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A Note on Significance of Complementarity Between Inputs in Neo-Classical Theory of Production

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INTRODUCTION

Inputs are not perfect substitutes; thus they are not perfect complements. This is the basic premise on which all other features of the neo-classical theory of production centre around. This note serves as a prelude in introducing the significance of complementarity between inputs in the production. The complementarity may be defined as

$$\left(\frac{\partial x_1}{\partial p_2}\right)_{u=\text{constant}} < 0 \quad \text{or} \quad \left(\frac{\partial x_2}{\partial p_1}\right)_{u=\text{constant}} < 0$$

These notations refer that inputs are complementary when their cross-partial derivatives of demand functions are negative. In particular, they define that if the compensatory variations in income keep the producer on the same indifference curve, an increase in price of one input will induce the producer to demand less of other input and vice versa. Inherent in this definition of complementarity is the concept of positive interaction between inputs. According to Upton (1976) the positive interaction means that if inputs of one factor are increased in relation to the inputs of another factor, although the marginal product per unit of the first factor eventually declines, the marginal product of the second factor rises.

LONG RUN ANALYSIS OF PRODUCTION

The neo-classical theory of production, based on time period, defines two types of production functions: Short run and long run, and separately illustrates the problem of optimization in these two respects. The main tool of analysis in the long run production function is isoquant which is amenable to depict in a two-dimensional diagram mainly because of its characteristic that a single isoquant represents the same level of production. However, the third dimension (output dimension) is embodied in the spacing of isoquants in the x-y plane. Of all the characteristics of isoquants, the convexity is the fundamental one which shows a diminishing marginal rate of technical substitution between inputs ($MRTS_{xy}$. The diminishing $MRTS_{xy}$ is based on the law of diminishing return -- a product of the complementarity between inputs. Thus, implicit in the convexity of isoquant is the concept of complementarity. If

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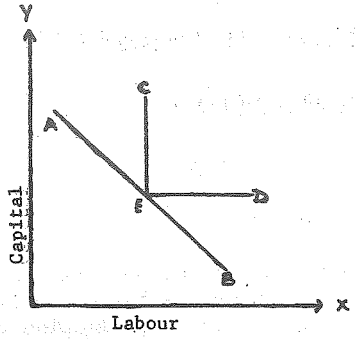
inputs are perfect substitutes the isoquants appear as a straight line, whereas if they are perfect complements the isoquants turn up as a right angle (Fig. 1). But they are neither perfect substitutes nor perfect

Figure 1



complements. Therefore, they do not yield such curves. However, there is one point (point E) common in both curves which may imply that inputs bear both the substitutability and complementarity characteristics. And to represent both characteristics the other points of the curve (isoquant) must lie in the regions AEC and BED. Whether the points lie near to the EC and ED lines or AE and EB segments again depends upon the extent of complementarity or substitutability between inputs. In essence, the degree of convexity of isoquant is determined by the extent of substitution between inputs. This is measured by the elasticity of substitution (σ) which is defined at equilibrium as the ratio of relative change in factor intensity to the relative change in marginal rate of technical substitution. Given the relative change in factor intensity, a higher percentage change in $MRTS_{xy}$ comes out with a low elasticity of substitution which hints that the inputs are poor substitutes. The lower and upper ranges of elasticity coefficients are zero and infinity referring to the two extremes: perfect complements and perfect substitutes respectively. The coefficient of elasticity of substitution is always negative because as one moves downwards along the isoquant, he ascertains an increase in MRTS but a decrease in the intensity of the factor measured on horizontal axis. Its magnitude depends upon the curvature of isoquant. A higher curvature of the isoquant is associated with a higher percentage change in the MRTS, but a lower percentage change in input ratio, and therefore it yields low elasticity signifying that inputs are not better substitutes. Thus, the elasticity of substitution of two inputs in a production function varies inversely with the curvature of their isoproduct curves.

The degree of complementarity also determines the methods of production and thereby helps define the range of productive/technical efficiency, i.e., economic region of the production function. The complementarity characteristic establishes that there are comparatively fewer technically efficient methods of production available for producing a product. It, therefore, builds the ground for determining the price/allocation efficiency or choice of the expansion path among the different isoc product lines. The choice of expansion path implies an economic efficiency. Again, it is the complementarity between inputs that has provided a

larger space to homogeneous production function, on which, indeed, all the features of the neo-classical theory of production are worked out. The fact that a linear function without constant term becomes a homogeneous function reflects the close correspondence between the complementarity of inputs and homogeneity of the production function. Moreover, the complementarity helps long run production function embrace the characteristics of short run production function. Thus, the diminishing marginal productivity of an input goes together with the constant and, in most occasions, with increasing returns to scale.

SHORT RUN ANALYSIS OF PRODUCTION

The complementarity of inputs also forms basis in the explanation of the short run production function, which is popularly known as law of variable proportions. In particular, it helps to explain the symmetry of the three stages of production. Some text books have a convention of defining border lines between the stages of production in terms of the relationships that exist between the total, average and marginal productivities of variable factors without paying any notice to the productivities of the fixed factor(s). Thus, they manifest the first boundary at the equality of marginal and average product of variable factor ($MP_V = AP_V$), i.e., where AP_V is maximum, and the second boundary at the zero marginal product of the variable factor. Such a delimitation may confound one as the first boundary is delineated by the AP_V, whereas the second one, by the MP_V. It, indeed, shows on assymmetry.

Intuitively, the solution lies in the consideration of the fixed factor, i.e., giving a cognizance of the complementarity between fixed and variable factors. In such an instance the three stages could be defined according to the signs of the marginal productivities of the fixed and variable factors as follows:

1. In the first stage the marginal product of the fixed factor is negative.

2. In the second stage the marginal products of both factors are positive and diminishing.

3. In the third stage the marginal product of the variable factor is negative.

Thus, by definition the first and the third stages are symmetrical, in that in each of these two stages the marginal productivity of one of the factors is negative. The symmetry has been portrayed by some authors (such as C.E. Ferguson and Richard K. Armey). They derive the total product and its derivatives for fixed factor from the products of the variable factor, and graph both sets of products in the same figure by measuring land-labour ratio rather than only labour in the horizontal axis. Such a formulation shows a relative increase in the use of either inputs as one proceeds from or towards origin, and thus depicts the behaviour of products of both factors. In particular, when one moves towards origin he could see the behaviour of products of fixed factor

which, to a large extent, resembles to that of the products of variable factor. Thus, at the first boundary where average product of variable factor is maximum the marginal product of fixed factor is zero, whereas at the second boundary where average product of fixed factor is maximum the marginal product of variable factor is zero. The latter level of input use is called as intensive margin from the view point of variable factor, but from the view point of fixed factor it is called as the technical optimum since the average product per unit of fixed resource is at maximum. Thus stage second, from the standpoint of either inputs, lies between the intensive and extensive margins. All these, however, explain the symmetry of the stages of production. And this symmetry is due to complementarity which allows for the positive interaction between inputs.

CONCLUSION

The preceding observations are sufficient to establish that underlying the neo-classical production function is a technology which assimilates the complementarity of inputs. Thus, the complementarity characteristic is the blood which flows into every vein of the neo-classical theory of production.

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BOOK REVIEW

Bose, Deb Kumar (1989): Energy Economics (New Delhi: Indian Council of Social Science Research), p. 47 including Index, Price Rs. 25.00 (I.C.).

This monograph authored by Deb Kumar Bose is a survey of literature on the economics of energy. Considering the vastness of literature on the subject since the oil crisis of 1973, the author has concentrated mostly on Indian writers and researchers.

Five topics have been included for review in the monograph. Firstly, views of economists as well as natural scientists on the relation of energy and economic development are presented. The view that the two are closely related came to be questioned and scrutinized after the oil crisis of 1973. The scrutiny failed to show a simple relationship between the two. Rather, the utilization of energy resources in a country was related in a complex way to the socio-economic conditions of a country. However, the question that still needs to be answered is whether both the consumption of energy and economic development are not influenced by the structure and the mode of production in an economy.

Dealing with the issues concerned with forecasting of demand for energy in a country, the author reviews a variety of methodologies. Among the various methodologies which are fraught with uncertainty, econometric models continue to be the main instruments of projections for future. This is because of the possibility of incorporating the elements of uncertainty into the models. The innovation of simulation models have further improved the matters. Since, econometric models are better guide to the future in times when there are no sharp changes in the conditions prevailing in the current period from those in the past periods, the simulation models allow for a greater flexibility in the assumptions for the models in times of sharp turn in situation.

The third topic reviewed is the economics of power generation. The author remarks that the problems of power generation are treated by economists at par with those for other kinds of productive activities. Since, the production function approach cannot accommodate adequately the more crucial effects of the variation in load factor on the economics of power generation, interaction with power engineers may lead to the achievement of better results. The fourth issue is concerned with the energy problem in the Third World. The oil crisis generated keen interest among scientists to search for alternative source of energy around the world. In this search, researchers have mainly concentrated on the supply side of the problem. This has created problems, especially in the Third World, where people in the relatively rural areas are facing high cost to generate electricity and for operating pumpsets with imported diesel. Things have not proceeded well with alternative technologies like bio-gas, windmills or solar cells in the rural areas.

The last issue considered in the monograph is the economics of exhaustible energy resources. Since the realization of the problems of energy and the prospect of the depletion of the exhaustible energy resources has now begun to be considered serious enough to be included in any study on the long-range perspective of an economy.

Thus, the issues raised in the monograph on the seriousness of the problems of exhaustibility and utilization of energy resources cannot be ignored. The author has successfully exposed the main issues of energy that confront our modern society. The author aptly concludes that it is less difficult to appreciate that the economic system cannot converge towards a stationary state if the resources on which it is based tend to exhaustion.

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