-0.1) | (2.7) | (-1.7) | (0.9) | (-2.5) | (0.1) | (3.4) | (-1.8) | (-1.7) |
| 23 | 0.710 | 3.195 | -1.19 | 0.64 | 0.36 | -0.24 | -0.03 | -0.03 | -0.01 | 0.132 | -0.10 | 0.037 | 0.015 | 0.104 | -0.015 |
| | (1.7) | (4.4) | (-1.2) | (5.4) | (3.1) | (-2.0) | (-0.1) | (-0.1) | (-0.5) | (0.7) | (-2.5) | (0.1) | (3.4) | (2.5) | (-3.4) |
| 24 | 3.42 | 0.91 | -1.10 | 0.16 | 0.84 | 0.055 | 0.096 | 0.096 | -0.03 | 0.201 | -0.05 | -0.09 | 0.012 | 0.05 | -0.012 |
| | (22) | (2.5) | (-2.5) | (5.7) | (32) | (0.6) | (7.7) | (7.7) | (-1.9) | (2.1) | (-0.3) | (-7.7) | (3.8) | (0.3) | (-3.8) |
| 25 | 3.84 | 0.55 | -0.49 | 0.18 | 0.82 | 0.049 | 0.088 | 0.088 | -0.02 | 0.101 | -0.04 | -0.08 | 0.19 | 0.044 | -0.019 |
| | (37) | (0.9) | (-0.5) | (3.8) | (17) | (0.5) | (3.8) | (3.8) | (-0.7) | (0.6) | (-1.6) | (-3.8) | (5.3) | (1.6) | (-5.3) |
| 26 | 2.93 | 1.566 | 0.057 | 0.24 | 0.76 | -0.03 | 0.042 | 0.042 | 0.060 | -0.04 | -0.08 | -0.04 | 0.019 | 0.089 | -0.019 |
| | (27) | (4.7) | (0.6) | (5.8) | (18) | (-0.1) | (1.9) | (1.9) | (0.2) | (-0.2) | (-3.4) | (-1.9) | (3.9) | (3.4) | (-3.95) |
| 27 | 1.906 | 1.558 | 0.179 | 0.01 | 0.99 | -0.06 | 0.130 | 0.130 | 0.019 | -0.07 | 0.166 | -0.13 | 0.104 | -0.01 | -0.010 |
| | (2.6) | (1.2) | (0.1) | (0.7) | (9.8) | (-0.3) | (4.9) | (4.9) | (0.4) | (-0.3) | (0.4) | (-4.9) | (1.8) | (-0.4) | (-1.8) |
| 28 | 3.24 | -0.10 | 0.849 | 0.19 | 0.81 | 0.169 | 0.107 | 0.10 | 0.163 | -0.12 | 0.064 | -0.10 | 0.071 | -0.06 | -0.071 |
| | (5.4) | (-0.9) | (0.6) | (1.5) | (6.7) | (1.0) | (3.1) | (3.1) | (0.4) | (-0.6) | (1.2) | (-3.1) | (0.7) | (-1.2) | (-0.7) |
| 29 | 2.240 | 1.832 | 0.511 | 0.15 | 0.85 | -0.04 | 0.055 | 0.05 | 0.253 | -0.14 | 0.010 | -0.05 | 0.069 | -0.01 | -0.069 |
| | (5.4) | (3.4) | (0.9) | (2.9) | (18) | (-0.7) | (2.7) | (2.7) | (1.7) | (-1.7) | (0.4) | (-2.7) | (2.0) | (-0.4) | (-2.01) |
| 30 | 3.124 | 1.146 | -0.23 | 0.25 | 0.75 | -0.01 | 0.120 | 0.12 | -0.01 | 0.080 | -0.16 | -0.12 | 0.043 | 1.60 | -0.043 |
| | (14) | (1.4) | (-0.7) | (3.2) | (10) | (-0.7) | (4.0) | (4.0) | (-0.1) | (0.1) | (-2.7) | (-4.0) | (3.6) | (2.7) | (-3.6) |
| 31 | 4.214 | -0.13 | -0.16 | 0.51 | 0.49 | 0.515 | 0.058 | 0.05 | -0.01 | 0.070 | 0.015 | -0.05 | 0.022 | -0.01 | -0.022 |
| | (5.8) | (-0.1) | (-0.4) | (6.0) | (5.7) | (0.4) | (1.8) | (1.8) | (-1.6) | (1.2) | (0.2) | (6.0) | (0.1) | (-0.2) | (-0.1) |
| 32 | 0.98 | 3.609 | -2.92 | 0.76 | 0.24 | -0.19 | (*) | (*) | -0.11 | 0.555 | -0.16 | (*) | 0.032 | 0.160 | -0.032 |
| * | (0.9) | (2.3) | (-1.3) | (6.0) | (1.9) | (-0.7) | | | (-1.6) | (1.4) | (-3.0) | | (3.6) | (3.0) | (-3.6) |
| 33 | 2.056 | 1.726 | 0.786 | 0.36 | 0.64 | -0.05 | 0.052 | 0.052 | 0.039 | -0.19 | -0.06 | -0.05 | 0.017 | 0.060 | -0.017 |
| | (5.4) | (2.0) | (0.5) | (5.9) | (10) | (-0.4) | (3.2) | (3.2) | (0.9) | (-0.8) | (-2.4) | (-3.2) | (5.4) | (2.4) | (-5.4) |
| 34 | 3.259 | 0.324 | -0.21 | 0.22 | 0.78 | 0.132 | 0.167 | 0.167 | -0.01 | 0.075 | -0.06 | -0.16 | 0.031 | 0.060 | -0.031 |
| | (13) | (0.5) | (-0.2) | (2.2) | (8.3) | (1.2) | (5.4) | (5.4) | (-0.4) | (0.3) | (-1.4) | (-5.4) | (4.0) | (1.4) | (-4.0) |
| 35 | 2.419 | 2.543 | -0.56 | 0.30 | 0.70 | -0.18 | 0.086 | 0.086 | 0.036 | 0.027 | -0.05 | -0.08 | 0.021 | 0.054 | -0.021 |
| | (12) | (5.7) | (-0.5) | (4.2) | (10) | (-2.8) | (3.5) | (3.5) | (0.1) | (0.1) | (-1.6) | (-3.5) | (3.4) | (1.6) | (-3.43) |
| 36 | 0.582 | 5.707 | -5.09 | 0.30 | 0.70 | -0.69 | 0.079 | 0.079 | -0.12 | 0.777 | -0.03 | -0.07 | 0.014 | 0.038 | -0.014 |
| | (1.1) | (5.6) | (-3.8) | (3.7) | (8.7) | (-4.4) | (3.1) | (3.1) | (-3.4) | (3.6) | (-1.2) | (-3.1) | (3.0) | (1.2) | (-3.0) |
| 37 | 1.562 | 3.072 | -0.03 | 0.62 | 0.38 | -0.22 | 0.103 | 0.103 | 0.030 | 0.028 | -0.23 | -0.10 | 0.051 | 0.239 | -0.051 |
| | (1.4) | (0.9) | (-0.7) | (5.3) | (3.3) | (-0.4) | (2.9) | (2.9) | (0.2) | (0.3) | (-5.1) | (-2.9) | (6.8) | (5.1) | (-6.8) |
| 38 | 2.332 | 3.414 | -2.39 | 0.40 | 0.60 | -0.29 | 0.084 | 0.084 | -0.05 | 0.342 | -0.05 | -0.08 | 0.023 | 0.052 | -0.023 |
| | (7.3) | (4.4) | (-1.5) | (5.2) | (8.0) | (-2.5) | (4.6) | (4.6) | (-0.8) | (1.1) | (-1.2) | (-4.6) | (2.5) | (1.2) | (-2.5) |
| 39 | 1.809 | 1.629 | -0.33 | 0.40 | 0.60 | (*) | 0.026 | 0.026 | (*) | (*) | 0.077 | -0.02 | (*) | -0.07 | (*) |
| * | (7.2) | (9.0) | (-6.0) | (6.7) | (10) | | (1.3) | (1.3) | | | (0.4) | (-1.3) | | (-0.4) | |
| 20- | 5.560 | -1.61 | 1.04 | 1.27 | 0.87 | -0.23 | 0.155 | 0.155 | 0.010 | 0.128 | 0.020 | -0.15 | 0.004 | -0.02 | - |
| 39 | (6.94) | (-1.6) | (1.5) | (1.6) | (11.4) | (-2.4) | (4.68) | (4.68) | (1.71) | (2.93) | (0.31) | (-4.6) | (0.09) | (-0.3) | 0.0042 |
| | | | | | | | | | | | | | | | (-0.09) |

Note: The numbers in the brackets indicating the t-statistic. Note:(*) The parameters in sector (32) are not presented due to the convexity restrictions, while the parameters in sector (39) by definition there is no technical change in the 39 sector (miscellaneous).According to the ISIC classification, we have the branches (the brackets show the categories): (20) food, (21) beverages, (22) tobacco, (23) textiles, (24) footwear and wearing apparel, (25) wood and cork, (26) furniture,

(27) paper, (28) printing -publishing, (28) leather, (30) rubber and plastic products, (31) chemicals, (32) petroleum,

(33) non-metallic mineral products, (34) basic metal industry, (35) metal products, (36) machinery & appliances

(37) electrical supplies, (38) transport equipment (39) miscellaneous industry.

**Table 2.2**
**Substitution, price elasticities, technical change and scales:(1959-1990)**

| | $\sigma_{LL}$ | $\sigma_{KK}$ | $\sigma_{KL}$ | $P_{LL}$ | $P_{KK}$ | $P_{LK}$ | $P_{KL}$ | c/l | TCH1 | TCH2 | TCH3 | MFP | Scale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Foodstuffs (20) | -0.839 | -1.101 | 0.957 | -0.44 | -0.51 | 0.44 | 0.51 | c.u | -0.812 | -0.00058 | 0.745 | -0.0679 | 0.858 |
| Beverages (21) | -4.222 | -0.184 | 0.875 | -0.72 | -0.15 | 0.72 | 0.15 | c.u | -1.385 | 0.017460 | 1.233 | -0.1348 | 0.655 |
| Tobacco (22): | -1.699 | -0.102 | 0.412 | -0.33 | -0.08 | 0.33 | 0.08 | c.u | -0.450 | 0.010289 | 0.383 | -0.0561 | 0.724 |
| Textiles (23): | -1.077 | -0.963 | 1.014 | -0.52 | -0.49 | 0.52 | 0.49 | c.s | -0.518 | 0.008332 | 0.480 | -0.0299 | 1.545 |
| Footwear & wearing (24): | -0.267 | -1.177 | 0.554 | -0.22 | -0.28 | 0.22 | 0.28 | c.u | -0.668 | -0.00399 | 0.600 | -0.0721 | 1.182 |
| Wood & cork (25) | -0.299 | -1.228 | 0.596 | -0.17 | -0.37 | 0.17 | 0.37 | c.u | -0.305 | -0.00866 | 0.301 | -0.0124 | 1.298 |
| Furniture (26): | -0.278 | -2.207 | 0.777 | -0.20 | -0.57 | 0.20 | 0.57 | c.u | 0.0994 | -0.02033 | -0.13 | -0.0533 | 0.964 |
| Paper (27): | -0.347 | -0.639 | 0.459 | -0.19 | -0.26 | 0.19 | 0.26 | c.u | 0.2635 | 0.008485 | -0.30 | -0.0361 | 1.501 |
| Printing-publishing (28) | -0.676 | -0.483 | 0.564 | -0.30 | -0.25 | 0.30 | 0.25 | c.u | 0.4473 | 0.000461 | -0.43 | 0.00994 | 1.366 |
| Leather (29): | -0.285 | -1.855 | 0.723 | -0.20 | -0.51 | 0.20 | 0.51 | c.u | 0.3845 | -0.00143 | -0.45 | -0.0751 | 2.076 |
| Rubber & plastics (30): | -0.416 | -0.645 | 0.508 | -0.22 | -0.28 | 0.22 | 0.28 | c.u | -0.344 | 0.001361 | 0.276 | -0.0667 | 0.644 |
| Chemical (31) | -1.383 | -0.427 | 0.731 | -0.46 | -0.26 | 0.46 | 0.26 | c.u | -0.248 | 0.001290 | 0.272 | 0.02507 | 4.445 |
| Petroleum (32) | -2.631 | -0.403 | 1.000 | -0.17 | -0.28 | 0.17 | 0.28 | c.s | -2.133 | 0.058802 | 2.048 | -0.0255 | 0.209 |
| Non-Metallic products (33): | -0.697 | -0.904 | 0.789 | -0.36 | -0.42 | 0.36 | 0.42 | c.u | 0.6072 | 0.009445 | -0.66 | -0.0498 | 0.941 |
| Basic metal industries (34): | -0.307 | -0.129 | 0.189 | -0.11 | -0.07 | 0.11 | 0.07 | c.u | -0.1874 | 0.023929 | 0.264 | 0.10102 | 1.579 |
| Metal products (35): | -0.587 | -0.738 | 0.653 | -0.30 | -0.34 | 0.30 | 0.34 | c.u | -0.1273 | -0.00067 | 0.0916 | -0.0363 | 1.228 |
| Machinery & appliances (36): | -0.486 | -0.952 | 0.672 | -0.28 | -0.39 | 0.28 | 0.39 | c.u | -2.7787 | 0.001201 | 2.7022 | -0.075 | 1.986 |
| Electrical supplies (37): | -1.070 | -0.275 | 0.529 | -0.34 | -0.17 | 0.34 | 0.17 | c.u | -0.172 | 0.000704 | 0.0999 | -0.065 | 0.464 |
| Transport equipment (38) | -1.214 | -0.339 | 0.615 | -0.40 | -0.21 | 0.40 | 0.21 | c.u | -1.1805 | 0.008928 | 1.1000 | -0.071 | 3.947 |
| Miscellaneous Manuf/ind. (39) | -0.634 | -1.265 | 0.890 | -0.36 | -0.52 | 0.36 | 0.52 | c.u | (*) | (*) | (*) | (*) | 1.582 |
| All manufacturing: | -0.285 | -0.385 | 0.309 | -0.14 | -0.16 | 0.14 | 0.16 | c.u | -0.126 | 0.0009419 | 0.12283 | -0.00227 | 0.8977 |

Note: $\sigma_{LL}$, $\sigma_{KK}$, $\sigma_{KL}$ = indicate the substitution elasticities, $P_{LL}$, $P_{KK}$, $P_{KL}$= indicate the price elasticities, TCH1, TCH2, TCH3=indicate the technical change, MFP, Scale= indicate the multifactor productivity and scale, respectively. Finally, c/l= indicate the capital-labor saving (where c.u. is the capital-using (or labor saving)); according to David and Van De Klundert, (1965) the technical progress is capital-saving if and only if the elasticity of substitution between capital and labor is less than unity in absolute values.

## Table 2.3

**Parameter estimations cross-section of translog-cost function in Greece 1959-1990**

| | $\alpha_0$ | $\alpha_Y$ | $A_{YY}$ | $\alpha_K$ | $\alpha_L$ | $\gamma_T$ | $\gamma_{KK}$ | $\gamma_{LL}$ | $\gamma_{TT}$ | $\gamma_{YT}$ | $\gamma_{KY}$ | $\gamma_{KL}$ | $\gamma_{KT}$ | $\gamma_{LY}$ | $\gamma_{LT}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 59 | 5.5 | -1.6 | 1.04 | 0.127 | 0.87 | -0.23 | 0.155 | 0.15 | 0.105 | 0.128 | 0.202 | -0.15 | 0.004 | -0.20 | -0.0042 |
| | (6.9) | (-1.6) | (1.5) | (1.67) | (11.4) | (-2.4) | (4.68) | (4.68) | (1.71) | (2.93) | (0.31) | (-4.6) | (0.09) | (-0.3) | (-0.09) |
| 60 | 5.40 | -1.15 | 0.608 | 0.125 | 0.874 | -0.24 | 0.143 | 0.143 | 0.101 | 0.124 | 0.57 | -0.14 | 0.006 | -0.05 | -0.0061 |
| | (6.7) | (-1.1) | (0.92) | (1.73) | (12) | (-2.6) | (5.06) | (5.06) | (1.84) | (2.88) | (1.03) | (-5.0) | (0.15) | (-1.0) | (-0.15) |
| 61 | 4.01 | 0.682 | -0.45 | 0.217 | 0.782 | -0.08 | 0.197 | 0.197 | -0.01 | 0.048 | -0.07 | -0.19 | -0.01 | 0.072 | 0.016 |
| | (5.3) | (1.02) | (-0.9) | (3.48) | (12) | (-0.7) | (5.83) | (5.83) | (-0.1) | (1.36) | (-1.1) | (-5.8) | (-0.4) | (1.19) | (0.438) |
| 62 | 4.18 | -0.27 | 0.268 | 0.239 | 0.760 | 0.033 | 0.227 | 0.227 | -0.09 | 0.031 | -0.10 | -0.22 | -0.01 | 0.108 | 0.019 |
| | (5.9) | (-0.4) | (0.68) | (4.16) | (13) | (0.35) | (10) | (10) | (-1.8) | (0.99) | (-2.5) | (-10) | (-0.6) | (2.55) | (0.64) |
| 63 | 3.89 | -0.17 | 0.132 | 0.171 | 0.828 | 0.059 | 0.177 | 0.177 | -0.01 | 0.055 | 0.021 | -0.17 | 0.028 | -0.02 | -0.028 |
| | (2.2) | (-0.8) | (0.10) | (1.9) | (9.4) | (0.39) | (6.57) | (6.57) | (-1.6) | (0.84) | (0.03) | (-6.5) | (0.81) | (-0.3) | (-0.819) |
| 64 | 3.72 | 0.49 | -0.38 | 0.122 | 0.877 | 0.010 | 0.159 | 0.159 | -0.08 | 0.061 | 0.047 | -0.15 | 0.051 | -0.04 | -0.051 |
| | (2.2) | (0.25) | (-0.3) | (1.34) | (9.63) | (0.07) | (6.14) | (6.14) | (-1.1) | (1.0) | (0.80) | (-6.1) | (1.48) | (-0.8) | (-1.48) |
| 65 | 5.214 | -0.77 | 0.221 | 0.086 | 0.913 | -0.12 | 0.142 | 0.142 | -0.02 | 0.102 | 0.092 | -0.14 | 0.075 | -0.09 | -0.075 |
| | (2.24) | (-0.3) | (0.17) | (0.67) | (7.04) | (-0.7) | (-5.1) | (5.1) | (0.32) | (1.55) | (1.28) | (-5.1) | (1.81) | (-1.2) | (-1.81) |
| 66 | 2.873 | 0.941 | -0.32 | -0.17 | 1.173 | 0.083 | 0.167 | 0.167 | -0.08 | 0.017 | 0.190 | -0.16 | 0.083 | -0.19 | -0.083 |
| | (1.44) | (0.48) | (-0.3) | (-1.7) | (12) | (0.56) | (9.92) | (9.92) | (-1.4) | (0.30) | (4.2) | (-9.9) | (2.9) | (-4.2) | (-2.97) |
| 67 | 2.644 | 1.652 | -0.73 | -0.04 | 1.045 | -0.04 | 0.178 | 0.178 | -0.01 | 0.030 | 0.123 | -0.17 | 0.032 | -0.12 | -0.032 |
| | (0.87) | (0.56) | (-0.5) | (-0.3) | (7.54) | (-0.2) | (5.46) | (5.46) | (-0.2) | (0.52) | (1.77) | (-5.4) | (0.87) | (-1.7) | (-0.87) |
| 68 | 3.124 | 1.202 | -0.51 | -0.06 | 1.069 | -0.07 | 0.182 | 0.182 | 0.002 | 0.030 | 0.142 | -0.18 | 0.013 | -0.14 | -0.013 |
| | (1.19) | (0.48) | (-0.4) | (-0.8) | (12) | (-0.5) | (10) | (10) | (0.03) | (0.66) | (3.63) | (-10) | (0.59) | (-3.6) | (-0.59) |
| 69 | 3.057 | 1.235 | -0.64 | 0.047 | 0.952 | -0.02 | 0.165 | 0.165 | -0.03 | 0.043 | 0.082 | -0.16 | 0.060 | -0.08 | -0.060 |
| | (0.74) | (0.32) | (-0.3) | (0.45) | (9.0) | (-0.1) | (8.4) | (8.4) | (-0.5) | (0.78) | (1.62) | (-8.4) | (2.46) | (-1.6) | (-2.46) |
| 70 | -5.47 | 8.003 | -3.21 | -0.04 | 1.041 | 0.137 | 0.129 | 0.129 | -0.05 | -0.02 | 0.173 | -0.12 | 0.023 | -0.17 | -0.0231 |
| | (-0.9) | (1.6) | (-1.5) | (-0.2) | (7.07) | (0.75) | (5.52) | (5.52) | (-0.9) | (-0.5) | (2.66) | (-5.5) | (0.85) | (-2.6) | (-0.85) |
| 71 | -2.24 | 5.343 | -2.03 | 0.126 | 0.873 | -0.43 | 0.205 | 0.205 | -0.01 | 0.029 | 0.075 | 0.126 | 0.034 | -0.07 | -0.0346 |
| | (-0.4) | (1.23) | (-1.1) | (0.78) | (5.42) | (-0.3) | (6.85) | (6.85) | (-0.3) | (0.6) | (1.04) | (0.78) | (1.55) | (-1.0) | (-1.55) |
| 72 | -9.60 | 11.19 | -4.25 | 0.407 | 0.592 | -0.04 | 0.245 | 0.245 | 0.031 | 0.013 | -0.39 | -0.24 | 0.054 | 0.039 | -0.0548 |
| | (-1.8) | (2.81) | (-2.8) | (1.88) | (2.74) | (-0.4) | (7.51) | (7.51) | (1.0) | (0.37) | (-0.4) | (-7.5) | (1.96) | (0.44) | (-1.96) |
| 73 | 16.99 | -8.05 | 2.658 | 0.017 | 0.982 | -0.15 | 0.161 | 0.161 | -0.09 | 0.060 | 0.140 | -0.16 | 0.020 | -0.14 | -0.0204 |
| | (1.70) | (-1.2) | (1.17) | (0.07) | (4.25) | (-0.6) | (4.74) | (4.74) | (-0.1) | (0.91) | (1.62) | (-4.7) | (0.73) | (-1.6) | (-0.73) |
| 74 | 2.149 | 1.699 | -0.56 | -0.23 | 1.233 | -0.03 | 0.152 | 0.152 | -0.09 | 0.046 | 0.226 | -0.15 | -0.05 | -0.22 | 0.00051 |
| | (0.21) | (0.26) | (-0.2) | (-1.1) | (6.3) | (-0.1) | (8.55) | (8.55) | (-1.8) | (0.62) | (3.59) | (-8.5) | (-0.1) | (-3.5) | (0.019) |
| 75 | 9.261 | -1.65 | 0.245 | -0.67 | 1.678 | -0.57 | 0.122 | 0.122 | -0.02 | 0.180 | 0.360 | -0.12 | -0.01 | -0.36 | 0.01719 |
| | (6.22) | (-0.2) | (0.11) | (-2.5) | (6.22) | (-1.7) | (4.9) | (4.9) | (-0.5) | (1.90) | (4.3) | (-4.9) | (-0.5) | (-4.3) | (0.57) |
| 76 | 49.11 | -22.6 | 5.89 | -0.08 | 1.089 | -1.28 | 0.154 | 0.154 | 0.014 | 0.314 | 0.168 | -0.15 | -0.0 | -0.16 | 0.1541 |
| | (2.81) | (-2.2) | (1.98) | (-0.2) | (3.26) | (-4.1) | (6.28) | (6.28) | (3.51) | (3.82) | (1.76) | (-6.2) | (-0.6) | (-1.7) | (6.28) |
| 77 | 15.98 | -5.78 | 1.57 | 0.350 | 0.649 | -0.05 | 0.209 | 0.209 | 0.006 | 0.014 | 0.038 | -0.20 | 0.006 | -0.03 | -0.0006 |
| | (1.37) | (-0.8) | (0.87) | (5.65) | (10) | (-0.6) | (53.2) | (53.2) | (1.11) | (0.60) | (2.28) | (-53) | (0.15) | (-2.2) | (-0.15) |
| 78 | 25.27 | -11.2 | 3.112 | 0.090 | 0.990 | 0.387 | 0.198 | 0.198 | -0.02 | -0.09 | 0.131 | -0.19 | -0.01 | -0.13 | 0.0188 |
| | (0.97) | (-0.8) | (0.86) | (0.02) | (2.30) | (0.69) | (6.59) | (6.59) | (-0.4) | (-0.7) | (1.24) | (-6.5) | (-0.8) | (-1.2) | (0.88) |
| 79 | -98.8 | 43.45 | -8.92 | -1.04 | 2.048 | 1.987 | 0.180 | 0.180 | -0.11 | -0.45 | 0.368 | -0.18 | 0.003 | -0.36 | -0.0003 |
| | (-0.8) | (0.82) | (-0.7) | (-0.8) | (1.73) | (2.23) | (3.64) | (3.64) | (-0.2) | (-2.2) | (1.35) | (-3.6) | (0.10) | (-1.3) | (-0.01) |
| 81 | -56 | 27.57 | -6.14 | -0.84 | 1.840 | -0.24 | 0.142 | 0.142 | -0.05 | 0.064 | 0.321 | -0.14 | 0.013 | -0.32 | -0.0012 |
| | (-3.5) | (3.94) | (-3.8) | (-1.3) | (3.02) | (-1.0) | (3.18) | (3.18) | (-2.0) | (1.42) | (2.50) | (-3.1) | (0.38) | (-2.5) | (-0.38) |
| 82 | -36.7 | 17.01 | -3.42 | -1.28 | 2.28 | 0.34 | 0.98 | 0.98 | -0.01 | -0.04 | 0.386 | -0.09 | 0.035 | -0.38 | -0.0355 |
| | (-1.5) | (1.7) | (-1.6) | (-2.1) | (3.8) | (0.9) | (2.37) | (2.37) | (-1.8) | (-0.6) | (3.19) | (-2.3) | (0.93) | (-3.1) | (-0.933) |
| 83 | -9.61 | 7.037 | -1.56 | -1.60 | 2.609 | -1.09 | 0.081 | 0.081 | 0.098 | 0.210 | 0.441 | -0.08 | 0.058 | -0.44 | -0.0581 |
| | (-0.3) | (0.54) | (-0.5) | (-3.2) | (5.29) | (-1.7) | 1.94 | 1.94 | (1.20) | (1.84) | (4.69) | (-1.9) | (1.92) | (-4.6) | (-1.9) |
| 84 | -51.7 | 22.76 | -4.50 | -1.33 | 2.336 | -0.51 | 0.110 | 0.110 | -0.02 | 0.114 | 0.369 | -0.11 | 0.069 | -0.36 | -0.0693 |
| | (-4.5) | (5.16) | (-5.1) | (-3.2) | (5.74) | (-2.1) | (3.91) | (3.91) | (-0.8) | (2.76) | (4.82) | (-3.9) | (2.14) | (-4.8) | (-2.14) |
| 85 | -124 | 51.15 | -10 | -2.41 | 3.413 | -1.49 | -0.01 | -0.01 | -0.01 | 0.305 | 0.544 | 0.011 | 0.026 | -0.54 | -0.0260 |
| | (-6.4) | (6.6) | (-6.4) | (-7.1) | (10) | (-2.9) | (-0.8) | (-0.8) | (-1.7) | (3.62) | (8.5) | (0.81 | (0.81) | (-8.5) | (-0.81) |
| 86 | -85.4 | 34.96 | -6.63 | -0.48 | 1.483 | -0.91 | 0.151 | 0.151 | 0.004 | 0.167 | 0.215 | -0.15 | 0.037 | -0.21 | -0.0377 |
| | (-5.7) | (6.41) | (-6.5) | (-1.0) | (3.12) | (-2.6) | (6.43) | (6.43) | (0.11) | (3.0) | (2.60) | (-6.4) | (1.0) | (-2.6) | (-1.02) |
| 87 | -61.3 | 25.5 | -4.77 | -0.63 | 1.633 | -1.33 | 0.163 | 0.163 | 0.092 | 0.223 | 0.249 | -0.16 | 0.038 | -0.24 | -0.0381 |
| | (-2.7) | (3.15) | (-3.1) | (-1.1) | (2.92) | (-2.7) | (4.7) | (4.7) | (1.39) | (2.90) | (2.64) | (-4.7) | (1.06) | (-2.6) | (-1.06) |
| 88 | -40.8 | 16.73 | -2.93 | -0.46 | 1.461 | -0.86 | 0.144 | 0.144 | 0.067 | 0.140 | 0.205 | -0.14 | 0.041 | -0.20 | -0.0410 |
| | (-1.8) | (2.20) | (-2.2) | (-0.7) | (2.24) | (-1.8) | (3.47) | (3.47) | (0.99) | (2.04) | (2.05) | (-3.4) | (1.20) | (-2.0) | (-1.20) |
| 89 | -22 | 9.64 | -1.61 | -0.59 | 1.598 | -0.60 | 0.117 | 0.117 | 0.038 | 0.098 | 0.219 | -0.11 | 0.035 | -0.21 | -0.0358 |
| | (-0.6) | (0.83) | (-0.8) | (-0.7) | (1.97) | (-1.1) | (2.30) | (2.30) | (0.47) | (1.26) | (1.83) | (-2.3) | (1.0) | (-1.8) | (-1.05) |
| 90 | 20.36 | -4.42 | 0.73 | -1.48 | 2.486 | -0.98 | 0.060 | 0.060 | 0.013 | 0.141 | 0.341 | -0.06 | 0.040 | -0.34 | -0.0402 |
| | (0.54) | (-0.3) | (0.37) | (-1.5) | (2.52) | (-1.8) | (1.07) | (1.07) | (1.85) | (1.86) | (2.42) | (-1.0) | (1.18) | (-2.4) | (-1.18) |

Note: The numbers in the brackets indicating the t-statistic. This analysis indicate all industries by each year, (the variables are weighted shares)

## Table 2.4
## Substitution & price elasticities, technical change and scale for period 1959-1990

| | $\sigma_{LL}$ | $\sigma_{KK}$ | $\sigma_{KL}$ | $P_{LL}$ | $P_{KK}$ | $P_{LK}$ | $P_{KL}$ | c/l | TCH1 | TCH2 | TCH3 | MFP | Scale |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1959 | -0.285 | -0.385 | 0.309 | -0.142 | -0.166 | 0.142 | 0.166 | c.s | -0.126 | 0.00094 | 0.128 | -0.00255 | 0.189 |
| 1960 | -0.409 | -0.411 | 0.368 | -0.185 | -0.187 | 0.181 | 0.187 | c.s | -0.138 | 0.00139 | 0.133 | -0.00352 | -2.995 |
| 1961 | 14.605 | -0.150 | 0.553 | -0.488 | -0.064 | 0.488 | 0.064 | c.s | -0.093 | -0.0037 | 0.066 | -0.03094 | -7.709 |
| 1962 | 5.8562 | -0.013 | 0.277 | -0.279 | 0.0027 | 0.279 | -0.0027 | c.s | -0.0697 | -0.0043 | 0.046 | -0.02797 | 3.108 |
| 1963 | -0.226 | -0.212 | 0.215 | -0.111 | -0.103 | 0.111 | 0.1038 | c.s | -0.0777 | 0.00573 | 0.078 | 0.006551 | 2.519 |
| 1964 | -0.371 | -0.286 | 0.294 | -0.157 | -0.137 | 0.157 | 0.137 | c.s | -0.0890 | 0.00957 | 0.094 | 0.015205 | 7.379 |
| 1965 | -0.461 | -0.379 | 0.375 | -0.196 | -0.178 | 0.196 | 0.178 | c.s | -0.1481 | 0.01151 | 0.173 | 0.036977 | -2.99 |
| 1966 | -0.276 | -0.273 | 0.256 | -0.128 | -0.127 | 0.128 | 0.127 | c.s | -0.0044 | 0.01364 | 0.032 | 0.041807 | 1.271 |
| 1967 | -0.265 | -0.220 | 0.224 | -5.039 | -4.194 | 4.270 | -0.117 | c.s | -0.0588 | 0.00567 | 0.058 | 0.005280 | 2.094 |
| 1968 | -0.190 | -0.189 | 0.183 | -0.092 | -0.090 | 0.092 | 0.0902 | c.s | -0.0679 | 0.00225 | 0.061 | -0.00351 | 1.713 |
| 1969 | -0.245 | -0.247 | 0.242 | -0.123 | -0.118 | 0.089 | 0.0882 | c.s | -0.0694 | 0.01020 | 0.097 | 0.038471 | 2.057 |
| 1970 | -0.524 | -0.355 | 0.398 | -0.212 | -0.180 | 0.218 | 0.180 | c.s | 0.07531 | 0.00316 | -0.06 | 0.009342 | -35.9 |
| 1971 | 0.0462 | -0.082 | 0.058 | -0.019 | -0.038 | 0.019 | 0.038 | c.s | -0.0613 | 0.00384 | 0.076 | 0.018688 | 1.933 |
| 1972 | 0.231 | 0.0714 | -0.08 | 0.058 | 0.0311 | -0.05 | -0.03 | c.s | -0.0168 | 0.00488 | 0.036 | 0.024108 | 0.149 |
| 1973 | -0.38 | -0.224 | 0.260 | -0.14 | -0.113 | 0.146 | 0.113 | c.s | -0.1671 | 0.00173 | 0.182 | 0.017306 | -0.87 |
| 1974 | -0.45 | -0.276 | 0.308 | -0.17 | -0.135 | 0.173 | 0.135 | c.s | -0.1391 | -0.0002 | 0.151 | 0.012476 | 2.613 |
| 1975 | -0.61 | -0.466 | 0.455 | -0.24 | -0.210 | 0.245 | 0.210 | c.s | -0.6081 | -0.0004 | 0.598 | -0.01030 | 0.319 |
| 1976 | -0.39 | -0.319 | 0.321 | -0.16 | -0.153 | 0.168 | 0.153 | c.s | -1.1302 | -0.0002 | 1.112 | -0.01809 | -0.54 |
| 1977 | -0.02 | -0.081 | 0.067 | -0.02 | -0.038 | 0.028 | 0.038 | c.s | -0.0520 | 0.00005 | 0.052 | 0.000384 | 0.518 |
| 1978 | -0.03 | -0.136 | 0.124 | -0.05 | -0.067 | 0.057 | 0.067 | c.s | 0.38514 | -0.0001 | -0.38 | 0.000020 | -2.76 |
| 1979 | -0.29 | -0.20 | 0.229 | -0.12 | -0.103 | 0.125 | 0.103 | c.s | 1.97499 | -0.0006 | -1.96 | 0.011265 | -0.31 |
| 1981 | -0.45 | -0.39 | 0.385 | -0.20 | -0.183 | 0.201 | 0.183 | c.s | -0.2967 | -0.0011 | 0.291 | -0.00613 | 0.152 |
| 1982 | -0.51 | -0.80 | 0.559 | -0.25 | -0.305 | 0.254 | 0.305 | c.s | 0.22542 | -0.0039 | -0.20 | 0.019652 | 5.761 |
| 1983 | -0.69 | -0.80 | 0.639 | -0.31 | -0.324 | 0.314 | 0.324 | c.s | -0.9872 | -0.0007 | 1.101 | 0.022614 | -0.49 |
| 1984 | -0.53 | -0.54 | 0.488 | -0.24 | -0.248 | 0.240 | 0.248 | c.s | -0.5470 | -0.0008 | 0.576 | 0.021308 | 0.932 |
| 1985 | -1.08 | -1.69 | 1.054 | -0.49 | -0.558 | 0.496 | 0.558 | c.s | -1.6270 | -0.0040 | 1.593 | -0.03803 | 0.008 |
| 1986 | -0.41 | -0.28 | 0.331 | -0.17 | -0.153 | 0.178 | 0.153 | c.s | -0.9117 | -0.0052 | 0.908 | -0.00870 | -0.10 |
| 1987 | -0.35 | -0.25 | 0.283 | -0.15 | -0.132 | 0.150 | 0.132 | c.s | -1.2344 | -0.0058 | 1.245 | 0.005730 | 0.149 |
| 1988 | -0.47 | -0.35 | 0.011 | -0.19 | -0.167 | 0.193 | 0.167 | c.s | -0.7942 | -0.0068 | 0.812 | 0.011590 | -0.851 |
| 1989 | -0.63 | -0.48 | 0.488 | -0.26 | -0.227 | 0.260 | 0.227 | c.s | -0.5666 | -0.0064 | 0.587 | 0.014652 | 0.705 |
| 1990 | -0.84 | -0.84 | 0.739 | -0.37 | -0.366 | 0.372 | 0.366 | c.s | -0.8402 | -0.0008 | 0.865 | 0.016348 | 2.812 |

Note: $\sigma_{LL}$, $\sigma_{KK}$, $\sigma_{KL}$= indicate the substitution elasticities, $P_{LL}$, $P_{KK}$, $P_{KL}$=indicate the price elasticities, TCH1, TCH2, TCH3=indicate the technical change, MFP, Scale = indicating the multifactor productivity and scale, respectively. Finally, c/l = indicate the capital-labor saving (where c.u. is the capital-using (or labor saving)); according to David and Van De Klundert, (1965) the technical progress is capital-saving if and only if the elasticity of substitution between capital and labor is less than unity in absolute values.

**Table 2.5**
**Comparison of the elasticities of substitutions**

| ISIC: | $\sigma_{KL}$ | $\sigma_{KL}$ (1) | $\sigma_{KL}$ (2) | $\sigma_{KL}$ (3) | $\sigma_{KL}$ (4) |
|---|---|---|---|---|---|
| Foodstuffs (20): | 0.957 | 0.944 | 0.460 | 0.663 | -10.11 |
| Beverages (21): | 0.875 | 0.877 | 0.745 | 0.503 | 2.457 |
| Tobacco (22): | 0.412 | 0.676 | 0.990 | 0.462 | 2.278 |
| Textiles (23): | 1.014 | 0.162 | 0.592 | 1.279 | 1.420 |
| Footwear and wearing(24): | 0.554 | 0.635 | 0.753 | 0.012 | 1.277 |
| Wood and cork (25) | 0.596 | 0.448 | 0.981 | 0.350 | 2.899 |
| Furniture (26): | 0.777 | 1.017 | 0.545 | 0.246 | 200.0 |
| Paper (27): | 0.459 | 0.851 | —— | —— | 1.852 |
| Printing-publishing (28) | 0.564 | —— | 0.177 | —— | 1.656 |
| Leather (29): | 0.723 | 0.852 | 0.625 | 0.775 | 1.855 |
| Rubber & plastics(30): | 0.508 | 0.855 | 0.772 | 0.588 | 1.608 |
| Chemicals (31) | 0.731 | 0.885 | —— | —— | 3.953 |
| Petroleum (32) | 1.000 | 1.027 | 0.545 | 0.342 | 12.658 |
| Non-Metallic products (33): | 0.789 | —— | 0.421 | —— | 2.571 |
| Basic metal industry (34): | 0.189 | 1.002 | 0.464 | 0.532 | 15.873 |
| Metal products (35): | 0.653 | 0.440 | 0.558 | 1.425 | 3.922 |
| Machinery & appl.(36): | 0.672 | 0.719 | 0.401 | 0.220 | 1.751 |
| Electrical supplies (37): | 0.529 | 0.191 | 0.736 | 0.387 | -9.804 |
| Transport equipments (38) | 0.615 | 0.325 | 0.933 | —— | —— |
| Miscellaneous manf/ind (39) | 0.890 | —— | —— | —— | —— |

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## ENDNOTES

[1]The estimated period covers only the years from 1959 throughout to 1990, due to the restrictions on the available data-set and also due to the application of a new recalculation system since 1991.