PRODUCTION ECONOMICS AND THE MODERNIZATION OF TRADITIONAL AGRICULTURES

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A traditional agriculture operates in a relatively static physical, economic and cultural environment and as a consequence becomes relatively well adjusted to that environment. Modernization of agriculture occurs when substantial and continuing change in the decision-making environment provides incentives to make new farming decisions. Farming then becomes dynamic as farmers attempt to reach constantly shifting points of equilibrium. Agricultural production economics in low income countries has been too much applied to a search for disequilibria within the given static environment and not enough to the possibilities and results of deliberately changing that environment.

The Nature of Traditional Agriculture

As compared to high-income, modernized agriculture, the low-income traditional agricultures of much of Asia, Africa and Latin America, employ a high proportion of their economies' resources at low levels of productivity [6, 9]. Output per man, per acre of land and even per unit of capital are low [11, 12].

Despite a shift of emphasis over the past decade, there remains some controversy concerning the extent to which the low productivity of resources in agriculture is at least in part due to inefficient allocation of resources by farmers. A number of empirical studies of input intensity and enterprise combinations support the view that farmers could increase their incomes if they would combine resources somewhat differently [1, 3, 15]. The contrary view, that farmers do combine enterprises so that the marginal value products of resources are equal in different enterprises and are equal to their marginal costs is more widely held [4, 9, 12, 17, 18].

This controversy has critical policy implications for agricultural development. If there are significant disequilibria within the existing agriculture then presumably the total production from the existing set of resources can be increased through production economics studies and educational programmes which help farmers recognize and remove disequilibria. If, however, farmers are 'poor but efficient', a more substantial effort is needed. The burden of development is shifted to policies for changing the decision-making environment. In addition to farmers, governments and institutions must be moved. This may not only be more difficult but it is likely to intensify competition for resources with development efforts in other sectors of the economy.

The argument that farm resources are used relatively inefficiently in a traditional agriculture assumes that the decision-making environment is so static that farmers have had ample opportunity to gravitate slowly towards an optimal use of resources. The argument does not assume that farmers are particularly effective decision-makers in a dynamic

context. Indeed, farmers used to a static environment may be ill-prepared for decision-making in a dynamic environment—emphasizing the need for production economics advice once the decision-making environment becomes more dynamic.

Empirical studies are likely to be biased towards a conclusion of inefficiency in farming in traditional agricultures because problems of specification and of variability in environment are particularly acute. Study of efficiency in resource allocation is built upon assumptions concerning factor costs, output prices and productivity. These are all highly variable and difficult to determine. Any error in these assumptions will cause a divergence between the farmer's action and the analyst's recommendation. Inefficiencies may be undetected or more likely will be seen where none exist.

The cost of labour input is particularly difficult to determine. In traditional agricultures labour is the most important means of influencing output, either through its importance as a direct input or through its derived importance as a creator of land through land clearing and reclamation activities and of capital through its use to dig wells and to level and terrace land.

The cost of labour in a peasant agriculture is largely determined by the subjective judgment of peasant farmers concerning the utility they derive from material goods and services on the one hand and from leisure on the other [10, 11, 13, 14, 16]. Capital is likewise provided largely from the peasant household and its cost is, therefore, largely determined by a subjective equilibrium between present and future consumption [11].

Clearly the observation that there is labour and capital formation potential available, the utilization of which could increase production, is no more a sign of disequilibrium in a traditional, low-income agriculture than in a modern high-income agriculture. The critical question is not whether added labour or capital would increase production but whether the incremental increase in value of production is greater than the incremental cost of the added labour or capital. It may be appropriate, under certain conditions, to view such labour and capital as costless to society, but it is certainly not costless to the individual. The few available studies on this subject suggest, quite consistent with theory, that the marginal productivity of labour in traditional economies is rather similar to the local wage rate [4].

Determination of discounts and premiums for differing risk and uncertainty situations is always a difficult problem in production economics studies. It is particularly difficult in the context of traditional agricultures because the extent of risk and uncertainty of recommended resource use changes may be particularly great and there may be large variation in the extent of risk aversion. Analyses of resource intensity and enterprise combinations based on assumptions of low risk premiums will often show farmers to be out of equilibrium. Thus in enterprise combination studies which include vegetables, farmers are almost always shown to be devoting too little land to vegetables. Likewise, farmers are usually shown to be using too small an input of purchased inputs such as fertilizers. In each case, the risk and uncertainty factor may be substantial.

Substantial inter-farm variation in enterprise combination and resource use suggest disequilibria, even though averaged data suggest the contrary. However, the relevant question is to what extent variability in resource

use is a result of inefficiency as compared to an economic response to variability in resource structure, resource productivity and input and output prices?

The decision-making environment varies considerably from one farm to another even within very small areas [12]. Certainly the subjectively derived equilibrium for labor allocations between productive work and the range of activities covered under leisure vary depending on the level of income, labour productivity and the utility and value patterns of the farm family [10]. Similar variability occurs in regard to capital cost and risk premiums [11]. The nature of labour force and capital markets are likely to cause even more variability in these matters in traditional agricultures than in modern ones.

Thus variation among farms in resource use may simply reflect substantial variation in the costs and returns to resources and perhaps inefficiency in the working of factor markets rather than inefficiency in the internal organization of farms. These circumstances suggest that in early stages of development any gains from informing farmers of improved production possibilities are likely to be small and they are likely to be single-opportunity gains, not providing the basis for continuous improvement over time.

The useful initial role for agricultural production economics is to provide an understanding of current resource use in agriculture and then from that to provide the basis for understanding what changes in the environment would make a different and more productive use of resources profitable to individual farmers. Once it has been successful in indicating necessary policy changes and these have been implemented, then production economics has an important role to play both by research and extension in demonstrating to the farmer the implications of the changed environment to his decision-making.

In most currently high-income countries there has developed a relatively clear dichotomy between production and farm management economists on the one hand, and public policy analysts on the other. The production economist tends to be oriented towards microeconomics and the making of recommendations to individual farmers. The policy analyst is oriented towards macroeconomics and draws upon and adapts the work of production economists.

In low income countries, where a paucity of knowledge as to how a peasant agriculture works co-exists with a great urgency to modify the environment to achieve increased productivity and production, public policy must be quickly and directly built from production economics research. There is a close unity of interest between production economics research designed to increase farmers' incomes and that destined to foster public policy consistent with public objectives. The common conflict in high income, agricultural surplus nations, whereby production economics research appears to be designed in significant part to help farmers thwart public objectives of lower production and transferral of resources out of agriculture, does not normally arise in early stages of development. Despite this congruence of farmer and public interest, production economics research, in order to fill the dual role of influencing policy and advising farmers, must be framed with a clear view of the policy context. Not all policy which might be helpful to farmers' incomes and production is consistent with the broader public objectives of a nation in early stages of economic development.

The Policy Context for Production Economics Research

Nations currently in early stages of economic development experience rapid growth in demand for food stemming from rapid rates of population growth and rising per capita income. Population growth also adds rapidly to the labour force, often in countries already experiencing heavy population pressures on resources and low and declining labour productivity. Under such circumstances, there is reinforcement of the pressures to shift output and labour allocation away from agriculture. The capital demands for this economic transformation are huge and agriculture as the dominant sector is a prime source for that capital [8, 9].

Thus the burden is on agriculture to increase production of food and fibre as well as to raise rural incomes in the face of severe competition for capital. This provides important constraints on the means of agricultural development and additional challenge to the production economist.

A special opportunity for agricultural development arises from the fact that the existing stock of land, labour and capital resources in the agricultural sector is used at low levels of productivity. It is, however, complicated by the need to greatly increase the use of inputs for which agriculture must compete with other sectors of the economy. Fertilizer is the prime example of such an input, but insecticides, herbicides and small tools represent other important examples. Trained manpower is another scarce, high opportunity cost resource for which agriculture must compete.

Effective intersectoral allocational policy requires a substantial body of knowledge concerning resource productivities in various sectors and under various conditions. Because production economists are in short supply and because they are frequently misdirected into unproductive channels, public policy decisions in these important areas are often made without the necessary facts, quite often to the detriment of development of the agricultural sector with consequent loss of agricultural production and rural income.

Policy Oriented Production Economics Research

Stated in its simplest form, policy oriented production economics research in low-income countries is concerned with discovering, in sequence, (a) what decisions farmers make, (b) why farmers make decisions as they do and (c) what must be changed in the environment to make it profitable for farmers to make different decisions which will increase production.

Public policy is concerned particularly with those output increasing inputs, such as fertilizer, which represent high opportunity cost resources for which agriculture must compete with other sectors of the economy. However, the productivity of these resources must be seen within the framework of their influence on the quantity of low opportunity cost resources which they may attract into production through their complementary relationships. Likewise, if study of such inputs is to be useful in a policy context, it cannot stop at simple description of the current levels of productivity. It must take the next step of analyzing the causes of given levels of productivity and diagnosing the policies which might raise resource productivities.

In viewing resource utilization for policy purposes, the production economist must be concerned with, (a) the physical response and the

potential for effective work in changing this response through research in the biological sciences, (b) the nature and extent of risk and uncertainty, and (c) the effect of present and alternative price relationships.

(a) *Physical Response*

Planning the availability of resources with a large foreign exchange requirement or long lead times requires knowledge of the physical response, under a wide range of conditions, from which an aggregate demand curve can be derived. Such information must be built from farm level data.

In most low-income countries, the aggregate response curve for resources such as fertilizer and water normally declines rather rapidly to levels of unattractive returns. Production economics studies may be useful in indicating the causes of such decline. The problem may be due to inadequate supply of complementary inputs. Large labour inputs may be required, perhaps suggesting direction of enquiry towards labour conserving devices. Insect damage may be important, calling for insecticide supply or perhaps research. Interaction of varieties and agronomic practices may call for education or agronomic research or both. And perhaps most important, basic deficiencies in existing varieties of crops may clearly place a ceiling on response to added input.

In analyzing physical production response, special attention should be given to developing recommendations for biological science research. What is the current response on farms, what problems do farmers have in maintaining profitable response to inputs, and under what conditions do farmers apply technology?

(b) *Risk and Uncertainty*

Both the levels of risk and uncertainty and the associated penalties are commonly high in low-income agricultures. Thus attention should be given to measures which might reduce risk and uncertainty and the efficiency of various public policies tuned to this end. Both the conceptualization of approach and the quantitative tools of analysis need sharpening if production economics is to contribute importantly in this area.

Analysis of risk and uncertainty problems requires attention to three major categories: (a) technical risk, (b) weather risk and (c) price risk. All three are important in the traditional agriculture of low-income nations. Technical risk is great because research and education have not been sufficiently developed and institutionalized to provide a high degree of certainty that a recommended variety or cropping practice will actually work under farmers' conditions.

Weather risk tends to be great because land improvements and water availability have normally not been sufficiently well developed to offset natural variation in weather. There is, of course, a high degree of interaction between new technology and inputs which increase the uniformity of production conditions. With traditional crop varieties, it is common for optimal input levels and yields to be so low that the savings from environmental control through irrigation, drainage and similar devices are relatively low and as a result, no more than minimal investments are made. Technological change greatly increases the returns to such investment. Intelligent and effective allocation of public resources for such

work cannot be made without careful study of the interaction between risk and uncertainty and technological change.

Price risk may also be high in a low-income country in which the distribution infrastructure and information may both be very limited. The result may be market imperfections which increase price instability.

(c) *Prices and Price Policy*

Public policy for agricultural development must deal with the question of the extent to which manipulation of prices and price relationships will influence agricultural production. Several studies indicate relatively elastic supply response to price in regard to substitutions among agricultural commodities [2, 5, 7]. Supply response varies with the underlying physical conditions. Consequently repetition of such studies is required if we are to know the extent to which price policy may be used for achieving a re-allocation of resources and production within the agricultural sector.

Policy for allocation of resources among sectors requires knowledge of aggregate supply response, an area in which existing theory and empirical knowledge are both deficient. Effective research in this area must usefully differentiate between (a) resources purchased from outside the family household and (b) resources supplied by the family household. In regard to purchased resources, the tendency within a traditional agriculture will be for the aggregate quantity used to be small and for the marginal physical response to decline sharply with added input. As the aggregate quantity of such inputs increases and as research raises or maintains physical response, the response of aggregate supply to price will increase. While the quantities of family labour and capital supplied tend to be relatively price inelastic, very little is known about these responses.

A concern with price relationships faced at the farm will draw the production economist into diagnosis of problems in the totality of the institutional framework of input supply and output marketing. In this area too, public policy determination is inhibited by lack of facts from the farm level.

Farm Oriented Production Economics Research

Farmers raised in a relatively static decision-making environment are in particular need of research and research-based educational activities, if they are to adjust to the dynamics of agricultural modernization. Two important sources of dynamism influence the agricultural sector as economic development commences. Shifts in demand with consequent relative changes in prices occur spontaneously as incomes rise and reflect themselves through widely disparate income elasticities of demand for various agricultural commodities [19]. Technological change also shifts the decision-making environment and requires knowledge and ability on the part of the farmer if he is to adjust profitably.

(a) *Changes in Demand*

Economic development brings increased per capita income and consequent rapid growth in demand for livestock products, fruits and vegetables, fats and oils, and other agricultural commodities which have relatively high income elasticities, commonly between unity and two

[19]. Rapid urbanization further reinforces these demand effects of rising income.

Agriculture can play an important role in the overall process of development by meeting such growth in demand through increased production, using the relatively low opportunity cost resources already in the agricultural sector. The alternative is for consumption to shift to other commodities which are likely to have a large component of foreign exchange and other high opportunity cost resources.

Although the rate of growth in demand is high for high income elasticity agricultural commodities, they have a small base of existing production. This poses two problems. First, farmers may not be well equipped by experience to provide increases in production. In this regard, production economics studies are particularly needed to guide farmers in the optimal combination of enterprises and choice of technology.

Second, and probably even more important, the marketing channels, because of the low level of production and marketings in the past, are apt to be inadequate to the rapidly growing demands placed on them. Clearly, the interaction between choice of marketing channels and location and form of production will be great. Here, of course, farm production economics interacts vigorously with public policy. Public policy is likely to play a key role in the growth and development of marketing channels and it is important that policy be guided by a clear view of the range of production possibilities. Public policy will also have to be tuned to the changing requirements for inputs and financing.

In addition to shifts in demand, other factors such as changes in transportation lines and in marketing systems may cause changes in comparative advantage among regions and even among individual farmers within a region. Production economics studies can help farmers understand the meaning of these shifts and to anticipate needed adjustments so that they may be made with a minimum of disruption and a maximum contribution to economic development.

(b) *Change in Technology*

The simplest type of technological change to study is a single-factor change in which a new variety or new insecticide, for example, increases productivity and profitability without any interaction with other inputs or practices. The simplicity of such studies dissuades many economists from making them. This is unfortunate because knowledge of the economics of such simple practices is of great importance and has potential for speeding acceptance of such innovation.

Many innovations have complex interrelationships with other inputs and practices. In these cases, production economics studies may contribute the basis for an educational programme which can greatly increase the profitability of such innovations under farm operating conditions. Such interaction may be with new forms of inputs, underscoring the need for co-ordinating supply of the various complements. Interaction may also occur with traditional input forms such as labour, raising its marginal productivity and inducing further input.

A particularly important form of interaction occurs between new technology and risk and uncertainty. Farmers need to know what changes in risk and uncertainty will result from innovation and how to adjust to them. Often the optimal adjustment is to obtain greater control of the

environment through added investment. Production economics studies can demonstrate such interaction and provide the basis for intelligent decisions as to the means of meeting it.

Special Problems of Production Economics Research in Low Income Countries

The sources of data and the tools of analysis for production economics problems are likely to be relatively similar in high-income and low-income nations. There are a few special problems of research in low-income countries which do influence the choice of tools and data sources.

(a) *Data Sources*

In low-income countries as in high-income countries, important data are drawn from farmers' experience through farm surveys and from experiment station data.

For lack of written records and accounts the interviewer must restrict his farm enquiry to questions for which recall is relatively accurate, or he must interview farmers at frequent intervals. A small number of interviews may be satisfactory for obtaining information about the stock of resources, about production patterns and about output and inputs which are harvested in a concentrated period of time. For inputs which are used over a period of time and for output harvested over a period of time, there may be no substitute for frequent and numerous interviews. Although labour is an important input for which flow information may be required, getting such information from a single interview is almost impossible. Even in cases in which recall might be expected to be satisfactory from a single interview, a combination of lack of experience of the farmer with the questions posed and a reluctance to give information in a context he does not understand may make multiple interviews necessary.

For a number of purposes, functional relationships need to be studied and understood in circumstances in which some variables are controlled more tightly than seems practical using farm data and current statistical techniques. Experiment station data may be used in such circumstances. Carrying over relationships from experiment station conditions to farm operating conditions represents a hazard, even under the best of conditions. In low-income countries, it is doubly difficult. First, experiment station data are often collected under conditions in which variables are more tightly controlled and known than under farm conditions. Second, even though variables may in general be loosely controlled, specific ones may be controlled in manners which are not typical of farm operations. The potential for effective use of highly sophisticated statistical techniques may be particularly high in situations in which a paucity of experiments exists and questions concerning reliability of data and efficacy of piecing them together arise.

Finally, the fact that data problems in low-income countries are somewhat different from those in high-income countries does not mean that research in low-income countries is necessarily less productive or even that it is more difficult. It simply means that consideration of the problem is required and adaptations must be made. Sometimes the adaptation will be to use simpler tools, sometimes to use more complex tools and in other cases it will influence the formulation of the problem.

(b) *Analytical Techniques*

In choosing techniques for analysis of data in low-income countries, three major factors merit special consideration. First we often start from a base of much less knowledge of the environment and hence with much less certain hypotheses. Second, the accuracy of data may be less than that in developed nations. Third, we are short of skilled research personnel.

The tenuousness of hypotheses means that a substantial amount of testing may have to be done. For example, in the context of farm budgeting and programming, uncertainty concerning the nature of restrictions may require setting a large number of restrictions to test the implications of various assumptions. Uncertainty concerning processes may call for trying many more processes in a programme than is typical in a high-income country. Thus, in a developed agriculture, optimal enterprise combinations may frequently be most easily studied by budgeting rather than by mathematical programming techniques, because other research enables us to reduce the restrictions and the number of processes incorporated to a few. In the context of a low-income country we may have to include very large numbers of processes and restrictions. With limited trained personnel, the labour saving characteristic of mathematical techniques may be very valuable. Likewise, if we are short of data, a number of experimental programmes to test the implications of various assumptions concerning the data can tell us in what areas small differences in values affect the results significantly and where they do not. This can help materially in setting priorities for data collection.

On the other hand, because of the paucity of data and experience, it is specially important that the analyst know his data well, which argues for data handling techniques which allow the analyst to see interrelationships as he proceeds. This suggests the great value of preliminary budgeting studies in conjunction with programming studies, as well as the value of iterative techniques of analysis.

Conclusion

With respect to low-income nations and traditional agricultures, agricultural production economics has so far been characterized by excessive emphasis on static description and on finding inefficiencies of operation within the given decision-making environment. It has been insufficiently attuned to the public policy implications of production economics research.

As agricultural development policy becomes effective, the scope for farm management oriented production economics will broaden considerably. The potential for such study grows naturally from demand shifts accompanying development. It is greatly speeded by the processes of technological change which grow out of activities in the public sector. The need for guidance in public policy towards agriculture is greatly increased by the competition for resources between the agricultural and non-agricultural sectors. Since the final objectives of development of both sectors are the same, the resolution of these conflicts lies with research in the economics of production and resource utilization.

Production economics research in low-income nations has the advantage of being able to draw upon the rapid development of research techniques in the last few decades. A more rapid pace of progress is possible

through judicious adaptation of the past advances in methodology made slowly and painstakingly in various parts of the world.

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