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Agricultural Supply Projections[1]

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Introduction

IN this paper I offer a brief review of some of the methods and models that have been proposed or used for making supply projections of the agricultural sector in poor countries. The reason for concentrating on supply projection work is simply that the prediction of agricultural supply is at once more important and more complex than the prediction of demand for agricultural commodities. And, whereas much work has been done in the field of demand projection, supply projection work is comparatively scanty and underdeveloped.

Need for projection

Projections of important magnitudes are indispensable for development planning. 'Whoever has to decide for the future must have some idea of the future.'[2] At the micro level an individual farmer must have some anticipations about weather and the behaviour of prices, in order to allocate the resources in his control in the best possible way. At the macro level, agricultural policy makers must project the demands and supplies of agricultural commodities, on the assumption that current policies will continue. If the projections reveal that serious surpluses or shortages are likely to emerge and, therefore, the real incomes of farmers or consumers are likely to suffer, policy changes can be designed to reduce the expected imbalances. A second series of projections of demands and supplies have then to be made on the assumption of the contemplated policy changes.

Kinds of projections

Projections can be grouped in many different ways. In the first place, we must distinguish between aggregative projections of magnitudes relating to the whole economy, and sectoral projections of magnitudes

[1] This paper was received too late to be presented at the Conference.
[2] Malinvaud, 1965, p. 1188.

relating to a single sector. Sectoral projections can be made only after the necessary aggregative projections of population, labour force, national income, price level, etc., have been made.

Secondly, a distinction must be made between short-term and long-term projections. Using the terminology of the National Bureau of Economic Research, New York, the former may be called *forecasts* and only the latter may be called projections proper.

> Short term forecasting . . . refers to prediction for a period not more than one or two years into the future. It is to be distinguished from two related aspects: the forecasting of long trends . . . and the underlying trends of growth, studied from a historical standpoint. . . .[1]

From the methodological point of view we can distinguish three broad classes of projections:

(1) projections based on interviews and judgements;
(2) projections based on simple statistical techniques; and
(3) projections based on econometric models.

What distinguishes econometric projections from others is that econometric models are based on theoretical propositions which postulate *causal* relationships between different variables and provide some clues as to the signs and magnitudes of coefficients. Non-econometric techniques rely either on the opinions and judgements of people, or on purely empirical regularities or trends detected in data. The regularities may often give good forecasts without necessarily having any theoretical causal basis.

Sometimes, of course, the regularities discovered by painstaking scrutiny of data provide challenges to the theoretician to develop new theoretical propositions causally connecting certain variables which have been found to be connected in fact.

Under the pressure of the requirements of planning, projections are currently being made with all kinds of non-econometric and quasi-econometric techniques. Administrators cannot wait for the slow improvement of the predictive power of econometric models. They must immediately have *some* predictions, with some rough empirical validity, about important variables, in order to make their decisions. Therefore, the output of projections has increased enormously.

The economist is in a peculiar predicament in this situation. Ideally, from his professional point of view, he cannot lend his unqualified support to projection procedures which imply crude and sometimes untenable assumptions about economic relationships. The most accurate possible projection (prediction) of important economic magnitudes is the very rationale of econometric research. His primary task, therefore, is to contribute to the development of theoretically and statistically sound econometric models. But at the same time, until he can provide his own best projections, he cannot just ignore the projections which official workers are doing in a hurry.

[1] Klein, 1955, p. 3.

Faced with this dilemma he must follow the middle path of contributing to the long-run improvement of econometric projections, and the short-run improvement of such *ad hoc* methods as the administrators and their statisticians are using.

Finally, we should distinguish between projections and targets. This distinction has a special significance in the case of the agricultural sector. Projections should be regarded as quantities which are likely to emerge as the result of the decisions of millions of consumers and producers, given a certain framework of government policies. Targets, on the other hand, are quantities which ought to be made to emerge. There are no imperatives of policy or action associated with mere projections; but targets, by definition, imply such imperatives. Targets may be based on projections, but they are not and need not be equal to projections and should be sharply separated from them.

Concepts of supply

When we have in mind the agriculture of poor countries we must distinguish between four concepts of supply: (1) the output of an individual commodity; (2) total agricultural output; (3) market supply of a single commodity; and (4) the market supply of all agricultural commodities. In countries where a major part of agricultural output consists of foodgrains and a major part of the output of foodgrains is directly consumed by the producers the distinction between output and market supply is evidently crucial.

The analytical task is the choice of the most appropriate specification of the supply function for predicting each of the four kinds of supply.

The term 'supply function' is used here not in the narrow, textbook sense of a function linking quantity supplied with the relevant relative price, *ceteris paribus*, but in the more inclusive sense of a function linking the quantity supplied (produced) with all the important explanatory variables.

Let us consider some of the specifications which have been used, in recent years, to predict supply, especially in poor countries.

Projection methods: non-econometric

Every method of projection involves the estimation of important parameters—slopes, ratios, rates of growth, and/or elasticities—linking the predicted variables with explanatory variables, from time series data or cross-section data of some past period. Parameters estimated from data about the recent past are then used to predict the values of the independent variables in future years. Thus retrojection always precedes projection.

When simultaneous equation models are used, a number of variables can be predicted together, if values of a few variables are known exogenously.

Simple methods which may be used to predict agricultural output have

been conveniently listed in the report of the third group of E.C.A.F.E. experts on programming techniques:

(*a*) A simple extrapolation of past trends.
(*b*) Use of regression between sectoral output and G.N.P. or its components, where it is assumed that the latter variables are known from the aggregate projection.
(*c*) Summing up anticipated figures provided by experts in different fields.
(*d*) Use of input–output matrices or commodity balances, together with estimated G.N.P. and its sectoral estimates on the demand side.
(*e*) Use of empirically derived results from international comparative studies.[1]

All these methods have many serious deficiencies. Although trend projection is very popular, it must be realized that there is no logical necessity that past trends should persist. For the specific factors causing the trends, in, say, area and yield per acre of a crop, may operate with different intensities in different time periods. Time may be a useful variable to be added to a well-specified predictive equation for picking up the effect of unspecified causal factors. But there is no basis for using it as the sole substitute for all specific causal variables.

The relationship between the output of a sector and the G.N.P. need not be stable at all. The specification of a simple relation between the two ignores the causal sequences connecting the two on the demand side and the supply side, and is bound to lead to arbitrary projections.

Figures anticipated by 'experts' in different fields are likely to have been arrived at by many different methods. A person who has special administrative or technological knowledge of a sector may be using very amateurish methods for predicting *economic* magnitudes about it. And since the art of econometric prediction is very young even the economist specializing in a certain sector may use very simple methods to produce some figures in a hurry. In any case, figures generated by a variety of experts by a variety of methods need not add up to good projections.

Input–output matrices give the output of individual commodities, on the assumption that final demands are known. But both the final demands and the estimates of total production required to meet them are more in the nature of targets than projections. In the agricultural sector of a poor country the output that should materialize on the basis of assumed input–output coefficients may be very poorly correlated with the output which does in fact materialize.

The difference is not due only to unpredictable climatic changes but also to the extremely high variance of actual output–input ratios in different geographical regions and on different types of farms. This makes average coefficients very unreliable for prediction. There is also the fact that aggregate output is the resultant of the independent decisions of millions of small farmers with their own peculiar ways of responding to changes in climate, technology, prices, and resource supplies. Fixed output–input coefficients abstract altogether from the *economic* responsiveness of farmers to these factors. But their decisions are as critical in the determination of output as merely technical relations.

[1] U.N., 1963, p. 45.

For similar reasons, the use of coefficients derived from different countries for predicting agricultural output in a particular country may be indefensible.

In spite of all their deficiencies, however, the simple projection methods listed by E.C.A.F.E. experts are being widely used. Thus, for example, the Institute of Asian Economic Affairs, Tokyo, has projected the production of different crops for many Asian countries as the product of projected area and projected yield. 'Area and yields per unit of area are both assumed to be functions of time, with parameters estimated by the method of least squares on the basis of statistical data over the 1950s period.'[1] The Institute states that a good deal of attention has been given to specific conditions of agriculture in each country; and many of these conditions have been mentioned. But the precise method whereby the effect of these conditions has been quantified has not been indicated.

In India the Perspective Planning Division of the Planning Commission has projected agricultural output for 1970–1 by projecting the rate of growth of area and yield per acre recorded during 1950–1/1964–5.[2]

In another exercise the targets of agricultural production, based on demand projections, have been justified on the basis of assumptions about area increases, and input-yield coefficients derived from experimental and survey data.[3]

The National Council of Applied Economic Research in India has also projected supply mainly by multiplying projected input supplies by output–input coefficients.[4]

It is not surprising at all that the actual course of output in India in the last few years has deviated from projections by a yawning margin.

Even though economists are unable, at present, to offer good econometric models for projecting agricultural supply, the fact remains that the simple projection methods currently in use will not stand much critical scrutiny. They are likely to produce very undependable projections; and therefore there should be more, not less, public scepticism about the present state of the numerical astrology of agricultural output.

Before any suggestions are made to improve the current projection methods, it is necessary to review the admittedly small amount of econometric work that has been done in poor countries in the field of agricultural supply analysis.

Econometric work

No econometric models seem to have been developed and tested as yet specifically for making projections. The aim of the work done so far is very modest: to test alternative models for their capacity to explain the behaviour of output (or acreage sown) or supply *in the past*. It is hoped, however, that if experiments with past data identify the important

[1] Institute of Asian Economic Affairs, 1964, p. 47.
[2] Government of India, 1966, pp. 33–6.
[3] Government of India, 1964, App. 4.
[4] N.C.A.E.R., 1962, Part III.

explanatory variables, and the appropriate forms of supply functions, they can be used later for projection.

So far as aggregate agricultural output is concerned, there is, as far as the present writer knows, little econometric work to be reviewed. A few attempts have been made to estimate time series production functions with a view to separating the marginal contributions of different input groups.[1] Two attempts to explain output growth in terms of input growth without regression analysis may also be noted.[2]

For explaining the output of individual crops in a multi-crop economy the model used most widely in recent years has been the Nerlovian distibuted lag model of acreage response.[3] The acreage sown, rather than output, is the dependent variable, and lagged relative price, rainfall or some weather index, and other 'supply shifters' such as irrigation capacity and some index of technological change are the explanatory variables. Lagged acreage also occurs as a variable due to the specification of an adjustment or expectation formation mechanism. Price elasticities of acreage with respect to the explanatory variables are considered good approximations of the elasticities of output on the assumption that when the acreage in a crop is varied, other inputs can be varied *pari passu*, and over the relevant ranges of the production function, returns to scale are not diminishing.

Examples of the use of this model to explain changes in crop acreage in poor countries can be found in Krishna, 1963; Mangahas, Recto, and Ruttan, 1966; Venkataramanan, 1958; Stern, 1962; and Behrman, 1966. These and other simpler studies of supply response in poor countries, and the ranges of price elasticities of the acreage of various crops are discussed in Krishna, 1967. The elasticities turn out to be positive in most cases; and lie between 0 and 0·4 in the case of food crops and between 0·4 and 0·7 in the case of the commercial crops, cotton and jute.

As regards market supply, again, very little work has been done so far. The basic reason is that time series of marketed supplies of foodgrains are simply not available. Only some cross-section data are available. These have been used to correlate the market supply with alternative explanatory variables such as acreage, output, or income.[4] The important findings of these studies are (1) that the (cross-section) elasticity of market supply with respect to output exceeds unity; (2) that the surplus-output ratio tends to fall and then to rise as holding-size increases; and (3) that for explaining the variation of the marketed surplus of foodgrains the output of foodgrains is perhaps a better explanatory variable than acreage or income.

A few attempts have also been made to estimate the *price* elasticity of the marketed surplus of wheat and rice indirectly.[5] But for various reasons these estimates are admittedly unreliable.

[1] Krishna, 1964; Parikh, 1965; Minhas, 1966.

[2] Falcon and Gotsch, 1966; and Yamada, 1966. [3] Nerlove, 1958.

[4] Krishna, 1965; Khan and Chowdhry, 1962; Mangahas, Recto, and Ruttan, 1966; and Dharm Narain, 1961.

[5] Krishna, 1962; Mubyarto, 1965; and Behrman, 1966.

In the absence of much progress in the construction of satisfactory marketed surplus models, and in the collection of time series data, official projectors continue to rely on average sale/output ratios of different crops, estimated from surveys, for projecting the marketed surplus. But it is obvious that the use of constant sale-output ratios is likely to produce very misleading projections of the marketed surplus. For making market supply projections the use of coefficients estimated from cross-section regressions of marketed surplus on output would be clearly preferable to the use of constant sale ratios.

Toward econometric projection

There is a crucial reason why the econometric models used hitherto to rationalize past data cannot be used directly for projection work.

If any single-equation model is to be used for predicting the dependent variable, the values of the explanatory variables in future years must be known, assumed, or projected. Thus in order to predict the acreage of a crop from a typical acreage response function, relative price, and weather indices must be known. But it is difficult, if not impossible, to predict these for many years. Similarly, if the yield per acre of a crop is to be predicted from a typical yield equation, input and weather series and indices of technological change must be available. Now, aggregate input levels can be projected on the basis of firm government targets, but there may be wide differences from year to year between total target supplies and actual supplies, and even greater differences between supplies available and supplies actually absorbed and applied by peasants. It is extremely difficult to know *ex ante* the inputs actually used, but these alone determine realized yields, not targets and total supplies. And it is no less difficult to project the course of technological change in agriculture.

These considerations must occasion a very reasonable pessimism about the prospects of projecting agricultural output. Professor D. G. Johnson, after showing how seriously wrong agricultural output projections in the U.S. and the U.S.S.R. have been, says that 'If it has so far proved difficult to make reasonably accurate projections for the United States or the Soviet Union, one can hardly be sanguine about the possibilities for Africa, Asia, or South America.'[1] He adds that projections are useful even though they are subject to substantial error. But it is necessary to be fully aware that due to the very nature of the variables that determine agricultural output they are likely to be always subject to substantial error.

Nevertheless we can deduce from the preceding review some improvements in projection methods which can reduce errors as much as possible.

It is clear, in the first place, that it is not very meaningful to attempt agricultural supply projections for distant years. In the present state of projection methodology we should usually go only a little beyond short-term forecasts, perhaps five or seven years at the most.

Secondly, supply projections must be made separately for reasonably homogeneous agricultural regions before they are aggregated for a whole

[1] Johnson, 1965, p. 1177.

country. This is the obvious way to reduce errors due to the wide geographical variation of important coefficients.

Thirdly, for any multi-crop region the model predicting the allocation of land between crops over time must be a simultaneous equation model, for decisions about the area to be devoted to individual crops are necessarily interdependent.

Fourthly, a great deal of work can and should be done by teams of co-operating economists, meteorologists, and statisticians to discover whatever empirical regularities can possibly be discovered from long-period weather data to make at least some projections of rainfall and other weather variables possible. So long as the behaviour of weather in the near future remains an area of total ignorance agricultural supply projections must remain infirm.

Fifthly, supply prediction models must include prices as endogenous variables. It is assumed here that fairly reliable demand projections are available. Price determination functions can then be included in a prediction model.

Finally, surveys should be conducted to establish some relationships between aggregate input availabilities and the rate of their absorption by peasants in different regions. Government targets can then be translated into real input use figures.

In summary we need to develop and try a simultaneous equation model for predicting the agricultural supply of a given region over a period of five to seven years. Its main constituents are: (1) acreage functions; (2) price determination functions, and (3) yield functions. Demand projections, weather projections, and projections of input supplies actually likely to be consumed, should be available from other studies, and used in the model as exogenous quantities.

It is possible, though not certain, that such a model may give us projections which are less erroneous then the projections now being made with *ad hoc* methods which have little causal–theoretical basis.

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GROUP F. REPORT

THE absence of a prepared paper hampered proceedings somewhat but discussants soon narrowed the topic down to problems of predicting supply response in the less-developed countries. It was agreed that in such countries it was extremely difficult to isolate the effect of price on production because there were so many other factors which influenced farmer's decisions such as the farm infrastructure, water availability, and soil fertility. In many countries, such as Pakistan, prices were not the limiting factor to increased output, nor was land—but rather water, the fertility of the soil, the availability of fertilizer, and existing beliefs.

Some members expressed the view that while economists have adequate tools to measure demand elasticities they lack adequate data on the supply

side—particularly as it related to the over-all farm response to the introduction of new policies or to changes in existing national policies. In such countries, trying to predict supply has nothing to do with supply elasticities as such but rather was conditional upon how much more of the increased supply the farmer would market or retain for his family. At present we lack basic measures of the income effects on production in the less-developed countries.

Other members pointed out that empirical evidence clearly indicates that farmers in less-developed countries are responsive to price changes—but rather than speak of elasticities under such circumstances a more meaningful and descriptive term is 'threshhold values'. In other words the farmer's response is not proportional to the change in price but rather there are certain critical points at which the stimulus of other factors together with price will lead to a large lumpy advance in production. It was pointed out that in such economies we should be trying to predict changes in opportunity and to do this economists would have to devise a measure of the response to learning new techniques or farming methods rather than to normative or traditional price supply factors. All the well-known difficulties relating to data and method should not prevent economists from exploring the potential offered by such situations in the less-developed countries.

It was suggested that studies made in India indicate that farmers there are responsive to price changes and that from such data governments could make policy decisions such as to curtail or limit specific imports.

Other members suggested that it was not difficult to determine supply elasticities but it was extremely difficult to do so at constant prices and it was much more difficult to determine the influence of price as an incentive measure.

In conclusion, despite the fact that economists in the less-developed countries did not have an adequate framework for determining supply response they had to advise with respect to the implementation of agricultural development plans and policies. How then were they to advise farmers, farm suppliers, and governments? It was agreed that the answer was that economists had to predict the outcome of alternative policies in such situations based upon the limited data available and that it was important to try and predict despite the known limitations. One could make predictions on the basis of trial and error but it should be borne in mind that there is a threshold price at which farmers are responsive and will utilize new techniques and increase production sharply. Under such circumstances economists should be aware that previous shortages of food could soon develop into surplus situations—and unless there was a thought-out policy to utilize such production many farm-production schemes could be jeopardized with unfortunate long-term consequences.

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