CAPITAL - LABOUR SUBSTITUTION POSSIBILITIES IN THE SUDANESE MANUFACTURING SECTOR.

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A problem of increasing interest in less developed countries is the failure of the industrial sector to absorb an adequate quantity of the large amount of labour unproductively employed in the traditional agricultural sector. Despite the rapid growth of output, employment in the manufacturing sector seems to have grown rather slowly, in many cases at a slower rate than population.(1)

Many observers have argued that modern manufacturing techniques do not permit very much substitution between capital and labour, and as a result the ability of the manufacturing sector to absorb labour is very limited. Others have argued that efficient factor substitution is, in fact, feasible, but that incorrect market prices of primary factors have conveyed the wrong signals to entrepreneurs.(2)

The central issue involved in this paper is the possibility of substitution between capital and labour in the Sudanese manufacturing sector. The paper attempts to estimate the elasticity of substitution between capital and labour in the manufacturing industries.

The advantage of estimating the elasticity of substitution is to cast some light upon capital intensity, choice of techniques, the problem of employment and the effect of various industrial policies on resource allocation.

[*i*] *Some Preliminaries:-*

In a pioneering paper Arrow,(3) Chenery, Minhas and Solow, have advanced a new class of production functions of great flexibility. Their work focuses attention on the following problem: if it is given that a certain relationship exists between wages and output per man-hour, then what sort of production function rationalizes this relationship. The equation for estimating the elasticity of substitution between capital and labour is given by:

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

where V is value added per worker, W is the wage rate and a is a constant. The elasticity estimate is given by the value of b.

Our data pertain to four manufacturing industries obtained from the Industrial survey of 1972 - 1973.(4) The survey covers two types of establishments; those employing more than twenty-five workers as well as those employing less than twenty-five workers. It gives information about gross output, gross value added, number of workers, total wages and total investment. Four manufacturing industries have been chosen for this study, viz, chemical, metal, textile and food industries.

Various activities performed by these four manufacturing industries are presented in table (1.l) below.

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Table [1] Percentage Share of Industries

Item	Food	Textile	Chemical	Metal	Total
No. of establish-ments	28.7	13.3	22.4	17.8	82.2
Value of production	43.7	28.0	13.9	8.6	94.4
Value added	29.7	45.9	7.1	8.3	91.0
No. of workers	24.2	40.5	11.2	13.2	89.1
Total wages	23.1	43.4	11.4	11.2	89.1
Total invested Capital	20.2	43.2	17.2	9.8	90.4

Source: Calculated from table (1) (1-1)
"Industrial Survey 1972 - 73"; ibid., pp. 14—20.

It is evident from the above table that these four industries alone cover more than 80 percent of the activities in the manufacturing sector under each item.

On an individual level the textile industry, generally, contributes most to the various activities followed by the food, chemical and metal industries. The high contribution of these four industries to the various activities (ie more than 80% under each item) gives a special emphasis to the degree of significance of our study and renders our sample representative.

Given the fact that we are interested in the substitution possibility between capital and labour, it may be instructive to attempt to clarity the so-called capital-intensity of the various industries where capital-intensity is measured by the capital-labour ratio. Some related indices which are also relevant to the analysis are the share of wages in total value added, ie labour's share, and excess capacity. Table (1-2) below summarizes those results where industries are ranked according to capital-labour ratio.

Table [2] Some Indicators of Capital Intensity In Sudanese Manufacturing Industries

Index	Chemical	Textile	Food	Metal
Capital-labour ratios Ls: (000) per man	5.29 (2.76)	3.76 (2.17)	3.20 (2.689)	2.90 (1.43)
Labour's share	83.92	49.62	40.78	62.69
Excess capacity (%)	13.07	27.5	18.07	28.3

Source: (a) Calculated from tables (1—6) and (2—8) Industrial Survey 1972-73, (Dept. of Statistics 1976)
(b) Figures between brackets are taken from A. A/Gadir "A Note on Substitution Possibilities in the Industrial Sector in the Sudan" Sudan Journal of Development Research, ESRC, NCR, vol:1 No. 1 Feb. 1977, Table (2).

The above table presents our own estimates of capital-labour ratios (5) based on data taken from the Industrial Survey of 1972 - 1973, as well as estimates made by Gadir (6) based on data extracted from the Industrial Survey of 1970 - 1971.

The table shows that our estimates for the four industries are higher compared to Gadir's estimates. This implies that capital-labour ratios have risen by 91.6%, 73.27%, 19.4% and 102.79% for the chemical, textile, food and metal industries respectively during the period 1970 - 1973.

Awad(7) cites a survey report on Khartoum industries in 1968 as showing capital-labour ratio to be Ls: 1603. In 1971 the average capital-labour ratio in the manufacturing sector was Ls: 2295.(8) Thus there has been a rise in capital intensity of about 43% during the period 1968 to 1971

For our own estimates, the highest capital-labour ratio is displayed by the chemical industry, followed directly by the textile, food, and metal industries.

On the other hand, taking labour's share index, we find that the chemical industry exhibits the highest share of labour in total value added (83.92 percent), followed by the metal (62.69 percent), textile (49.62 percent) and food industries. (40.78 percent).

As regards excess capacity, the above table shows that the chemical industry exhibits the lowest excess capacity (13.07 percent), followed by food (18.07 percent), textile (27.5 percent), while the metal industry displays the highest excess capacity (28.3 percent).

If capacity utilization is taken as an indicator of efficiency then the chemical industry will display the highest degree of efficiency, followed by the food, textile and metal industries.

[*ii*] *The Findings:-*

The results of our regression analysis on fitting available data to equation (1) together with Gadir's results(9) are summed up in table (1.3) below.

Table [*3*] *Elasticity of Substitution in the Sudanese Manufacturing Sector 1970/71 —1972/73*

Index / Industy	Food	Metal	Textile	Chemical
Elasticity Estimates	2.593 (1.086)	2.39 (1.287)	1.105 (0.7063)	0.8015 (1.234)
R^2 (%)	64.1	90.8	37.3	68.8
t — values	2.21	6.44	1.20	2.32
No. of Observations	9	11	11	8

Figures between brackets are Gadir's estimates, (See A.A/Gadir, op.cit., table (3)).

Our elasticity estimates, with the exception of the textile industry, look quite good in terms of explanatory power and level of significance. For example, R^2(%) value are greater than 64 percent for three estimates except for textile which has got the lowest R^2 (%) value of 37.3 percent.

On the other hand, the elasticity estimates are significant at a 5% level of significance

for metal, chemical and food and insignificant for the textile industry.

By way of comparison, the above table shows that our elasticity estimates for the food, metal and textile industries are higher than Gadir's estimates. In Gadir's sample, with the exception of textile, all the other thress industries have elasticity greater than unity. The variation in the elasticity estimates for the two samples may be due to differences in data used for estimating the elasticity as far as the model and its assumptions are the same.

Within our own sample the food industry displays the highest possibility of substitution between capital and labour (with elasticity of 2.598), followed by metal, textile and chemical industries. A high elasticity of substitution indicates that there exists flexibility in the face of external changes such as those which occur in the international markets, and that prospects for output growth are relatively good, since the faster growing primary factor can be substituted relatively easily for the slower growing one. It follows that the food industry seems to provide the highest possibility of substitution between capital and labour compared to the other industry. With the exception of the chemical industry all the remaining industries (with elasticity greater than unity) allow a high flexibility of substitution between capital and labour.

Let us assume that the economy is experiencing an increase in capital relative to labour. If substitution is comparatively easy (the elasticity is comparatively high as in the case of food, metal and textile) the industries (or firms) can be induced to absorb the increase of capital by comparatively small rises in wages and comparatively small fall in the interest as entrepreneurs seek profit maximization. On the other hand, if substitution is relatively difficult (the elasticity is relatively low as in the case of chemical in our sample) then competitive firms will absorb increased capital (in relation to labour) only after they have bid down the interest rate and bid up wages by comparatively greater amounts.(10)

However, at this stage of analysis, it is useful to compare our own elasticity estimates for the Sudan with existing estimates in the literature. One rather important reservation regarding this comparison is the fact that there may possibly exist a vast difference in the data used for these studies resulting from different economic structures, as well as different stages of economic development in the selected samples of countries.

Since differences in specification and level of aggregation might lead to biased estimates of the eleasticity of substitution and hence to unjustified comparison, we shall compare results for Argentina, with those of the Philippines, Nigeria, Japan, the United States and the Sudan, where in all cases equation (1) is used.

Table (4) below presents the elasticity estimates of chemical, food, textile and metal industries in these prescribed countries.

Table [4] Elasticity of Substitution: A Comparison Between Countries:

Country	Chemical	Food	Textile	Metal
Sudan	0.810	2.598	1.105	2.39
Philippines	1.090	1.37	0.44	1.36
Argentina	0.900	1.35	0.98	0.87
Nigeria	1.802	—	1.348	0.978
U. S. A.	1.030	0.9715	1.0327	0.7503
Japan	0.900	0.930	0,80	1.410

Sources:
(a) Figures for the Sudan are our own estimates.
(b) Figures for Philippines, Argentina, and Nigeria are taken from GAude, (1975), p. 44 table 5).
(c) Figures for U.S.A. and Japan are taken from Arrow, (Arrow *et.al.,*) (1961), p. 240, table 5.

The above table shows that the elasticity of substitution estimates differ from one country to the other as well as from one industry to the other. There are many factors that are responsible for these variations. Among these factors, source and reliability of data, methods of calculation and the assumptions of the model are of special significance.

Table (4) shows that the substitution flexibility, for Sudan, the Philippines, Nigeria, Japan and U.S.A., is fairly respectable. For the Sudan, Philippines and Argentina the food industry displays the highest degree of flexibility with an elasticity of substitution greater than unity, whereas for the Sudan, Philippines and Japan, metal industry displays a high flexibility with elasticity of substitution greater than unity.

As regards the textile industry only Sudan, Nigeria and the U.S.A, are with elasticity of substitution greater than unity. It is evident that for the U.S.A. with the exception of the food industry all the other industries have elasticity of substitution greater than unity, while for Japan with the exception of the metal industry all the other industries have elasticity of substitution less than unity.

In fact, one rather important point that comes out fo this comparison is the fact that some industries in developing countries like Sudan, Philippines and Nigeria display a high substitution possibility between capital and labour, and sometimes an even higher rate of substitution compared with some developed countries like U.S.A. and Japan. The implication of this finding is a sort of strong refutation of the assumption that industries in developing countries do not permit high and flexible substitution between capital and labour.

[iii] Some Implications and Concluding Remarks:

Utilizing the above results the following appear to be the implications of our scrutiny:-

The first implication of our findings hat to do with capital - intensity. The results of our calculations show that the four manufacturing industries examined in this study exhibit high capital-labour ratios, (compared to Gadir's estimates), indicating a high

degree of capital-intensity. This important finding is validated by our elasticity estimates. For example with the exception of the chemical industry all the remaining industries have displayed elasticity of substitution greater than unity.

In the Sudan it is evident that the rise in capital intensity is caused by two well-intentioned policies. On one hand, the government policy aiming at raising the standard of living of the working people through raising minimum wage levels coupled with the trade union pressures to push up wages in the face of rising cost have remarkably affected the wage-rental-ratio and rendered the price of labour as high compared to its opportunity cost. On the other hand, the concessionary policies advanced by consecutive governments since 1956 to encourage both private national and foreign investment by providing generous fiscal and non-fiscal incentives, have made the price of capital cheaper than its opportunity cost.

Secondly, another implication of our results pertains to the problem of choice of techniques in the Sudanese industrial sector. From our results, it is clear that manufacturing industries in the Sudan are highly dependent on capital intensive techniques. Although the question of choice of appropriate technology — to the best of my knowledge — has never been put as a serious topic in the industrialization process int the last two decades, yet from the beginning it seems that planners have solved it in favour of capital-intensive technology. The industrial policies pursued under the auspices of the four concession Acts of 1956, 1967, 1972 and 1974, have encouraged import-substitution and capital intensive technology through the provision of tax-holidays, tax rebates, full or partial exemption from duties on imported capital goods, spare parts, equipments and raw materials. In addition to that the four Acts provided protection for home industries against competitive imported goods, guarantees against nationalization and confiscation as well as exemption from Business Profit Tax (B.P.T.) for a period extendable from tive to ten years. As a result of these incentives the price of capital was depressed and investors tended to rely very much on these generous concessions and to choose capital intensive methods in their industrial production activities.

A third implication of our findings which has to do with income distribution is related to the behaviour of income inequality. It is widely observed that in a developing economy characterized by a dual structure of production, inequality of income tends to increase overtime.(11) The nature of production technology is widely assumed to be one of the contributing factors for such a behaviour. The relationship between production technology and income inequality has been most clearly shown by Gadir when he said that:

> "... for a production function with an elasticity of substitution greater than unity, and on the assumption that the economy is in the region where capital stock is growing faster than urban unemployed labour, we found that inequality tends to increase overtime".(12)

Our findings in this paper seem to fully support the above statement. With an elasticity of substitution greater than unity for three manufacturing industries, and with very high capital-labour ratios for the four manufacturing industries, we would expect the nature of the production technology in the manufacturing sector in the Sudan to have contributed to worsening income distribution.

FOOTNOTES

(1) Baer, W., and M. Herv'e,: "Employment and Industrialization in Developing countries", Quarterly Journal of Economics, vol. 80., No. 1, Feb. 1966, pp. 488 — 533.

(2) Raiis, G.,: Ranis, G. Output and Employment in the 70's: Conflict or Complements", in R. Ridker and H. Lubell: Employment and Unemployment Problems of the Near East and South Asia (Vihas Publications, Delhi, 1971).

(3) Arrow, K., H. Henery, B. Minhas and R. Solow,: "Capital-Labour Substitution and Economic Efficiency", Review of Economics and Statistics, vol. 43, No. 3, Aug. 1961, pp. 225 — 250.

(4) Ministry of Finance, Planning and National Economy. "The Industrial Survey 1972-73" (in arabic), Department of Statistics (Industrial Section) 1976. The survey gives information on various activities of the manufacturing industries for two years. Each manufacturing industry is composed of various small units. The total number of observations used in this study is 29. These observations are broken down according to manufacturing industries as follows:
(a) Food industry has nine observations,
(b) Metal industry has eleven observations,
(c) Textile industry has eleven observations,
(d) Chemical industry has eight observations.

(5) The capital-labour ratio (K/L) is calculated as a ratio of the stock of investment in fixed capital and in working capital to the flow of labour working with it (see for example, A. Sen: "Choice of Techniques of Production: With Special Reference to East Asia", in Kenneth Berrill (ed.): "Economic Development With Special Reference to East Asia", (London, Macmillan, New York, St. Martin's Press, 1964).

(6) Gadir, A.A.: "A note on Substitution Possibilities in the Industrial Sector in the Sudan", in Sudan Journal of Development Research, vol. 1, No. 1, Feb. 1977.

(7) Awad, M.H.,: "Government Policy Towards Private Industry in the Sudan", L'Egypte Contempe raine, 1970.

(8) Naseem, S.M.,: "The Impact of Trade Policies on the Growth of Employment and Output in Manufacturing Industries in the Sudan", in A.M. El-Hassan (ed.): A Selection of Papers Presented to the ILO, Comprehensive Employment Strategy Mission to the Sudan, 1974 - 75. ESRC, NCR) K.U.P. 1977.

(9) Gadir, A.A.,: op. cit., Table (3).

(10) Gaude, J.,: "Capital-Labour Substitution Possibilities: A Review of Empirical Evidence", in A.S. Bhalla (ed.): "Technology and Employment in Industry", ILO, Geneva, 1975, p. 35.

(11) Gadir, A.A.: Op. Cit., p. 133.

(12) Gadir, A.A.: ibid.,