SOME ANALYTICAL AND QUANTITATIVE ASPECTS OF AGRICULTURAL SUPPLY AND SUBSTITUTION FUNCTIONS : INDIA*

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Recent controversy over PL 480 imports has once again spotlighted the old problem of price elasticity or inelasticity of agricultural produce in India. On the one hand, it is argued that wheat imports have had deleterious effects on wheat production *via* the unfavourable shift in wheat prices, assuming thereby that production is price elastic. On the other hand, on the assumption that it is the relative and not the absolute prices that affect production, it is asserted that the performance is to be judged on the basis of all substitute crops and not on a single crop. And since the performance is not universally bad, how can PL 480 imports be blamed for any shortfall? One surprising and rather unsavoury aspect of the controversy is that the opposition to PL 480 has mainly come from those who have all along denied the price elasticity of agricultural produce, and the support has emanated from those who continuously affirmed faith in that functional relationship. It marks a strange (or not very strange) reversal of roles under the stress of politics.

There have appeared, over the last few years several econometric and non-econometric studies analysing farmers' response to prices in under-developed region of Indo-Pak sub-continent.[1] Some of these studies claim to have discovered some reasonably 'predictive farm supply function' for policy formulation, while others refute this hypothesis. Dr. Raj Krishna's contribution in this field is outstanding, though the claim made thereof that he has refuted 'the widely prevalent notion that peasants in poor countries do not respond, or respond very little or negatively to price movements,' is either exaggerated or misplaced. Un-

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* I had the benefit of discussing this paper with Professor A. W. Phillips, Shri J. L. Roy, Professor S. Chakravarty and Dr. Raj Krishna. Discussion, however, implies neither approval for opinions expressed nor responsibility for any errors in the paper.

1. Raj Krishna, "Farm Supply Response in India-Pakistan," *Economic Journal,* Vol. LXXII, No. 291, September, 1963, and "Some Production Functions for the Punjab," *Indian Journal of Agricultural Economics,* Vol. XIX, Nos. 3 & 4, July-December 1964; R. N. Poduval and P. Sen, "Prices, Trade and Marketing of Agricultural Commodities in India" in J. P. Bhattacharjee (Ed.): Studies in Indian Agricultural Economics, Bombay, 1958; S. C. Gupta and A. Majid : Producers' Response to Changes in Prices and Marketing Policies, Bombay, 1965; N.S. Joshi and B.R. Dhekney: Irrigation and Agriculture in the First Five-Year Plan, Poona, 1954 ; Mahesh Chand, "Agricultural Terms of Trade and Economic Growth" and B. Misra and S. P. Sinha, "Agriculture and Its Terms of Trade with special reference to India," *Indian Journal of Agricultural Economics,* Vol. XIII, No. 1, January-March, 1958 ; Walter C. Neale, "Economic Accounting and Family Farming in India," *Economic Development and Cultural Change,* Vol. 7, Part I, April, 1950; R. O. Olsen, "Discussion: Impact and Implications of Foreign Surplus Disposal on Underdeveloped Economies," *Journal of Farm Economics,* Vol. 42, No. 5, December, 1960; D. Romesh, "A Dynamic Model Analysis of Foodgrains Production and Prices" and "Long and Short run Elasticities of Acreage under Crops," *Agricultural Situation in India,* Vol. XIX, No. 4, July, 1964 and Vol. XX, No. 5, August, 1965 respectively; V. M. Jakhade and N. A. Mujumdar, "Response of Agricultural Producers to Prices—The Case of Jute and Rice in India," *Indian Journal of Agricultural Economics,* Vol. XIX, Nos. 3 & 4, July-December, 1964; C. H. Hanumantha Rao: Agricultural Production Functions, Costs and Returns in India, Bombay, 1965; Also see contributions by several participants in the Conference issue of *Indian Journal of Agricultural Economics,* Vol. XX, No. 1, January-March, 1965; S. M. Hussain, "A Note on Farmers' Response to Price in East Pakistan," *The Pakistan Development Review,* Vol. IV, No. 1, Spring, 1964.

fortunately, these studies, quantitative or analytical, only revive periodically the old and sterile controversy about price elasticity (or inelasticity) of agricultural commodities. This is so because global generalisations and claims are made on the basis of some specific case study, in support or refutation of a particular hypothesis, which itself could be subjected to different interpretations.

It is the purpose of this paper (1) to state the various different ways the term supply function is defined, yielding as many models as there are definitions; (2) to point out that whatever be the elasticity magnitudes obtained from these econometric models, their usefulness is limited in the context of any major question pertaining to the programme of Indian agriculture; and finally (3) to show that a non-linear model is more inclusive and gives a better fit than a linear model within the assumptions and specifications of a particular hypothesis.

One other problem relating to this type of study must be disposed off first. Ever since the inception of planned economic development in India, almost every economic policy has become a subject of political controversy. And controversy about price elasticity and hence about price policy has come to have very large political and ideological connotations which thwart serious economic discussion. The argument largely rests on the determination of levers of control; if price is a significant variable, a small effort would be required on the part of the state to change the supply of a commodity, and if it is not significant the state intervention will have to be large. From these two respective positions of what Schultz calls the command approach and market approach flows the controversy over the precedence given to price determining or price determined sequences and of increasing or decreasing role of prices.

The controversy, unlike that in the U.S., goes beyond that about price support programme; it is about non-price measures called 'physical controls.' Stripped of its political trappings, the controversy can be narrowed down to relevant alternatives if controls imply not the heavy hand of the state clamping down on individual farmer's enterprise and initiative but the choice to be made between different positive state actions to fill the necessary gaps in improving farming activity, *i.e.*, if the term controls is applied to a variable in the econometric sense. A decision variable can be either a structural parameter or an exogenous variable; and in turn, structural parameters and exogenous variables that are decision variables can be called controlled variables as distinct from uncontrolled variables (both exogenous and endogenous) and parameters.[2] This is not always easy to determine. For example, when the government fixes the prices of a crop, farmers' response is uncontrolled; thus what is uncontrolled from farmers viewpoint is exactly the opposite from the government's viewpoint. Those who claim high price elasticity would like to treat price as a structural parameter, and their opponents like to accept it only as an exogenous variable. The latter approach is simple but unrealistic and indeterministic while the former is more realistic but complicated and somewhat ineffectual for policy decisions.

2. Jacob Marschak, "Economic Measurement for Policy and Prediction" in W. C. Hood and Tjalling C. Koopmans (Ed.): Studies in Econometric Methods, New York, 1955, pp. 7-8.

II

The term supply function or supply response in agriculture is used in at least five distinct or different ways which are not interchangeable but may overlap with one another.

(1) The distinction between short term and long-term supply functions. For an individual commodity, a short term supply function means different amounts produced or offered for sale at different relative prices, while other things remain the same. In a long-term supply function other factors are allowed to vary. In agriculture the former is confined to one period horizon and the latter to more than one, depending on when changes in inputs and outputs coincide with each other. (2) The distinction between gross and net supply functions. The former relates the supply of a commodity to the ratio of prices of substitute products, *i.e.*, relative product price, whereas the latter relates supply to the ratio of prices received by the farmer to those paid by him. The distinction can also be extended to a difference, for an individual commodity, between a product equation and a yield equation with other explanatory variables remaining the same. (3) The distinction between actual production of crop and that part of it which is sold in the market. The two magnitudes may be highly correlated but they are not the same, particularly in subsistence agriculture; sometimes they may move in the opposite directions. Besides, the former takes account only of the production alternatives, the latter includes alternatives between consumption and sale as well. (4) The distinction between an acreage function and a product function for a single crop. The distinction essentially arises from the circumstances of uncertain weather conditions. Under certain assumptions the two functions can be treated as one, and this is the practice adopted in most econometric models of agricultural supply response. But at no stage must it be ignored that land in the final analysis is an input, and its product an output. (5) Distinction between crop substitution function (CSF) and true supply function (TSF). It is for want of better terms that these two functions are so described.[3]

It is this last distinction which is most important. It is so because (1) most of the aforementioned studies make use of a model of CSF, (2) whereas conclusion they draw are more relevant to TSF, and (3) pertinent problems of Indian agriculture relate mainly to TSF.

A farmer's response to price changes for substituting acreage between crops, with all other resource inputs being fixed or small, which is defined here as a CSF, is not the same thing as productivity or total supply of produce response to changes in the art of production, factor supplies or factor-products price ratios; the latter is defined as a TSF. Rate of substitution between crops as an increasing function of prices, even if high, is different from rate of production as some function of price and non-price factors. For there must clearly be drawn a distinction between

3. There is one more distinction which has important policy implications, namely, the distinction between a positive supply function and a normative supply function. In econometric sense the first is a statement of the farmers' behaviour in the past when some factors changed and others did not. Econometric studies based on regression models fall in this category. The second, normative supply function, implies farmers' response under controlled experiments when factors or variables are used deliberately in different combinations to get the best possible results. Programming models fall in this second category.

an efficient allocation of given resources, mostly of land and labour in backward agriculture, and an optimum rate of investment devoted to increasing the stock of old and new resources. It is impossible to conceive of a TSF without taking into account factor demand and supplies and their prices as given. Beyond that the TSF must take into account all the relevant input variables, and then the two functions would rest on two different hypotheses. All the econometric studies referred to earlier totally abstract from input changes and production function and then go straight to make comparisons of both short and long-term elasticities thus derived with those from studies of other countries, and also illegitimately draw major policy conclusions for price and non-price factors. Substitution magnitudes are mistaken for supply magnitudes.

The difficulty lies partly in the absence of data on input supplies and prices. No series of prices paid by the Indian farmers are available, and thus the very forms of econometric equations and their economic specifications, say, between India and the U.S., are incomparable. The lack of data does not justify a mechanical replication of even the most sophisticated acreage-price model that explicitly abstracts from productivity, for if it is assumed that the elasticity of yield or productivity is zero, what then emerges is not a farm TSF but a CSF; the latter is important in itself but is not to be confused with the former. The two, however, can be treated as substitutes either if land is not a fixed factor or, if it is fixed, technology and other resources can be abundantly applied as substitutes of land.[4] Since in Nerlovian type models long-term elasticities are derived from short term elasticities given by econometric equations and none of the other conditions is obtained in Indian agriculture, CSF must be sharply distinguished from the TSF.

The main problems of Indian agriculture are poor productivity per acre and large total, against individual, commodity deficits.[5] Although the overall average productivity per acre is itself a weighted average of productivities of individual crops, and each crop has its own elasticity for acreage planted, it is not legitimate to build up the total supply function, weighted or unweighted and as defined earlier, from individual elasticities of acreage to price changes. Marc Nerlove, whose distributed lag supply model is the basis of several studies on individual commodities, stated that "High elasticity among crops on individual farms do not, however, entail a high elasticity of supply for industry as a whole."[6] This crucial distinction is often overlooked.

Nevertheless, a CSF is quite important for achieving optimum allocation of given resources as well as for knowledge about the extent of mobility of factors and directions in which development effort should most fruitfully be concentrated. The function is important in both static and dynamic settings. Significant elasticities derived from econometric equations of crop acreage in India, with no input changes, go some way to prove the efficient working of the CSF. Professor

4. For example, fertilizers are treated as substitutes for land.

5. The word productivity is used here in a broad sense to include changes in production through both changes in actual inputs and changes in technology. The two cannot be easily separated, as we know from scores of studies in production functions, because technology is itself partly a function of resource utilization.

6. Marc Nerlove: The Dynamics of Supply, Baltimore, 1958, p. 24. Zvi Griliches writes: "The fact that individual commodity estimates may be positive and relatively high does not preclude the aggregate supply elasticity from being zero or negative." "Estimates of the Aggregate U. S. Farm Supply Function," *Journal of Farm Economics*, Vol. 42, No. 2, May, 1960.

Schultz has, by consolidating studies of traditional agriculture of different countries, including India, came to the conclusion that agricultural sector in a large class of poor countries is relatively efficient in using factors of production at its disposal, and that there are few significant inefficiencies in the allocation of these factors. He also seems to have implicitly drawn the line between CSF and the TSF, when he says : "When farmers are limited to traditional factors of production they reach a point after which they can make little or no contribution to economic growth because there are few significant inefficiencies in the allocation of factors, the removal of which would increase current production and because investment made to increase the stock of traditional factors would be costly source of economic growth."[7] Indian farmer is not stupid as is commonly believed; significant elasticities of CSF do not support this belief. Relative prices are an index of profitability and he takes good advantage of it. The risk of facing serious price fluctuations may stimulate him not to postpone but to take the advantage as quickly as possible and allocate acreage according to principles of marginal opportunity costs. When other factors supplied are fixed or are small, opportunity cost of land will be large in relation to product price changes of different crops.

However, there are enough limitations both on the efficiency and usefulness of CSF. These are generally reflected in low price elasticities of some crops, particularly pure subsistence crops.

III

A major reason that lies behind the perennial confusion and controversy over the supply or substitution response is the failure to carry the analysis at the sub-sectoral level. The entire acreage in India could be broadly allocated between commercial and food crops. Food crops are predominantly subsistence crops but a part of the major food crops, such as wheat and rice, is also marketed. Commercial and subsistence sectors differ not only in response but also in methods of production and capital formation. Farmers who operate both subsistence and commercial farms in varying degrees are not likely to show the same degree of response to external stimuli. Three types of substitution elasticities emerge : (1) between one commercial crop and another ; (2) between a commercial crop and a food crop, the latter being either subsistence or partly marketable ; and (3) between one food crop and another, largely of subsistence character. Elasticity will be different in each case ; it will also be different for any one crop in relation to another when moved from one category to another. Elasticities will be different not only because of the character differentiation, but also because of magnitudes involved. For example, because of the smallness of the commercial sector and overall preponderance and importance of the subsistence sector, a given relative shift of acreage between them will appear proportionately large in the former and small in the latter and so will be the corresponding elasticities. Price elasticity will have more content in it if it is known which particular category or sub-sector it refers to ; otherwise one is likely to fall into the trap of making unwarranted generalizations in aggregates.[8] Price elasticity is likely to be high

7. T. W. Schultz: Transforming Traditional Agriculture, New Haven, 1964, p. 24.

8. "The complexity of the structure of production in agriculture frequently leads us to study sub-sectors, which may be geographic, product or both. Aggregation problems arise when an attempt is made to use such results for purposes of national agricultural policy." Marc Nerlove, "Time Series Analysis of the Supply of Agricultural Products" in Earl O. Heady and Others (Ed.): Agricultural Supply Functions, Ames, Iowa, 1961, p. 32.

for the first, low for the second and insignificant for the third. That is why in Raj Krishna's study, price elasticity in the same region varies from 0.1 to 0.7 for different crops and is even negative for jowar, which is a pure subsistence crop. This is not very surprising, though he looks for unconvincing explanation. For example, he makes barley and grain depend entirely on rainfall, *i.e.*, no economic explanatory variable is involved.[9]

Indian agriculture is an inextricable mixture of commercial and subsistence farming, the latter being overwhelmingly more important. Prior to the last quarter of the 19th century, about 95 per cent the area was under subsistence farming; even today it cannot be less than 75 per cent. The traditional division of acreage between food and non-food crops is approximately in the ratio of 8.5 to 1.5 and this ratio has persisted for decades. An increase in income accruing from favourable prices of food crops can cause the expansion of exchange sector only to a limit beyond which the process is reversed, because the farmer is induced to consume more within the family. Even the ratio of farm to non-farm prices becomes of less importance, the greater is the subsistence sector in a region. So long as productivity per acre remains low, pressure on subsistence will further increase by the growth of population. A continued decline in cultivated acreage per head, unaccompanied by a significant increase in productivity, not only militates against commercialisation, but also causes through fragmentation and sub-dividion hundreds of thousands of land holdings becoming uneconomic and of pure subsistence character.[10] This dominance of subsistence explains why acreage always runs close to capacity whatever the prices and however small the unit of cultivation. The smaller the size of the farm, the fewer are the opportunities for crop substitution beyond subsistence. The decline in food surpluses, or rather alarming growth of deficits, shows that subsistence agriculture has nearly reached its development possibility limits within the present state of technology, and that it does not fulfil efficiency conditions for utilizing land as a production base.

There is a crucial relation between subsistence and uncertainty, particularly price uncertainty or the possibility of a given price change being sharply reversed from one season or year to another. Uncertainty here refers not to simply any change in price, but to the unexpectedly high degree of fluctuations and wide variations in price, as well as to uncertainties in production. Despite a given favourable change in price, a farmer's choice of substitution is limited by the risk he runs of having to buy back food later in the season at even higher prices. Even a small miscalculation could easily wipe out livelihood for some members of the family. The farmer simply does not have what Nash has appropriately called the Freedom to Fail. A certain degree of uncertainty can be indirectly included in the econometric model through the addition of the random term in the equation and the use of the expectation function. But it is not possible to take account of the type and degree of uncertainty analysed above in a linear supply or substitution equation.

Thus subsistence and uncertainty set a floor below which acreage of a given crop will not go and a ceiling for the corresponding substitute crop above which

9. Raj Krishna, *Op. cit.*

10. Japan experienced an even bigger decline in acreage per head, but by improving productivity she has met most of her needs internally.

the latter cannot rise. Ceiling and floor to acreage introduce non-linearities in the function. The results produced in section IV below show that a non-linear form of the equation gives a much better fit. Scatter diagrams do not support linearity in any of the known cases in all the three aforementioned categories. The nearest analogy is that of Permanent Income Hypothesis. The acreage for food may change nearly proportionately with change in population, the permanent factor of demand for food, while the price may affect the allocation of the remaining acreage between any two or more substitute crops, particularly between food and non-food.

It has also been noticed that substitution between crops in unirrigated areas, which are also areas of both low resource utilization and poor yield, is rather low unless enough water is available from rainfall. Substitution of one crop for another beyond a limit may result in a fall in the yield per acre.[11] Not only does uncertainty freeze subsistence farming, the latter accentuates the former. When prices fall, more product is likely to be sold to get the minimum cash or barter and thus pushing prices to still higher levels. More often than not, price change in one direction in one period follows the reverse movement in the next. For example, the analysis of relative prices of jute and rice in the Bengal 1909-10 to 1946-47 (38 observations) shows that only for 5 observations the price in the second year moved in the same direction as in the first, and there is only one period of 5 years when prices continuously moved in one direction because of exceptional circumstances, *i.e.*, the period happened to occur in the depression of the 'thirties.[12] A more reliable proof is furnished by our econometric equations of section IV. In the acreage equations for jute and rice, which are substitute crops for each other, the sign of the coefficient or elasticity is positive with respect to price with one period lag, P_{t-1}, and negative with respect to price variable with two periods lag, P_{t-2}. This negative and positive sequence of elasticities reveals that, contrary to the assumptions of lagged models of Raj Krishna and others, there is no continued or lagged adjustment towards a possible optimum. Uncertainty thus reinforces the resistance to efficient substitution and supply functions.

A fundamental difficulty is the introduction of modern commercial activity at some functional level for some clear responsiveness and adjustment to profit-making. Frequent failures of food and raw materials policies of the Government of India, despite a vast planning machinery, can partly be attributed to market inflexibilities, lack of integration and adjustment between different markets, and undue speculation and panicky behaviour of the market operators. When price change in one market is not reflected in another and price differentials become large, arbitrary and economically less functional, farmers' rational economic decisions become difficult. Market uncertainty here refers to the wide range of variations in price and other variables. In such a situation not only is the linear form of the equation inappropriate, but different estimates may also be obtained for the regression coefficients according to the range of variations in different markets and at different periods.[13]

11. M. L. Dantwala, "Trends in Yields per Acre" in N. V. Sovani and V. M. Dandekar (Ed.): Changing India, Bombay, 1961, pp. 21-22.

12. Jute, Commodity Series No. 28, Food and Agriculture Organization of the United Nations, Rome, 1957.

13. S. J. Prais and H. S. Houthakker: The Analysis of Family Budgets, Cambridge, 1955, pp. 47-48.

IV

The following three equations, which are taken from the simplified Nerlove model, are most commonly used in econometric studies in agriculture.

$$Y_t^* = a + bP_{t-1} + u_t \quad \ldots (1)$$

$$Y_t - Y_{t-1} = B(Y_t^* - Y_{t-1}) \quad \ldots (2)$$

$$Y_1 = \alpha + \beta P_{t-1} + \gamma Y_{t-1} + v_t \quad \ldots (3)$$

Y_t^* is the acreage farmers would like to plant for crop Y in period t ; P is the relative price, *i.e.*, the ratio of the product price of Y to that of its substitute; t is subscript for time; u is a random term. The first equation is assumed to depict the long-term supply relation, while the second is called the adjustment equation and B is the adjustment coefficient since there are difficulties assumed for desired adjustment in the short period. The last equation is derived from the first two and is the one which is actually regressed to yield long-term elasticities or coefficients from : $\alpha = aB$, $\beta = bB$ and $\gamma = (1-B)$, and $v_t = Bu_t$.

The most important feature of Nerlove model is not its search for new and more appropriate elasticities, which of course, the model achieves, but the dynamising of both the supply and substitution functions by introducing expectations explicitly, though expected values are not directly observable. Since there are adjustment difficulties, short term and long-term elasticities are bound to be different; the model is made more realistic and amenable to different policies by the introduction of adjustment coefficient. It is to be noted, however, that whereas elasticity is constant around a mean, B, the adjustment coefficient, is constant for every period by assumption, for which no economic justification exists. Although it is conceptually accepted that a full matrix of coefficients, which specify important relationships among all relevant commodities and other variables, is needed for any integrated policy decision, a single equation for supply function with distributed lags cannot be much improved upon by a simultaneous system of equations. In a sense the demand function is implicitly taken account of by the inclusion among independent variables such variables as prices and the dependent variable both with same time lags. Of course, the treatment makes the supply equation more suspect than the demand equation and creates several statistical estimation problems.

Nerlove type functions have not only been extensively used in time-series analysis of supply functions in many countries, but they have also been subjected to continuous searchings, criticism and improved modifications. It is impossible to encompass in this paper all or even major problems involved, particularly those of statistical estimation. However, a brief critical assessment of highly relevant features of the model as applied to backward agriculture is necessary because there is the real danger of either too much or too little being read into it and unnecessary controversies about elasticities cropping up. Remarks would be confined to the type of equations used by Raj Krishna and others and their logical and policy implications for the backward agriculture of India. An alternative algebraic equation is also fitted.

(*i*) The economic specifications of these equations do not justify these equations being called supply relations or functions. No factor inputs other than land are included in the model. Truly it is not easy to handle fixed resources with time-series regression models. But by excluding such variables as factor demand prices, ratios of factor-product prices, or the ratio of prices received and paid by the farmer, etc., the limited usefulness of the Nerlovian model in Indian conditions is clearly brought out, and, therefore, nothing more than a simple crop substitution function emerges from such equations. In the same model as applied to scores of agricultural commodities in the U.S., relative price is defined as the ratio of price received for the commodities to the prices paid by the farmers (thus the function being implicitly if not explicitly a supply function), but in Raj Krishna's and other models one harvest price is deflated by a similar price of the substitute crops. This last mentioned ratio is not relevant in the case of substitution between a commercial crop and a subsistence crop. Though the same model is applied to the U.S. and Indian agriculture, each is based on different specifications ; hence any comparison between their respective elasticities is illegitimate.

(*ii*) The form of the equations in all Indian models is linear. This form is neither supported by scatter diagrams nor by any other test of linearity; it is also inappropriate for reasons mentioned in previous sections, namely, the existence of floors and ceilings to individual crop acreage as set by subsistence and uncertainty. The whole underlying theory of traditional agriculture refutes linearity. As suggested earlier, the most desirable and interesting model would be the one which positively suggests or deals with substitution between food and commercial crops and not the one which limits itself within each group taken separately. We have chosen the most significant and typical case, first of the three aforementioned three categories of highly substitutable commercial and food crops of jute and rice in the Bengal for periods both before and after the Partition. About 95 per cent of the total cultivated area of this State is allocated between jute and rice, the former is purely a commercial crop and the latter predominantly a subsistence crop.[14]

Of the several non-linear functions fitted, the following one gave the best results.

$$1 - \frac{Y_t}{Z_t} = \text{Exp.} - (a_0 + a_1 P_{t-1} + a_2 X_{1t} + a_3 X_{3t} \ldots + u_t \quad \ldots \quad (4)$$

where Y is acreage of jute, Z is acreage for rice. P is relative price and X_1, X_2, etc., are other relevant variables such as yield, rainfall, etc., and u is a random

14. Before the war, India enjoyed monopoly in the supply of jute in the World market and the undivided Bengal Province, situated in the Ganges-Brahmaputra delta, accounted for 90 per cent of total output. The environmental factors like plenty of rainfall, alluvial soil, humidity together with cheap labour made the Bengal an ideal place for the cultivation of jute and its substitute crop, rice. The Partition split the nucleus of the jute belt between India and Pakistan, giving the latter about four-fifth of production. Jute is a fibre used for several purposes ranging from carpet making to ordinary packing.

term. Results from linear and non-linear equations of jute are given below. Figures in brackets are for respective standard errors.

TABLE I

	Price elasticity	R^2	Durbin-Watson Test
Linear	.63 (·11)	·62	1.8
Non-linear	1·21 (·22)	·82	1·8

The two elasticities, however, are not strictly comparable. In the linear equation the elasticity is estimated straight for Y, the jute acreage, whereas in the non-linear equation, it is estimated for a ratio as given in the left hand side of equation (4). If it is desired to derive the elasticity of Y alone from this equation, it will not be a constant but will be dependent on the value of Z, the rice acreage, and will be given by $\eta Y_p = -a(Z-Y)\frac{P}{Y}$. The economic reason behind the concept of varying elasticity is that the farmer's decision about allotting acreage to a commercial crop is taken simultaneously with the decision to fix acreage for subsistence. If other input variations were possible to achieve necessary subsistence supplied from a given land, the assumption of constant elasticity would be perfectly valid. But this is not so. Besides, it is not a simple question of any ratio of acreage of one crop to another, but of the ratio which relates to that part of acreage which is substituted at the margin with limits set by relevant floors and ceilings. That is why the following linear model fitted for the ratio of Y (Jute) to Z (Rice), say K, did not show any remarkable improvement and the elasticity of K with respect to price was .68 against .63 of Y alone. A similar equation for Pakistan jute has yielded still poorer results.[15]

$$K_t = a_o + a_1P_{t-1} + a_2K_{t-1} + u_t \qquad \text{.........(5)}$$

It was suggested earlier that the linear form of the function is also inappropriate for reasons of uncertainty and wide range of variations in prices and other variables. If the period of study is sufficiently long and it could be sub-divided according to some economic reasoning, different estimates are likely to result for each sub-period. "While the application of the least squares regression techniques will still lead to a minimization of the sum of squares of the residuals, they will not be minimized uniformally, and over some ranges the fit will be much better than others. The adoption of an appropriate non-linear form thus has the purpose of minimizing deviations uniformlly over the whole range investigated and is therefore a refinement on the general least square criterion."[16] For the Bengal Province of India Table II gives the estimates of elasticities of jute acreage with

15. S. M. Hussian, *Op. cit.*

16. S. J. Prais and H. S. Houthakker : *Op. cit.*

respect to lagged relative price for different sub-periods as derived from the Nerlovian model. The results provide evidence for the above-mentioned statement of Prais and Houthakker.

TABLE II

Period	Elasticity	R^2	Durbin-Watson Test
1911-1947	.63 (.11)	.62	1.8
1911-1935	.50 (.09)	·71	1.9
1936-1947	1.20 (.39)	.81	2.4
1911-1922	.62 (.14)	.79	2.1
1923-1934	.54 (.12)	.74	1.5
1935-1947	.75 (.24)	.54	1.6
1911-1919	.38 (.19)	.80	1.9
1920-1929	.60 (.19)	.80	1.9
1929-1937	.92 (.22)	.80	1.5
1929-1947	.85 (.22)	.60	1.7

(*iii*) There is some conflict in the justification for taking a longer period for statistical reasons and for not taking it so long for economic reasons. Longer the period , *i.e.*, larger the number of observations, the more consistent and significant are likely to be the values of the parameters in the statistical sense, but the relation fitted would be assumed invariant over the entire period of observations. Consequently, a constant elasticity of expectations, which underlies Nerlovian model can be justifiably assumed only for short periods, and not for long periods. From the point of view of economics, a shorter period may be desirable because economic factors and policies, environment and institutions, and motivations and responses may have undergone such radical changes that past values of the parameters of a relatively longer period may not be relevant for prediction.[17] For example, with the partition of the Bengal Province into India and Pakistan in 1947, and with this partition most of the jute acreage under cultivation going over

17. George Stojkovic has found from study of Swedish agricultural products that despite the goodness of fit for the supply relation, the forecasts in some cases predict changes in the wrong direction. "Market Models for Agricultural Products" in H.O.A. Wold (Ed.): Econometric Model Building, Amsterdam, 1964, p. 414.

to Pakistan whereas most of the factories remaining in India, a very serious situation developed in both countries. A vigorous policy of diverting land to jute was pushed forward by the Indian Government for self-sufficiency, particularly after Pakistan's refusal to devalue her rupee in 1949.

For purposes of comparison with other linear models, the following linear equation for jute acreage for the period 1948-1962 was also fitted:

$$Y_t = a_o + a_1 P_{t-1} + a_2 E_t + u_t \qquad \text{.........(6)}$$

A new variable, E, defined as the annual target of jute fixed officially, was explicitly introduced. The equation produced the best sub-set relation of jute acreage with E and also improved the price elasticity from .60 to .83. This change in elasticity was obviously due to the strong influence of non-price variable and possibly a high coefficient or expectation that was likely to go with it. Whether this was a real improvement or only an addition of upward bias is the sort of problem this model applied to time-series cannot easily answer. It can, however, be said that in economic time-series, just as changes in the dependent variable are unlikely to be independent of what occurred in the past, so are these changes unlikely to be independent of future targets in planning models. The whole problem of prediction takes a different turn: prediction is no longer related to past values of the parameters, but to the changing values of these parameters and to new variables.

(*iv*) In the Nerlove model long-term and short term elasticities are so distinguished and are based on such economic assumptions that the long-term elasticity is bound to be higher than the short term elasticity. On such economic grounds as less than perfect elasticity of input supplies, specificity of factors, etc., it is quite reasonable to argue that long-term elasticity will be higher. But this itself is derived from the equation of short term elasticity, which is defined as the acreage elasticity with respect to price lagged one period. Thus we know the long-term elasticity without knowing the long-term price and long-term quantity or how long is long. This is done by the assumption of constancy of the coefficient or elasticity of adjustment, *i.e.*, B. It is assumed that the producer adjusts his acreage towards some unobservable equilibrium by a constant proportion of the difference between the acreage planted in the previous period and the current equilibrium acreage. Besides, it is only to short term elasticity that a test of significance can be applied and not to the long-term elasticities, because the latter depends on the ratio of his coefficients in the actual equation regressed. Consequently if the adjustment coefficient is estimated low (high), it would automatically mean an over-estimation (under-estimation) of long run elasticities. Equally if short term elasticity is over-or under-estimated, the long-term elasticity will also be over-or under-estimated. Since elasticity of adjustment is independent of prices, its value has to be below unity for long-term elasticity to be higher than short term. If it is unity, the two elasticities will be equal. This elasticity or coefficient of adjustment is derived from the value of the parameter, (1—B) from equation (3). The parameter must take the value $0 < 1-B < 1$ for B to lie between 0 and 1 so that long-term elasticity is greater than shorter term. B is less than unity by assumption. But our econometric linear equations for jute for different periods yield sometimes positive and sometimes negative values, with absolute values less than unity. This means sometimes short term elasticity is higher than long-term, as given in Table III. Another interesting feature is that there is no big difference between short term and long-term elasticities. Hence there is no great functional importance of parameter B, the adjustment coefficient so long as inelasticity of inputs persists. This unusual quantitative result has a strong economic reasoning behind it. Farmers know by experience that change of price in one direction is likely to be reversed in the next period. Once having adopted their acreage in a given period, they are more likely than not to allocate their acreage in the reverse direction unless there are strong reasons for a given price change not to reverse itself. This is their only insurance against risks of serious and wide price fluctuations. In fact, when input supplies are low and fixed, long-term elasticity has no particular meaning. "Under secular expansion, agricultural output slides up a long-run supply curve, but during depression contraction, it falls down a short-run supply function."[18] However, if long-term elasticity has to be brought in, a high CSF elasticity is quite consistent with short term elasticity being higher than long-term. Consequently, no definite policy decision about price policy emerges except that wide fluctuation of prices should be removed.

TABLE III

Period (Jute)	Long-term elasticity	Short-term elasticity
1911-47	.79	.63
1911-35	.43	.50
1935-47	·73	·75
1920-29	.48	.38

V

Whether econometric models and resultant elasticities provide useful knowledge depends upon what problems require answers. If the question to be answered is whether the Indian farmer distributes his fixed land, even if it is very small, between crops in such a way as to maximize profit or total revenue, given a particular set of relative prices and inelasticity of inputs, then the CSF is the proper function to which this question should be addressed. Almost all the econometric studies referred to earlier, including ours, fall in this category. Even then, a CSF relevant to the conditions of rapid and continuous increase in agricultural production, like those of the U.S., and another CSF emerging from stagnant conditions, like those of India, will not answer the same question and not yield the same policy conclusions. It may not be legitimate to compare their results, for it is possible that the CSF with input inelasticity, as being the only relevant function left for farmers' decision-making, may show a higher price elasticity than that shown by a CSF with inputs elastic. To interpret these high elasticities from CSF as a good response would require to state clearly the extremely restricted definition of the term response used in this case as distinguished from other definitions and to make no claim about refuting or supporting a hypothesis which does not fall within the definition of the CSF. Our analysis on jute and rice falls in the same category, though the algebraic form and economic specifications of the function provide a better fit and are more inclusive than the

18. E. O. Heady : Economics of Agricultural Production, New York, 1952, p. 201.

alternative functions. This analysis is also only regional and no national or international comparisons are made. However, it is possible that the Bengal agriculture being more typical of the Indian agriculture, our results may throw some light on agricultural problems of a similar situation in other States.

No major price policy conclusion really emerges from Nerlovian type model, not even the need for removing large price fluctuations. Our model at least points towards this direction. Moreover, Nerlovian models certainly do not provide any guidance for non-price policies like investment planning, educational and extension programmes, etc., which entails a wide range of empirical techniques. What Raj Krishna calls as supply shifters do not seem to shift the supply function at all. Individual crop acreage response and total supply response may conflict with each other under static conditions, and, therfore, it would be fruitless to judge economic performance by price changes alone; the real economic phenomenon and the circumstances surrounding price determination must come first.

Very little has been said so far on TSF. Very few studies in this function exist even in the developed world. A TSF, whether for a single commodity or for aggregate production, must include, directly or indirectly, physical, economic and pricing factors that enter into the production and exchange of agricultural commodities. A single equation models have generally failed to tackle such problems. Neither the economic specifications nor their algebraic forms devised so far have been able to comprehend the true supply functions with all these requirements. A straight supply function defined as product being a linear function of all other quantifiable factors cannot be relied upon because (1) it would involve a very high degree of aggregation, (2) the generality of the fitted function will be reduced since it would apply to only particular combination of all the factors and (3) most of the explanatory variables will be either jointly determined or will be dependent on each other and hence will give biased coefficients.

Therefore a true supply function to be useful will have to be a derived one. It could be derived from the production function under condition of appropriate economic principle (*e.g.*, maximization of profit) so as to yield marginal coefficients which would show whether algebraically significant differences exist between output levels with different discrete treatments. This information, in turn, could be used for economic interpretation of the supply equation. In the absence of this knowledge about production coefficients, some profit may be lost to the farmers unless an input is used at levels that give the most profitable yield. The most commonly used production function is Cobb-Douglas type. The reliability of this function as applied to agriculture has been in serious doubt because several cross-section studies have revealed wide variability of results from year to year, from model to model and from one farm size to another. However, an algebraic derivation of the function in terms of the parameters of the production function and prices of outputs and inputs can be made and Cowling and Gardner have provided such a derivation.[19] But the most important difficulty had been one of data, and this is almost an insuperable problem in India. There is very little information on production functions of Indian agriculture.

19. Keith Cowling and T. W. Gardner, "Analytical Models for Estimating Supply Relations in the Agricultural Sector : A Survey and Critique," *Journal of Agricultural Economics*, Vol. XV, No. 3, June, 1963.

However, an attempt has been made to fit for Indian agriculture an aggregate function which, with whatever data are available, could be treated as approximating to some supply function. It is a crude model and hence its results should be taken with caution. The period is from 1948 to 1962.

$$X_t = a + bP_{t-1} \; cX_t + u_t \qquad \text{..............(7)}$$

X is the all-India index of agricultural production, P is the ratio of index of agricultural prices and that of prices of manufactures, u is a random term. It would have been better to use the index of prices paid by the farmer instead of index of manufactures, but no such series exist. Price elasticity of aggregate output turned out to be —.04. Although the result is statistically not significant and hence not reliable (standard error is more than twice the size of the elasticity), the negative sign of the elasticity was a surprising fact. Output in this period increased by about 30 per cent. Therefore, one may say that (1) either price was not an important factor or other non-price factors, as a part of planning programme, were more relevant or (2) the price policy of the government had not been very rational and helpful to the farmer. With a better price policy, production could have increased much more. Or both (1) and (2) may be correct. No generalization, however, can be made on the basis of this model.

It would be more fruitful to lay stress on normative studies, *i.e.*, studies which use any crucial information for and point towards improving current production methods. Some efforts must be directed towards building up a production function and setting up connection between production, supply and substitution functions for both products and factors, for which it is first necessary to set up a satisfactory economic and mathematical theory for a backward agriculture that would underly any empirical investigation. In the U.S. there is growing emphasis on combining positive and normative approaches by carrying analysis simultaneously with regression models, mathematical programming, budgeting, etc. This approach becomes even more relevant for developing countries in which the government is directly participating in improving agriculture.