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FACTOR SUBSTITUTION POSSIBILITIES IN INDIAN MANUFACTURING INDUSTRIES

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FACTOR SUBSTITUTION POSSIBILITIES IN INDIAN MANUFACTURING INDUSTRIES

Sharif Mohammad *

Relative factor prices and the extent of substitution possibilities among factors of production play an important role in formulating policies for generating more employment opportunities and thus redistributing income in the developing countries. The argument for developing small scale industries, in such countries, through encouraging these industries by providing cheap loans, raw materials, marketing facilities, etc., is generally justified on the ground that these units use labour intensive technology. In a labour-surplus (and short of capital) economy the most appropriate technology is one which reflects the relative supplies of these factors.

In the present exercise we attempted at estimating the substitution elasticities between labour and capital (two main factors of production) using a standard CES-production functions (which is a generalized variable elasticity of substitution function).

Elasticity of substitution (σ) may be defined as the measure of the ease with which the varying factor can be substituted for others; Hicks (1) It is defined as:

$$\sigma = - \frac{dx}{x} / \frac{dR}{R} \quad \dots(1)$$

where R is the marginal rate of substitution of labour for capital:

$$R = - \frac{dK}{dL} = \frac{\partial V / \partial L}{\partial V / \partial K} \quad \dots(2)$$

where V = value added, L = labour, and K = capital.

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If the production function is homogeneous of degree 1, σ can be written as:

$$\sigma = \frac{av/aK \cdot av/aL}{v \cdot a^2 v/aKaL} \quad \dots(3)$$

Allen (2).

Substituting partial derivatives and cross-second derivatives into (3) we obtain; (according to Lu and Fletcher (3): Elasticity of substitution:

$$\sigma = \frac{b}{1-cf/xf'}$$

or

$$\sigma = \frac{b}{1-c(1+R/x)} = \frac{b}{1-c(1+\frac{wL}{rK})} \quad \dots(4)$$

where wL = share of labour in value added,

rK = share of capital in value added,

X is capital labour ratio and b and c are coefficients derived from the production function estimated and discussed below:

Starting with the following functions:

$$\log V/L = \log a + b \log W + c \log K/L + e \quad \dots(5)$$

when the production function $V = F(K,L)$ is homogeneous of degree one, then $V/L = F(K/L,1)$. Set $V/L = Y$ and $K/L = X$, then we have $Y = f(X)$ or $V = L f(X)$. Let W be the wage rate with output as numeraire. Assuming competitive markets for labour as well for the product; Arrow, Chenery, Minhas, and Solow (4);

$$\begin{aligned}
 W &= f(X) - xf'(X) \\
 &= Y - x \left(\frac{dy}{dx} \right), \text{ and} \quad \dots(6) \\
 r &= f'(X)
 \end{aligned}$$

where $f'(X)$ is the marginal product of capital, $f(X) - f'(X)$ the marginal product of labour and r returns to capital. Now by substituting (6) into (5) we get:

$$\log Y = \log a + b \log (Y - X(dY/dX)) + c \log X \quad \dots(7)$$

By solving for dY/dX and substituting for $Z = Y^{\frac{1-b}{b}}$, Lu and Fletcher (5) derive the following function:

$$v = [\beta K^{-\rho} + \alpha \eta (K/L)^{-c(1+\rho)} L^{-\rho}]^{-\frac{1}{\rho}} \quad \dots(8)$$

where

$$\rho = \frac{1}{b-1}, \quad \eta = \frac{1-b}{1-b-c}, \quad \alpha = a^{-\frac{1}{b}}, \text{ and } \beta \text{ is the constant of}$$

integration. By setting $\alpha = (1-\delta)r^{-\rho}$ and $\beta = \delta r^{-\rho}$, we obtained:

$$v = r[\delta K^{-\rho} + (1+\delta)\eta(K/L)^{-c(1+\rho)} L^{-\rho}]^{-\frac{1}{\rho}} \quad \dots(9)$$

This function is a generalized form of CES production function.

Lu(6) has shown the following properties of this function:

- (1) Positive marginal products,
- (2) Downward sloping marginal product curves over the relevant ranges of output,
- (3) Homogeneity of degree one, and
- (4) Variable elasticities of substitution.

Data and Estimation of Elasticities

We have used the Annual Survey of Industries (ASI) (7) data, for the year 1966. Out of more than 50 industries (or group of industries), given in the ASI Reports, we have estimated elasticities for 43, industries. In this cross section of data various States' information were the observations for each industry. For capital (K) we have taken only fixed capital into consideration. With this data we have estimated following equations to test different hypotheses about the form of production, returns to scale and elasticity for each industry: (8):

$$(10a) \quad \text{Log } V/L = \log a_1 + b_1 \log w + U_1$$

$$(10b) \quad \text{Log } V/L = \log a_2 + b_2 \log w + C_2 \log K/L + u_2$$

$$(10c) \quad \text{Log } V/L = \log a_3 + b_3 \log w + C_3 \log K/L + d_3 \log L + u_3$$

where

V = value added in Rs.

L = Employment (total workers, i.e., production plus non-production workers)

w = Average wage rate of workers in Rs. per man-days.

K = total fixed capital in Rs.

The form of production function can easily be tested. For example:

(a) our null hypothesis may be $H_0: d_3 = 0$ tests whether the returns to scale are constant,

(b) $H_0: C_1 = 0$ tests whether the production function is of CES or VES form

(c) Further $b_1 = 0$ when $C_1 = 0$, or that $b_1 = 1$ tests whether production function is of the Cobb-Douglas type; and

(d) That $b_1 = 0$ when $C_1 = 0$ tests whether the production function is of the fixed input coefficient (Leontief) type. (Cf, Yeung and Tsang (9)).

Results

Table I presents the details of the three equations (10a, 10b, and 10c) estimated for 43 ASI industry groups for the year 1966. The first thing to be noted is that out of 43, 11 industries have $d_3 \neq 0$ or in other words d_3 is significantly different from zero at 5 per cent level of significance and for six more industries it is different from zero at 10 percent level of significance. That means 17 industries show constant returns to scale. Some of the important industries, which do not show constant returns to scale, are wood and wood products, paper and paper products, rubber and rubber products, drugs and pharmaceuticals, cement and its products, machine and tools, non-ferrous metals, railway rolling stocks, and generation, transmission and distribution of electricity. In this group of industries only one industry, machine and tools, shows Leontief type of production function. The rest of the industries of this group show either Cobb-Douglas or CES/VES types of production function. Industries based on agriculture and mining are showing the Cobb-Douglas form and the others CES/VES. The main industries which are not showing constant returns to scale but showing Cobb-Douglas form are silk and art silk manufactures, rubber products, and cement. Other industries showing Leontief type of production functions are edible oils (including hydrogenated oils) and chemicals and fertilizers which also show constant returns to scale.

Out of the 27 industries, which show CES/VES, 16 show constant returns to scale and 11 variable returns to scale. Two out of three Leontief type industries show constant returns to scale. Similarly, 8 out of 13 Cobb-Douglas type show constant returns to scale.

Elasticities estimated by the formula (4) show the following pattern. Fifteen industries have an elasticity coefficient of 1.0 or less than 1.0. Seventeen show an elasticity between 1.0 and 2.0 and rest of the eleven industries have an elasticity, 2.0 and above. The lowest elasticity turns to be .049 for machines and tools, and the highest for ships and boats (17.4631) which looks to be very high. The second highest elasticity is for sugar (5.4183).

Conclusions

It can be implied from the results about the elasticity of substitution that quite a large number of industries in India, have elasticities above unity which means there are ample opportunities of substituting labour for capital and thus sufficient employment may be generated in the economy so that the share of labour in the economy is not falling and hence the income distribution is not deteriorating. However, in the case of industries where elasticities are below unity, the scope for more employment generation is very limited.

These results also give support to the argument for developing the small-scale-sector even at the cost of providing subsidies and cheap loans (both in form of cash and raw materials and import licences), as these industries generally employ labour intensive technology which results in

higher employment and more equitable income distribution. The same argument may be extended to bring into its fold the foreign trade sector; by arguing for the expansion of labour intensive exports and import-substitution (particularly in capital intensive industries).

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Table I: Production Function in Indian Manufacturing Industries - 1966

Industry	Elasticity of substitution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃	Form of the function	R ⁻²	R ²
1 Flour Mills	.9861	.782 (2.1305)*							.228	.292
				.605 (1.54)**		.221 (1.155)			CES/VES .250	.575
					.816 (2.471)*		.087 (.528)		-.282 (-2.48)*	.505
2 Rice Mills	2.5960	2.295 (3.745)*							.650	.700
				2.140 (3.169)*		.097 (.790)			CES/VES .619	.728
					2.324 (2.749)*		.141 (.790)		.075 (.845)	Constt. R. S. .547
3 Sugar	5.4185	1.608 (2.928)*							.587	.458
				1.728 (3.508)*		.397 (1.98)*			Cobb-Douglas .515	.593
					1.695 (2.919)*		.411 (1.727)*		.014 (.128)	Constt. R. S. .462
4 Misc. Food Products	1.0240	1.047 (6.098)*							.838	.861
				.889 (2.181)*		.088 (.434)			CES/VES .813	.866
					1.053 (2.015)*		.054 (.241)		-.115 (-.575)	Constt. R. S. .784

Contd..

Industry	Elasticity of substitution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃	Form of the function	R ²	R ²	
5 Nitro Oil	.4898	.488 (1.49)**							.087	.157	
				.520 (1.286)		-.041 (-.159)			Leontief	.005	.158
					.282 (.618)		.165 (.480)	.155 (1.156)	Const.	.031	.255
6 Tea & Coffee	2.5044	1.728 (4.020)*							.684	.729	
				.938 (2.378)*		1.011 (2.928)*			Cobb-Douglas	.860	.900
					.938 (2.007)*		1.011 (1.806)*	.000045	Const.	.828	.900
7 Tobacco & Prods.	.4464	.304 (1.321)							.085	.1996	
				.145 (.886)		.384 (3.142)*			Cobb-Douglas	.597	.697
					.0989 (.557)		.403 (3.113)*	-.078	Const.	.564	.728
8 Cotton Textiles	1.1456	.859 (7.637)*							.782	.795	
				.919 (5.585)*		.0484 (.507)			VES/CES	.770	.799
					.912 (.408)		.049 (.4888)	.002 (.050)	Const.	.753	.799

Contd..

Industry	Elasticity of substitution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃	Form of the function	R ²	R ²
9 Textile Dying, Bleaching etc.	2.2629	1.686 (7.659)*							.878	.895
				1.705 (7.024)*		.085 (.528)		VES/CES	.860	.895
					2.251 (6.150)*		.255 (.973)		-1.180 (-1.777)	Const. R _s
10 Silk & Art Silk	2.3151	1.947 (11.807)*							.939	.946
				1.585 (9.756)*		.2075 (3.159)*		Cobb-Douglas	.971	.977
					1.502 (9.539)*		.224 (3.588)*		.0694 (1.448)**	
11 Thread Ball, Carpet making etc.	.1190	.5897 (1.925)*							.268	.335
				.0584 (.252)		.301 (3.212)*		Cobb-Douglas	.621	.690
					.205 (.999)		.289 (3.928)*		.1487 (2.5802)*	
12 Saw Milling and Plywood etc.	.8958	.9915 (2.866)*							.445	.507
				1.4446 (2.571)*		-.259 (-1.022)		VES/CES	.448	.571
					1.537 (1.944)*		-.248 (-.964)		-.0354 (-.1762)	Const. R _s

Contd..

Industry	Elasticity of substi- tution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃ Form of the function	R ²	R ²
13. Wood & Furniture Manufacturing	.7892	.6983 (1.525)**	.4778 (.6860)	1.45215 (1.846)*	.2752 (.4432)	-.4751 (-.716)	.5322 Cobb- (1.859)* Douglas	.141	.249
								VES/CES .0302	.275
								.3119	.5699
14. Paper & Paper Products	1.4580	1.6188 (1.837)*	1.7463 (1.748)*	.7106 (.779)	-.1018 (-.345)	.0470 (.1921)	.3868 (2.351)*	.192	.273
								VES/CES .104	.283
								.429	.5965
15. Printing & Photography etc.	3.4429	1.0515 (5.117)*	.796 (3.6407)*	.696 (3.057)*	.2500 (2.171)*	.216 (1.672)*	.0619 (1.279) Constt. Rta.	.611	.638
								.689	.727
								.702	.758
16. Leather & Leather	.6591	1.009 (3.116)*	.9569 (3.289)*	.9518 (3.134)*	-.2446 (-1.511)	-.2082 (-1.192)	.0866 (.8206) Constt. Rta.	.592	.960
								.675	.784
								.647	.823

Contd..

Industry	Elasticity of substitution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃ Form of the function	-R ²	R ²	
17. Rubber Products	4.9514	1.5859 (3.641)*						.656	.688	
			.4668 (1.259)		.607 (5.167)*			.855	.896	
				-.177 (-.9246)		.7585 (9.403)*	.2252 (5.525)*	Cobb-Douglas	.978	.987
18. Chemicals & Fertilizers	.211	.1114 (.228)						-.073	.004	
			.5185 (.6566)		-.2554 (-1.5108)			Leon- tief's	-.016	.129
				.4806 (.7118)		-.246 (-1.208)	-.0814 (-.576)	Const. Rts.	-.094	.140
19. Drugs & Pharmaceuticals	1.5681	1.5298 (5.614)*						.718	.741	
			1.5087 (5.467)*		-.0725 (-.897)			VES/CES	.715	.761
				1.9818 (5.071)*		-.0494 (-.646)	-.16534 (-1.605)**		.751	.814
20. Refractories	.5085	.5250 (2.474)*						.565	.454	
			.75296 (2.76)*		-.1267 (-1.284)			VES/CES	.407	.539
				.4894 (1.908)*		.0006 (.0065)	.1884 (2.099)*		.601	.734

Contd..

Industry	Elasticity of substi- tution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃ Form of the function	R ²	R ²	
21 Glas & Glass Ware	1.3113	1.3781 (13.366)*						.962	.968	
				1.4884 (6.440)*				VES/CES	.957	.969
					1.5671 (7.196)*					.964
22 Chinaware & Pottery	2.1232	1.6617 (3.234)*						.512	.567	
				1.5611 (2.793)*				VES/CES	.472	.589
					1.4235 (2.386)*					.446
23 Cement & its Products.	-.3413	.9063 (1.433)**						.087	.170	
									.907	.924
										.964
24 Stone other minerals etc.	1.0992	1.09091 (7.9319)*						.8609	.875	
				1.0477 (3.9102)*					.844	.875
										.829

Industry	Elasticity of substi- tution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃	Form of the function	R ²	R ²
25 Iron & Steel	.1849	.0736 (.440)	.0968 (.6593)	.1803 (1.19)	.2365 (2.2335)*	.3612 (2.4299)*	-.1214 (-1.177)	Cobb. Douglas Constts. Rts.	-.061	.0146
26 Iron & Steel, Forging & Casting	.7114	1.3681 (1.4964)**	2.3038 (1.902)*	2.1803 (1.6444)**	-.5597 (-1.1566)	-.5596 (-1.0078)	.0723 XXXX (.3095)	Constts. Rts. VES/CES	.087	.157
27 Iron & Steel Structural	1.3893	1.5864 (5.4869)*	1.6329 (4.6555)*	1.8489 (5.118)*	-.0453 (-.2612)	-.1493 (-.8385)	-.1525 (-1.4931)**	VES/CES	.708	.732
28 Non-Ferrous Basic Metals	2.1136	1.948 (5.4000)*	1.929 (4.986)*	2.5561 (5.910)*	.067 (.513)	.054 (.524)	-.2385 (-2.0334)*	VES/CES	.8009	.829

Contd..

Industry	Elasticity of substi- tution	b ₁	b ₂	b ₃	c ₂	c ₃	c ₃	Form of the function	R ²	R ²
29 Metal Containers	.4738	.575 (2.141)*	.929 (2.573)*	.9903 (2.324)*	-.414 (-1.364)**	-.385 (-1.128)	-.0388 (-.391)	VES/CES	.339	.433
									.422	.587
								Const. Rts.	.304	.602
30 Bolts & Nuts, etc.	1.4471	1.459 (3.795)*	1.471 (2.353)*	1.096 (1.606)**	-.007 (-.026)	.009 (.033)	.145 (1.212)	VES/CES	.573	.615
									.519	.615
								Const. Rts.	.546	.682
31 Metal Rods (Except Machinery)	1.4072	1.709 (7.122)*	1.909 (6.259)*	1.922 (5.677)*	-.194 (-1.055)	-.106 (-1.012)	-.0086 (-.118)	VES/CES	.793	.809
									.795	.826
								Const. Rts.	.774	.826
32 Textile, Sugar and Tea Machinery	.4155	.3221 (1.537)**	.241 (1.083)	.232 (.959)	.1736 (1.029)	.1573 (.846)	.027 (.417)	VES/CES	.146	.252
									.153	.365
								Const. Rts.	.0135	.386

Industry	Elasticity of substi- tution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃	Form of the function	R ²	R ²					
33 Machine & Tools	.0429	-.227 (-.266)							-.102	.008					
				.0717 (.069)					Leontief	-.197	.043				
					-.8493 (-.833)		-.193 (-.541)				.110	.377			
34 Agricultural Machinery	1.1588	1.705 (5.673)*													
				1.598 (4.899)*						VES/CES	.776	.801			
					1.597 (4.589)*		-.185 (-.903)				.771	.822			
35 Steam Engines & Turbines	1.1075	.9445 (3.421)*													
				.947 (3.259)*							-.227 (-.931)	-.058 (-.388)	Constt. Rts.	.739	.826
					.8738 (2.215)*		.046 (.479)				VES/CES	.543	.594		
36 Elect. Cables, Wires,	1.3605	.959 (1.917)*													
				.6358 (1.300)							.033 (.297)	.035 (.301)	Constt. Rts.	.419	.613
					1.411 (2.047)*		.346 (1.692)**					.2414 (1.199)	-.233 (-11488)**	Cobb. Douglas	.467

Contd..

Industry	Elasticity of substi- tution	b_1	b_2	b_3	c_2	c_3	d_3	Form of the function	\bar{R}^2	R^2	
37 Batteries & Radios	1.0554	.974 (5.107)*						CES/VES	.781	.813	
				.8524 (1.9897)*		.1024 (.3247)				.744	.817
					.848 (1.758)*		.0937 (.2486)	.0136 (.064)	Constt. Rts.	.6798	.817
38 Ships & Boats	17.4631	.8328 (3.754)*						CES/VES	.621	.668	
				.7868 (3.659)*		.1605 (1.269)				.651	.738
					.7776 (2.919)*		.1565 (1.077)	.007 (.907)	Constt. Rts.	.582	.739
39 Railways & Rolling Stock	1.0897	1.2116 (6.3135)*							.795	.816	
				1.2192 (5.976)*		-.0168 (-.298)			CES/VES	.772	.818
					.8965 (4.287)*		-.0233 (-.5227)	.0712 (2.418)*		.858	.9007
40 Man. of Motor Vehicles	1.3714	1.3568 (4.219)*							.604	.640	
				1.2192 (5.976)*		-.0168 (-.298)			CES/VES	.772	.818
					1.8265 (2.712)*		.1092 (.412)	-.2195 (-1.0674)	Constt. Rts.	.567	.685

Industry	Elasticity of substi- tution	b ₁	b ₂	b ₃	c ₂	c ₃	d ₃	Form of the function	R ²	R ²
41 Repair of Motor Vehicles	1.1220	1.2714 (8.911)*	1.2859 (8.683)*	1.2214 (8.719)*	-.0189 (-.547)	-.0141 (-.422)	.0344 (1.5193)**		.813	.824
								CES/VES	.805	.827
									.820	.850
42 Motor Cycles and Bicycles	1.8114	.8585 (3.84)*	.6414 (3.352)*	.8001 (2.125)*	.299 (2.473)*	.274 (1.973)*	-.064 (-.502)	Cobb.	.632	.678
								Douglas	.787	.840
								Constt. Rts.	.757	.848
43 Gen. Trans. & Dist. of Electricity	2.0318	1.6096 (2.057)*	1.5141 (1.803)	1.5679 (2.491)*	.1625 (.410)	-.241 (-.75)	.5196 (3.341)*	CES/VES	.177	.232
									.125	.242
									.509	.607

Figures in brackets are t-values.

* significant at 5% level of significance

** significant at 10% level of significance.