CHAPTER VII

PRODUCTION FUNCTION IN INDIAN SUGAR INDUSTRY

Production function is an engineering relationship between inputs and outputs which shows for a given level of technology the maximum output which can be achieved with the application of given level of inputs. The production function analysis of an industry provides answers to i) Whether the industry in question enjoys the economies or diseconomies of scale; ii) whether firms purchase and utilise factor inputs in the most efficient way which helps in making inter-regional comparisons in resource allocations; iii) Whether returns on a particular factor input are increasing or decreasing so as to ascertain the desirability of subsidizing or taxing the particular input, and/ or iv) Whether there exists any substitution possibility between inputs.

The literature on production function generally covers the following forms:

a) Linear Production function.

b) Leontief fixed coefficient production function.

c) Cobb-Douglas production (C.D) function.

d) Constant Elasticity of substitution (CES)
Production Function.

e) Variable Elasticity of substitution (VES) Production Function.

The use of the first two functions is limited because of their concept of linearity of factors and fixed proportionality as their names themselves suggest. The Cobb-Douglas type of function makes output dependent on at least two productive factors, with both factors variables. It depicts constant returns to scale. Payment to each factor to its marginal product will exactly exhaust total output. The property of unitary elasticity of substitution in Cobb-Douglas production function means that provided factors are paid at the rate corresponding to their marginal products, factor shares will remain constant. The CES and VES production function do not assume any specific value for the elasticity of substitution, but the CES function takes the elasticity as a constant while the VES allows it to vary. Thus the elasticity of factor substitution determines the form of the production function. All these functions are characterised by a numerical value of the elasticity of factor substitution.

This chapter mainly analyses factor productivities, marginal productivities of capital and labour, relative factor shares, returns to scale, rate of neutral technological change and elasticity of substitution. This analysis is carried out for All

India, and six selected regions viz. Andhra Pradesh, Bihar Karnataka, Maharashtra, Tamil Nadu and Uttar Pradesh. The selection of these regions for the purpose of analysis is guided by availability of data on output and inputs in Annual survey of Industries and their contribution to total sugar production. These regions together contribute at an average of 86.48 per cent of total sugar production. The production functions have been fitted to the time series of aggregate data for the Indian Sugar industry during the period 1973-74 to 1990-91.

VES Production Function

It is worthwhile to find out by fitting the VES function derived by LU and Flectcher (1968) to the data, whether the industry is having variable elasticity of substitution between its factors of production (Capital and Labour) over the period under study or whether the elasticity of substitution is constant throughout the period of study or if it is having unitary elasticity of substitution. To test for the variability of the elasticity of substitution in the sugar industry both at All India and regional levels, we have fitted equation (1) with the time series data covering the period 1973-74 to 1990-91.

$$\text{Log } V/L = a + b \text{ Log } w + c \text{ Log } K/L + u \qquad (1)$$

Where

V = value added.

L = number of persons employed.

w = real wage rate.

K = capital stock adjusted for capacity utilisation at constant prices.

u = error term.

a,b and c are parameters to be estimated.

The expression for the elasticity of substitution 'σ' derived by LU and Flectcher from the production function is

$$\sigma = \frac{b}{1 - c\,(1 + WL/rK)} \qquad (2)$$

where 'b' and 'c' are parameters of the equation (1) WL/rK is the relative factor share which changes when K/L and wage rate vary disproportionately leading to variable elasticity of substitution. If c = 0, 'σ' will be equal to the coefficient 'b'. If b = 0, σ = 0[1].

The function (1) can be estimated by using the ordinary least squares (OLS) method. The regression results without time variable are presented in Table.1.

Considering the high values of R^2 and F the fit of the regression is good for All India and six selected regions under consideration. The total variations explained in the function for the regional and national levels range from 66 per cent in Bihar to 93 per cent in All India. The values of Durbin-Watson statistics indicate that there is no evidence for auto correlation in general.

TABLE 7.1

VES PRODUCTION FUNCTION
[1973-74 TO 1990-91]

Log V/L = a + b Log W + c Log K/L + u

Region	Regression Coefficient: Constant a	Regression Coefficient: Wage Rate b	Regression Coefficient: K/L c	R^2	F	D.W
All India	0.44	1.281* (0.255)	0.061 (0.147)	0.93	99.82	1.58
Andhra Pradesh	0.46	1.256* (0.220)	0.125 (0.159)	0.90	71.05	1.44
Bihar	0.13	0.698 (0.421)	0.135 (0.272)	0.66	14.30	2.49
Karnataka	0.67	1.634* (0.237)	0.006 (0.189)	0.93	92.84	1.77
Maharashtra	-0.59	1.172* (0.621)	0.241 (0.357)	0.67	15.50	1.92
Tamil Nadu	-0.65	1.483* (0.404)	0.241 (0.212)	0.86	44.72	1.12
Uttar Pradesh	-0.03	-0.042 (0.312)	0.665* (0.165)	0.86	47.93	1.33

* Indicates coefficients are significantly different from zero at 5 per cent level.

D.W statistics indicates there is no auto correlation at 1 per cent level.

Figures in brackets are standard error.

Table 7.1 clearly shows that 'b' is not significantly different from zero in Bihar and Uttar Pradesh. This indicates that σ appears to be zero from equation (2). Further 'c' is not significantly different from zero for All India and other regions except in Uttar Pradesh. This implies that $\sigma =$ b from equation (2). Hence the elasticity of substitution is either zero or constant. This finding thus clearly rules out the possibility of variable elasticity of factor substitution in the Indian sugar industry both at the regional and national levels.

VES Production Function With Time in Sugar Industry

Variable elasticity of substitution production function of the following type has been fitted to the time series data for the sugar industry at the regional and national levels. A trend variable 't' has been added to the equation (1) to test for the neutral technological progress in the sugar industry.

$$\text{Log } V/L = a + b \text{ Log } w + c \text{ Log } K/L + dt + u \qquad (3)$$

Where

V = value added

L= number of persons employed, w = wage rate

K = real capital stock adjusted for capacity utilisation

t = time, u = error term

a,b,c and d are parameters to be estimated. The results are presented in Table 7.2.

TABLE 7.2

VES PRODUCTION FUNCTION WITH TIME
[1973-74 TO 1990-91]

Log V/L = a + b Log W + c Log K/L + dt + u

	Regression Coefficient						
Region	Constant a	Wage Rate b	K/L c	Time d	R^2	F	D.W
All India	0.67	1.280* (0.245)	0.440 (0.268)	-0.026 (0.015)	0.94	75.17	1.51
Andhra Pradesh	0.50	1.250* (0.228)	0.196 (0.252)	-0.004 (0.012)	0.91	44.68	1.41
Bihar	0.27	0.714 (0.434)	0.217 (0.337)	-0.009 (0.021)	0.66	9.09	2.44
Karnataka	0.75	1.636* (0.293)	0.152 (0.257)	-0.009 (0.011)	0.93	60.90	1.75
Maharashtra	-0.31	1.014 (0.637)	0.090 (0.723)	-0.036 (0.035)	0.70	10.78	2.23
Tamil Nadu	-0.61	1.511* (0.431)	0.163 (0.301)	-0.006 (0.012)	0.86	27.99	1.04
Uttar Pradesh	0.30	-0.024 (0.312)	0.963* (0.338)	-0.027 (0.027)	0.87	32.33	1.47

* Indicates coefficients are significantly different from zero at 5 per cent level.

D.W statistics indicates there is no auto correlation at 1 per cent level.

Figures in brackets are standard error.

The fit of the equation is good with significant 'F' values. The introduction of time variable does not change the pattern of estimates very much. The value of R^2 varied from 0.66 to 0.94. The coefficient of wage rate is positive but insignificant for Maharashtra. The coefficient of time is negative and insignificant. The coefficients of wage rate are not statistically significant in Bihar, Maharashtra and Uttar Pradesh. It is found that the coefficient of capital-labour ratio (c) is not statistically different from zero in all the regions except Uttar Pradesh indicating that the assumption changes in capital-labour may not influence the value of elasticity of substitution and thus VES production function model may not be quite applicable to the sugar industry for the calculation of elasticity of substitution. In all the regions and All India, the rate of neutral technological progress is found to be negative and insignificant[2].

CES Production Function

The CES function of the following form is fitted to the time-series data from 1973-74 to 1990-91 for the sugar industry at the regional and national levels to examine the value of the constant elasticity of factor substitution.

$$\text{Log } V/L = a + b \text{ Log } w + u \qquad (4)$$

where

V = value added

L = number of persons employed

w = real wage rate

u = error term

a and b are parameters to be estimated.

Equation (4) is a familiar SMAC function based on the assumption of constant returns to scale, prevalence of perfect competition both in the factor and product markets and profit maximisation. Further, it assumes that the wage rate and value added per labour are independent of capital stock. The estimate of 'b' gives the elasticity of substitution between capital and labour. The estimated results of equation (4) are presented in Table 7.3.

TABLE 7.3

CES PRODUCTION FUNCTION
[1973-74 TO 1990-91]

$$\text{Log } V/L = a + b \text{ Log } W + u$$

Region	Regression Coefficient		R^2	F	D.W
	Constant a	Wage Rate b			
All India	0.48	1.378* (0.295)	0.93	210.40	1.64
Andhra Pradesh	0.52	1.403* (0.267)	0.90	144.90	1.42
Bihar	0.16	0.895* (0.163)	0.65	29.58	2.55
Karnataka	0.68	1.639* (0.417)	0.93	198.10	1.77
Maharashtra	-0.69	1.346* (0.275)	0.66	31.62	1.93
Tamil Nadu	-0.73	1.668* (0.472)	0.85	93.51	1.12
Uttar Pradesh	-0.67	1.112* (0.174)	0.72	40.70	0.81#

* Indicates coefficients are not significantly different from unity at 5 per cent level.

# Indicates that the test for auto correlation is inconclusive at 1 per cent level.

Figures in brackets are standard error.

The fit of the equation is quite satisfactory with significant R^2 and F ratios. In the case of All India and Karnataka 93 per cent of the total variation in V/L has been explained by real wage rate. The value of the coefficient of determination (R^2) varied from 65 per cent to 93 per cent. The Durbin-Watson (D.W) statistics indicates the absence of the first degree auto correlation for all the selected regions except Uttar Pradesh and All India and it is inconclusive for the region Uttar Pradesh. The coefficients of wage rate are statistically significant and have positive sign for all the selected regions and All India during the study period. The coefficients of wage rate is much high in Tamil Nadu (1.668) and followed by Karnataka (1.639). The estimated coefficient of wage rate from the equation (4) is used to test the following hypothesis.

Null hypothesis : Elasticity of substitution between the factor inputs is unity.

Alternative hypothesis : Null hypothesis is false.

$$t^* = \frac{\hat{b} - 1}{S.E(\hat{b})}$$

The computed value of t^* is compared with the critical value of t 0.05 with n-k degree of freedom. If $t^* < t$, we can accept the null hypothesis. On the other hand If $t^* > t$, we can accept the alternative hypothesis. The values of t^* (Computed) and t (Table value at 5% level) are given below.

	t^*	t 0.05
All India	1.281	1.746
Andhra Pradesh	1.509	1.746
Bihar	-0.644	1.746
Karnataka	1.532	1.746
Maharashtra	1.258	1.746
Tamil Nadu	1.415	1.746
Uttar Pradesh	0.644	1.746

As $t^* < t$ 0.05 level of significance for 16 degrees of freedom for all the regions and All India, we may accept the null hypothesis. This shows that the elasticity of substitution between capital and labour is unity in all the selected regions and All India. In the above circumstances, a Cobb-Douglas type of production function is the one where the choice lies for the industry in the selected regions and All India.

Equation (4) does not measure the technical progress. Hence an exponential time trend has been incorporated in the following equation to account for and measure neutral technological change.

$$\text{Log } V/L = a + b \text{ Log } w + ct + u \qquad (5)$$

where

V = value added

L = number of persons employed

w = Real wage rate

t = time

u = error term

a,b and c are parameters.

The estimates of a,b and c have been obtained by the method of least squares. The estimates of the production function (5) are presented in Table 7.4.

TABLE 7.4

CES PRODUCTION FUNCTION WITH TIME
[1973-74 TO 1990-91]

$$\text{Log } V/L = a + b \text{ Log } W + ct + u$$

Region	Regression Coefficient			R^2	F	D.W
	Constant a	Wage Rate b	Time c			
All India	0.56	1.460*	-0.004	0.93	100.10	1.68
		(0.202)	(0.008)			
Andhra Pradesh	0.47	1.358*	0.003	0.90	68.50	1.45
		(0.179)	(0.008)			
Bihar	0.19	0.915*	-0.002	0.65	13.89	2.54
		(0.298)	(0.017)			
Karnataka	0.77	1.724*	-0.005	0.93	95.34	1.75
		(0.482)	(0.781)			
Maharashtra	-0.70	1.517*	0.001	0.66	14.83	1.93
		(0.503)	(0.017)			
Tamil Nadu	-0.73	1.619*	0.002	0.85	43.91	1.12#
		(0.372)	(0.012)			
Uttar Pradesh	-0.74	0.328	0.040*	0.80	30.14	1.18#
		(0.350)	(0.016)			

* Indicates coefficients are not significantly different from unity at 5 per cent level.

# Indicates the test is inconclusive at 1 per cent level.
Figures in brackets are standard error.

The total variance explained in equation(4) and equation(5) are more or less same ranging from 65 per cent to 93 per cent. (See Tables 7.3 and 7.4). Wage rate elasticities of average productivity(b) are not significantly different from unity at 5 per cent level. The neutral time trend(c) shows low and positive values in Andhra Pradesh, Maharashtra, Tamil Nadu and Uttar Pradesh. It is negative in the remaining regions and All India. The coefficient of time trend variables are also not statistically significant expect for the region Uttar Pradesh. The value of Durbin-Watson (D.W) indicates that there is no auto correlation at 1 percent level for the first five functions. It is found that the elasticity of substitution between capital and labour is unity in all the selected regions except Uttar Pradesh and All India.

As the Cobb-Douglas production function is characterised by unit elasticity of factor substitution one may infer that there is an evidence of Cobb-Douglas production function for the sugar industry in the selected regions and All India.

By and large, the coefficient of time trend variable is statistically insignificant at 5 per cent level. This clearly shows that there is no evidence for the neutral technical progress for the industry at the regional and national levels during the period under study.

Cobb - Douglas Production Function

Consider the Cobb-Douglas production function

$$V = A\ L^{a}\ K^{b}\ e^{ct} \qquad (6)$$

where

V= value added

L = number of persons employed

K = Adjusted fixed capital

T = Time variable

C = coefficient of time variable

a and b are partial elasticities of output with respect to labour and capital respectively.

For the purpose of finding out the estimates of input elasticities, neutral technical progress and returns to scale, Cobb-Douglas production function in log linear form is used. Its log transformation is specified below.

$$\text{Log } V = A + a \log L + b \log k + ct + u \qquad (7)$$

The estimates of A,a,b and c have been obtained by the method of ordinary least squares. The estimates of the parameters of the production function for All India and six selected regions are tabulated in Table 7.5.

TABLE 7.5

UNCONSTRAINED FORM OF COBB-DOUGLAS PRODUCTION FUNCTION WITH TIME [1973-74 TO 1990-91]

$$\text{Log } V = A + a \text{ Log } L + b \text{ Log } K + ct + u$$

Region	Regression Coefficient				R^2	F	D.W
	Constant A	Labour a	Capital b	Time c			
All India	-0.48	1.238* (0.489)	0.140 (0.319)	-0.002 (0.021)	0.84	24.59	1.32
Andhra Pradesh	-0.61	1.925* (0.501)	0.293 (0.289)	-0.019 (0.019)	0.80	18.86	1.55
Bihar	0.57	1.117* (0.617)	0.342 (0.371)	-0.023 (0.021)	0.28	1.77	2.37
Karnataka	0.55	1.009* (0.511)	-0.369 (0.339)	0.034 (0.018)	0.75	14.05	1.79
Maharashtra	-0.03	1.235** (0.776)	0.015 (0.621)	0.004 (0.036)	0.64	8.31	1.67
Tamil Nadu	0.90	0.196 (0.930)	-0.209 (0.268)	0.056* (0.021)	0.80	18.36	1.22
Uttar Pradesh	0.80	0.122 (0.359)	0.419 (0.284)	0.006 (0.021)	0.81	20.51	1.36

* Indicates coefficients are significant at 5 per cent level.

** Indicates that corresponding coefficient is significant at 10 per cent level.

D.W statistics indicates there is no auto correlation at 1 per cent level.

Figures in brackets are standard error.

The goodness of fit (R^2) for the regression equations corresponding to All India and six regions is found to be a low of 28 per cent for Bihar and a high of 84 per cent for All India. The value of Durbin-Watson (D.W) statistic indicates that there is no auto correlation for all the regression equations corresponding to All India and six selected regions. From Table 7.5 it may be observed that the coefficients of capital (b) are insignificant for all the regression equations corresponding to All India and six regions. It is also negative for the regions of Karnataka and Tamil Nadu. The insignificant capital coefficient implies that the effect of capital on output is insignificant. The negative value of capital coefficient is economically meaningless because this shows that the marginal product of capital is negative which is practically inconceivable. In the estimates of equation(7) the coefficient of labour is insignificant for the regression equations corresponding to Tamil Nadu and Uttar Pradesh. Elasticity of output with respect to labour is found to be statistically significant at 5 per cent level for All India, Andhra Pradesh, Bihar and Karnataka and at 10 per cent level for Maharashtra. From Table 7.5 it is evident that the coefficient of time trend is insignificant for the regression equations corresponding to All India, Andhra Pradesh and Bihar. It is positive but insignificant for the regions of Karnataka, Maharashtra and Uttar Pradesh. Coefficient of time trend is significant only for the region Tamil Nadu. This shows that there can be significant technological growth in the sugar industry in Tamil Nadu during the study period (1973-74 to 1990-91). Since the time trend which is to measure technical progress itself is insignificant except the region Tamil Nadu, the Cobb-Douglas production function without time trend is considered to be the best fit. It leads to the inference that there had been no technical progress in the industry during the study period (1973-74 to 1990-91). The negative and insignificant values of the coefficient of capital may be due to multicollinearity problem, since the independent variables are highly correlated.

In the estimates of equation (7) the coefficient of time trend is negative and insignificant, hence time variable is dropped from the equation (7). Therefore the following Cobb-Douglas production function is fitted to know the elasticities of output with respect to labour and capital and returns to scale.

$$V = A\ L^a\ K^b \qquad (8)$$

when transformed into Log form

$$\text{Log } V = A + a \text{ Log } L + b \text{ Log } K + u \qquad (9)$$

where

V = value added

L = number of persons employed

K = Adjusted fixed capital stock

u = error term.

The estimates of A, a and b have been obtained by using the method of ordinary least squares (OLS). The estimates are given in Table 7.6.

TABLE 7.6

UNCONSTRAINED FORM OF COBB-DOUGLAS PRODUCTION FUNCTION [1973-74 TO 1990-91]

$$\text{Log } V = A + a \text{ Log } L + b \text{ Log } K + u$$

Region	Regression Coefficient			R^2	F	D.W
	Constant A	Labour a	Capital b			
All India	-0.42	1.222* (0.421)	0.121 (0.192)	0.84	39.50	1.33
Andhra Pradesh	-0.23	1.570* (0.354)	0.070 (0.184)	0.79	27.77	1.51
Bihar	0.32	0.858** (0.573)	0.029 (0.237)	0.21	2.04	2.45
Karnataka	-0.02	1.505* (0.479)	0.002 (0.301)	0.69	16.34	1.20
Maharashtra	-0.13	1.263* (0.714)	0.069 (0.411)	0.64	13.33	1.67
Tamil Nadu	-0.37	1.776* (0.819)	0.074 (0.287)	0.70	17.62	0.88#
Uttar Pradesh	0.69	0.148 (0.336)	0.486* (0.143)	0.82	32.75	1.33

* Indicates coefficients are significant at 5 per cent level.

** Indicates that corresponding coefficient is significant at 10 per cent level.

# Indicates that the test is inconclusive at 1 per cent level.
Figures in brackets are standard error.

After dropping the time trend variable from the equation (7), the value of R^2 does not change very much. The value of F has increased for All India and other selected regions expect Tamil Nadu. The value of Durbin-Watson statistic indicates that there is no auto correlation at 1 percent level for all the regression equations except the sixth equation.

From Table 7.6, the elasticity of output with respect to labour is found to be statistically significant at 5 percent level for the regression equations corresponding to All India, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu and at 10 per cent level for Bihar. Elasticity of output with respect to labour is statistically insignificant for the region Uttar Pradesh. It is evident from Table 7.6 We notice that labour elasticity of output is the highest in Tamil Nadu and lowest in Uttar Pradesh. The labour elasticity of output coefficient in Tamil Nadu is 1.776 and it is 0.148 for Uttar Pradesh. The labour elasticity of output is greater than one i.e., 1.222, 1.570, 1.505, 1.263 and 1.776 in All India, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu respectively.

Regarding the capital elasticity of output, the coefficient is statistically significant for the region Uttar Pradesh only. The coefficients of capital are statistically insignificant and low for All India and other remaining regions.
The coefficient of capital is the lowest for Karnataka i.e. 0.002.

Regarding the capital elasticity of output, Uttar Pradesh comes first. Further, except Uttar Pradesh, All India and in the remaining regions labour elasticity of output is greater than the capital elasticity of output.

The low value of coefficient of capital in Table 7.6 may arise due to the cumulative effect of the following factors:

(a) The deepening of capital has decreased the value of coefficient of capital. During the study period the real capital stock in this industry had increased at an annual compound rate of 8.2, 5.0, 7.5, 4.3, 7.6, 6.4 and 11.1 per cent in All India, Andhra Pradesh, Bihar, Karnataka, Maharashtra, Tamil Nadu and Uttar Pradesh respectively (See Appendix Table A.9). This has also been pointed out by Mehta[6], Asit Banerjee[7] and Sastry[8]. Variations in relative prices and changes in the industrial structure have been responsible for increasing capital deepening.

(b) Entry of large number of new industrial units, the full capacity utilisation of which is yet to be achieved.

(c) Existence of a large number of uneconomic units which are carrying on production with worn out machineries. Plant and machinery are relatively old and out-moded in Uttar Pradesh and Bihar compared to other regions under study[9]. This may be the cause for low value of capital coefficient.

(d) The low value of capital coefficient may be due to multicollinearity and measurement errors in the capital input.

Returns to Scale

In the Cobb-Douglas production function the sum of factor elasticities gives an indication of returns to scale. The sum of (a+b) has been statistically tested by using 'F' test so as to find its deviation from unity. In other words we want to test the hypothesis

HN : $a + b = 1$ against the alternative hypothesis.

HA : $a + b \neq 1$

The hypothesis may be tested with an F ratio as suggested by R. Tinter[10] as follows:

$$F^* = \frac{\Sigma e_2^2 - \Sigma e_1^2}{\Sigma e_1^2} (n-k) \qquad (10)$$

where

F^* = computed value of F

Σe_1^2 = sum of squared residuals from the unrestricted function

Σe_2^2 = Sum of squared residuals from the restricted function

F distribution with $V_1 = 1$ and $V_2 = n-k$ degrees of freedom.

The computed value of F^* is compared with the theoretical (tabular) value of $F_{0.05}$ with $V_1 = 1$ and $V_2 = (n-k)$ degrees of freedom.

If $F^* > F_{0.05}$ we reject our basic hypothesis that is, we accept that $a + b \neq 1$.

The computed value of F^* and table value of $F_{0.05}$ are given below:

	F^*	$F_{0.05}$
All India	14.14	4.54
Andhra Pradesh	22.70	4.54
Bihar	1.03	4.54
Karnataka	9.31	4.54
Maharashtra	3.75	4.54
Tamil Nadu	7.22	4.54
Uttar Pradesh	3.95	4.54

As $F^* > F_{0.05}$ for 15 d.f for the region All India, Andhra Pradesh, Karnataka and Tamil Nadu and $F^* < F\ 0.05$ for the remaining regions. We may come to the conclusion that there is an indication of increasing returns to scale in All India, Andhra Pradesh, Karnataka and Tamil Nadu and constant returns to scale in other regions under investigation viz., Bihar, Maharashtra and Uttar Pradesh. The equation of Cobb-Douglas production function with constant returns to scale is

$$V = A\ L^a\ K^{1-a} \qquad (11)$$

The equation (11) has been transformed into

$$V/K = A\ (L/K)^{a} \qquad (12)$$

For empirical estimation this can be transformed with linear focus and log form

$$\text{Log } V/K = A + a \text{ Log } L/k + u \qquad (13)$$

where

V = value added

k = adjusted fixed capital stock

L = number of persons employed

A and a are parameters.

The equation (13) has been estimated by using ordinary least squares method for the regions Bihar, Maharashtra and Uttar Pradesh and the results are presented in Table 7.7.

TABLE 7.7

CONSTRAINED FORM OF COBB-DOUGLAS PRODUCTION FUNCTION

Log V = A + a Log L + (1-a) Log K + u

SAMPLE PERIOD [1973-74 TO 1990-91]

Region	Regression Coefficient			R^2	F	D.W
	Constant A	Labour a	Capital (1-a)			
Bihar	-0.04	0.450* (0.114)	0.550* (0.114)	0.49	15.52	2.26
Maharashtra	-0.23	0.159 (0.173)	0.841 (0.173)	0.05	0.84	1.74
Uttar Pradesh	-0.05	0.353* (0.062)	0.647* (0.062)	0.67	32.26	1.23

* Indicates coefficients are significant at 5 per cent level.

D.W. statistics indicates that there is no auto correlation at 1 per cent level.

Note: a + b = 1 for constrained form of the Cobb-Douglas Production function.

Since, b = 1 - a; S.E (1-a) = S.E(a) = S.E(b)

The total variations explained in the regression equation for Bihar and Uttar Pradesh by labour and capital are nearly 49 per cent and 67 per cent respectively. The fit of the regression for Maharashtra is very poor which is evident from low value of R^2 and F. i.e., 5 per cent and 0.84 respectively. The value of Durbin-Watson(DW) shows that there is no evidence for auto correlation for the regions Bihar, Maharashtra and Uttar Pradesh. The labour elasticities of output (a) are statistically significant for the regions Bihar and Uttar Pradesh. It is insignificant for Maharashtra. The capital elasticities of output(1-a) are statistically significant at 5 per cent level for Bihar, Maharashtra and Uttar Pradesh. Comparing Table 7.6 with 7.7, the elasticities of labour and capital vary strangely between Tables 7.6 and 7.7 for the regions Bihar, Maharashtra and Uttar Pradesh. For example, in Bihar when unconstrained form of Cobb-Douglas production function is used the coefficients of labour and capital are 0.858 and 0.029 respectively. When constrained form of the Cobb-Douglas production function is used, the elasticities of labour and capital in these regions have become 0.450 and 0.550 respectively. This change may be due to multicollinearity.

Marginal Productivity of Factors of Production

The concept of marginal product refers to the additions to output by a unit increment in any one input, ceteris paribus. The marginal products are useful in an inter temporal comparison of efficiency of inputs, their comparative utilisation and in the determination of the point of factor saturation[11]. Marginal productivity of a factor is variable over time. It varies directly with the corresponding variation in output-input ratio. Marginal productivities of labour and capital have been computed for each year during the period from 1973-74 to 1990-91 and the mean of marginal productivities of labour and capital is arrived at.

If the Cobb-Douglas production function is of the form $V = A L^a K^b$, then the marginal productivities of labour and capital can be arrived by differentiating partially the function V with respect to labour and capital. The marginal productivities of labour and capital are arrived as follows

$$\frac{\delta V}{\delta L} = MP_L = a \frac{V}{L} \qquad (14)$$

$$\frac{\delta V}{\delta K} = MP_K = b \frac{V}{K} \qquad (15)$$

where MP_L and MP_K are the marginal productivities of labour and capital respectively. On the other hand, if the Cobb-Douglas production function is of the form $V = A\ L^a\ K^{1-a}$, then the marginal productivities of labour and capital are:

$$\frac{\delta V}{\delta L} = MP_L = a\ \frac{V}{L} \qquad (16)$$

$$\frac{\delta V}{\delta K} = MP_K = (1-a)\ \frac{V}{K} \qquad (17)$$

From the estimated production function [equation (9) of Table 7.6] the values 'a' and 'b' and [equation (13) of Table 7.7] the values 'a' and '(1-a)' are substituted at each observation for the corresponding regions and All India separately for the period 1973-74 to 1990-91. Then the MP_L and MP_K have been computed at geometric mean for All India and six selected regions separately.

TABLE 7.8

MARGINAL PRODUCTIVITIES OF INPUT FACTORS

SAMPLE PERIOD [1973-74 TO 1990-91]

Region	M.P.L. (Average)	M.P.K. (Average)
All India	2.58	0.110
Andhra Pradesh	3.41	0.060
Bihar	0.83	1.070
Karnataka	3.92	0.002
Maharashtra	0.40	0.510
Tamil Nadu	5.25	0.090
Uttar Pradesh	0.64	0.780

From Table 7.8 we observe that the average marginal productivities of labour is larger than the average marginal productivities of capital for All India, Andhra Pradesh, Karnataka and Tamil Nadu. Whereas the average marginal productivities of capital is larger than average marginal productivities of labour for the remaining regions Viz., Bihar , Maharashtra and Uttar Pradesh. It is interesting to note that the average marginal productivity of labour is larger than All India average and the marginal productivity of capital is lower than All India average for the regions Andhra Pradesh, Karnataka and Tamil Nadu. In Bihar, Maharashtra and Uttar Pradesh the average marginal productivity of labour is lower than the All India average while the average marginal productivities of capital is larger than the All India average. The marginal productivities of labour is the highest in Tamil Nadu (5.25) followed by Karnataka(3.92), Andhra Pradesh (3.41), Bihar (0.83), Uttar Pradesh(0.64) and Maharashtra(0.40). The marginal productivity of capital is the lowest in Karnataka (0.002) and it is the highest in Bihar (1.07).

Sources of Output Growth

In the production function analysis, the coefficients of the variables are simply the partial elasticity of output with respect to factor inputs. They will not help us directly to find out the relative contribution of factors of production to output growth. Nevertheless, the data on inputs and output together with the coefficients of labour and capital could be used to quantify the relative contributions. This measure is important for policy determination. Following Subramaniyan (1986) the relative contribution of labour and capital can be determined as below:

$$R_L = \hat{a} \frac{\sum_{i=1}^{n} | \blacktriangle \log Li |}{\sum_{i=1}^{n} | \blacktriangle \log Vi |} \qquad (18)$$

$$R_K = \hat{b} \frac{\sum_{i=1}^{n} | \blacktriangle \log Ki |}{\sum_{i=1}^{n} | \blacktriangle \log Vi |} \qquad (19)$$

Where $\hat{a}$ and $\hat{b}$ are the estimates of labour and capital coefficients. Using the relations (18) and (19), the sources of output growth for the industry under study have been determined for all the regions separately and the results are given in Table 7.9.

TABLE 7.9

SOURCES OF OUTPUT GROWTH FOR THE SUGAR INDUSTRY IN ALL INDIA AND SELECTED REGIONS

[1973-74 TO 1990-91]

Region	Relative Contribution of Labour in percentage	Relative Contribution of Capital in percentage
All India	59	11
Andhra Pradesh	51	05
Bihar	21	51
Karnataka	57	01
Maharashtra	06	47
Tamil Nadu	63	10
Uttar Pradesh	22	66

Note: 100 - (RL+RK) represents the relative contribution of other factors.

From Table 7.9 it will be noticed that the relative contribution of labour to value added is higher than that of capital in All India, Andhra Pradesh, Karnataka and Tamil Nadu. It is also supported by ' factor elasticity ' and marginal productivity (See Tables 7.6,7.7 and 7.8) in these regions. It is also to be noted that the relative contribution of labour to value added is lower than that of capital in the remaining regions viz., Bihar, Maharashtra and Uttar Pradesh . Alternatively, The relative contribution of capital to the value added is higher than relative contribution of labour to the value added in Uttar Pradesh, Bihar and Maharashtra. $R_L + R_K$ gives the relative contribution of labour and capital to value added together. 100-(R_L+R_K) represents the percentage of contribution to value added by the other factors. From this it follows that ceteris paribus, increase in labour productivity is attributed to capital intensity in these regions.

As labour is relatively more efficient than capital, it suggests that the industry has the potentiality of absorbing labour force in these regions. In Andhra Pradesh, Karnataka and Tamil Nadu, we find $a > b$ which implies that in these regions labour is marginally more efficient than capital,while the reverse holds good in Bihar, Maharashtra, and Uttar Pradesh ($a < b$). Thus it follows, ceteris paribus, the labour productivity in sugar industry in the country as a whole is likely to go up in Andhra Pradesh, Karnataka, and Tamil Nadu are made more labour intensive and Bihar, Maharashtra and Uttar Pradesh are made capital intensive.

Conclusions

From the foregoing analysis we may derive the following conclusions which seem to be most relevant that could be taken as a guideline for the future expansion of the Indian sugar Industry.

The VES production function with and without time variable is estimated by using the ordinary least squares method. The elasticity of substitution between capital and labour is either zero or constant. Thus our findings clearly rule out the possibility of variable elasticity of factor substitution in the Indian Sugar Industry both at the regional and national levels. Further, there is no evidence for neutral technological progress over the study period.

The estimates of the elasticity of substitution between capital and labour based on logarithmic regressions of value added per labour on the wage rate and time for sugar industry corresponding to All India, and six selected regions covering the period 1973-74 to 1990-91 show that the elasticity of substitution between capital and labour is unity. Thus from our findings we may infer that there is an evidence of Cobb-Douglas production function for the sugar industry in the selected regions and All India. These results are comparable with Asit Banerjee (1975)[12] and Subramaniyan (1986)[13]. Banerjee finds that the elasticity of substitution between capital and labour is one for the period 1946-62. Results of this study are quite different from the ones obtained by Diwan and Gujarati (1968)[14] and Sankar (1970)[15]. The variation in the estimates of elasticity of substitution between capital and labour may be due to differences in period covered and data used. From the time trend coefficients we may infer that sugar industry as a whole has not benefited much from technological change during the study period. These results are comparable with those of Mehta (1976)[16].

The elasticity of substitution between capital and labour is unity which implies that the relevant form of production function at All India and six selected regions is the Cobb-Douglas one, for the sugar industry. From our findings, the labour elasticity of output is found to be a more important factor than capital in terms of 'factor elasticity', 'marginal productivity' and 'relative contribution' to the output growth in All India, Andhra Pradesh, Karnataka and Tamil Nadu. The labour elasticity of output is the highest in Tamil Nadu in terms of average marginal productivity (5.25) and relative contribution to output growth (63 per cent) followed by Karnataka (3.92 and 57 per cent) and Andhra Pradesh (3.41 and 51 per cent). Further increase in labour productivity in these regions is attributed to capital deepening. The capital elasticity of output is found to be more important factor than labour in terms of 'factor elasticity', marginal productivity and relative contribution to output growth in Bihar, Maharashtra, and Uttar Pradesh.

Finally, the estimated value of the degree of returns to scale parameter, as obtained by the sum of the coefficients of labour and capital turns out to be an increasing returns to scale in All India, Andhra Pradesh, Karnataka and Tamil Nadu and constant returns to scale in other regions under investigation, viz., Bihar, Maharashtra and Uttar Pradesh Mehta (1976)[17] has found the sum of the exponents of labour and capital in the Cobb-Douglas production function for the Indian Sugar Industry at the aggregate level was 0.77 for the period 1953-1965. Yeh (1966)[18] has shown that the returns to scale turns to be 0.79 for the industry at the aggregate level for the period 1953-1958. Sengupta (1965)[19] found evidence in favour of neutral technical change in this industry for the period of 1948-58. The average shares of labour and capital in this industry were 0.296 and 0.704. Diwan (1967)[20] has found out that the sum of the exponents of labour and capital was 1.68 for the industry at the aggregate level for the period 1953-58. On the basis of Cobb-Douglas production function Subramaniyan (1986) [21] has found an increasing returns to scale in All India and Tamil Nadu and constant returns to scale in Uttar Pradesh, Bihar , Maharashtra and Andhra Pradesh for the period 1953-1963. In our study it is found that Andhra Pradesh experienced an increasing returns to scale during the period 1973-74 to 1990-91. This shows that there is a shift from constant returns to scale to increasing returns to scale in Andhra Pradesh. It is also evidenced from the fact that in recent years increasing number of sugar industries are being established in south especially in Andhra Pradesh.

FOOTNOTES

1. LU, Y.C and Flectcher, L, " A Generalisation of the CES production function", **Review of Economics and Statistics**, Vol.50 No.4 1968 P.449.

2. Ferguson calls such cases as technological retrogression (Ferguson, CE., " Time-Series production function and technological progress in American Manufacturing Industry ", **Journal of Political Economy**, April 1965, P.300).

3. Gupta, G.S. and Kirit Patel, (1976) P. 315.

4. Asit Banerjee, (1975) P.118.

5. Mani.C and Sathyanarayana, E (1991) P. 263.

6. Mehta, S.S (1974) P.197.

7. Asit Banerjee, (1975) P. 116.

8. Sastry, V.S.R.K (1960) P. 70.

9. **Report of the Sugar Enquiry Commission** 1972 P.42.

10. Tinter, G. "**Econometrics**" , Newyork, Wiley, 1952 P. 90-1.

11. Point of factor saturation is attained when the factor yields a zero marginal product.

12. Asit Banerjee, (1975) P.116.

13. Subramaniyan, G. (1986) P.120.

14. Diwan, R.K. and Gujarathi, D.L (1968) P.29-67.

15. Sankar, U. (1970) P.399-41.

16. Mehta, S.S (1976) P. 205.

17. Metha S.S (1976) P. 205.

18. Yeh (1966) P. 275.

19. Sengupta (1965) P.

20. Diwan (1967) P. 364.

21. Subramaniyan , G (1986) P. 65.