PART I

Introduction

Chapter 1

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Uses and Concepts in Supply Analysis*

PROBLEMS of supply have long been dominant in agriculture. Less developed countries have needed to understand supply phenomena in order to coax output to levels accommodating adequate human nutrition and larger populations and also to promote general economic development. In more developed economies, and particularly that of the United States, the major recent need has been greater understanding of supply phenomena in order to control surpluses and to raise farm prices and resource incomes. Fundamentally, the need even here is more basic knowledge which relates product output to factor inputs and provides a framework for adjusting production and resource employment to economic growth prospects or trends.

Aside from major developmental concerns with product supply and factor demand in agriculture, improved knowledge would also be useful in other directions. It would make possible more precise forecasts and predictions to aid farmers in making better short-run and long-run decisions on investments and planning. It would be useful in formulating policies directed toward greater stability in farm prices and incomes, and in developing the storage, price, and auxiliary mechanisms which contribute to this end. It would be useful for investment planning by firms producing inputs used by agriculture. On a less aggregative basis and in an interregional competition framework, improved knowledge of product supply and factor demand phenomena would provide a better basis for program projection by extension services and for planning by regional or community bodies. Finally, greater empirical output in respect to supply structure and response would help to satisfy the academic appetites of agricultural and other economists.[1] The major societal concern will, however, remain outstandingly that of gearing food output and resource employment of agriculture to economic growth goals.

In this conference, the questions posed to participants (and, presumably, the papers which they will present) deal quite largely with

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[1]Added information is forthcoming on supply. For example, see Nerlove (15), Heady and Dean (9), and Halvorson (7).

estimating supply parameters and structure. As an end *per se*, quantitative analysis of supply serves mainly to satisfy the academic appetite. Society, in the investment it makes in agricultural economics research for these purposes, would more nearly view quantitative analysis of supply as a means. Supply analysis should eventually serve as a means or foundation for adjusting or changing the structure of the agricultural industry in line with the more ultimate ends of concern to the relevant publics or sectors of society. Useful in this context, supply analysis would specify the relevant variables, along with magnitude of their associated coefficients, to be manipulated in bringing outputs, inputs, and prices of products and resources into line with goals held relative to farm family incomes, food targets, economic growth, or related ends. Certainly these concerns, including the surplus and income problems of the agricultural industry, provide the important reasons for intensification of research in agricultural supply and related functions.

More than ever before, answers to the major problems of American agriculture rest on supply response or output quantities and their inseparable relationships with resource inputs and prices. I emphasize this point because it illustrates certain of the most important needs in empirical work. Useful quantitative analysis of supply will need to extend beyond mere estimates of product supply or factor demand elasticities and coefficients. These are descriptive largely of quantities in past decades and are useful only for projections or forecasts over the short run where the major structure of agriculture might deviate insignificantly from the recent past. Most nations faced with problems of agricultural output, whether from the standpoint of surpluses or food deficits, wish to alter the supply structure, rather than to extend past structure into the future. Productive effort in the area of supply analysis would tell them how to do this and would need to extend far beyond the capacities of most empirical supply studies made to date.

Even in respect to guidance for individual farmers and communities, the major questions of importance are those of changes in supply structure. Largely, they rest on considerations of interregional competition and the relative changes in the structure of supply among regions. They are brought about by technical change, institutional innovations such as vertical integration, and changes in managerial skills of farm operators, as well as the more conventional observations on prices and other variables which economists conventionally have been able to measure and incorporate into their models. Forecasts relating to short-run outlook and year-to-year decisions on hog farrowing, potato acreage, etc., need depend much less, and perhaps scarcely at all, on models which recognize continuous change in basic supply structure. A model or equation based on time-series data allowing forecasts for a single period ahead may be relatively efficient for these purposes. But the set of ultra-short-run choices and decisions which it aids are of much less social import than those which can be aided only by estimates which consider changes in basic structure of supply.

SUPPLY, ADJUSTMENT, AND FACTOR DEMAND

Directly, the major problems of American agriculture are those of supply. They are manifested in commodity cycles with extreme price and income fluctuations for enterprises such as hogs and cattle, in growing surpluses and increasing public costs of storage programs, and in depression of farm income and low relative returns to resources in agriculture. But indirectly and more fundamentally, the basic problems of American agriculture have their roots in the various facets of demand for (use) and supply of resources by the industry. Conceptually, it is impossible to analyze product supply apart from factor demand and prices. Practically, in solving the major adjustment problems of American agriculture, product supply research has little meaning unless it relates closely to explanations of the short-run and long-run supply of and demand for factors in agriculture. In this same vein, it needs to relate to resource productivity, as inputs are used at different levels and in different mixes and as output varies accordingly. Finally, quantitative analyses of supply aimed at providing the solutions to major adjustment problems of agriculture must be made in conjunction with demand analyses, if we are to obtain a more general equilibrium view of the outputs and inputs which might be expected to prevail in a free market, under various alternatives in production and price policies or with alternative programs for altering the mobility of resources attached to farming.

Extremely refined estimates of supply coefficients and elasticities may be unnecessary as a basis for public decision. Most policies representing manipulation of variables to alter product supply and resource employment may well be put into effect before any major flow of new research results, useful for the purpose, is available. Certainly this will be true unless additional resources and vigor are injected into supply analysis. Even then, existing quantitative and qualitative knowledge may already be sufficient for development of improved or necessary policies in respect to product supply and resource employment of agriculture. Should this prove true, agricultural supply research will be restricted largely to the role of guidance for individual farmers and as an exercise in convenience. The competitive structure of agriculture lends itself to measurement and application of conventional empirical models better than other industries. But this writer has greater hopes. Supply research, although complex for the purpose, could provide the basis not only for guidance in general policy formulation, but more specifically for indicating the magnitude by which relevant variables need to be manipulated.

Ideally, models which generate estimates of these types would necessarily be complex and of general equilibrium types. They would entail estimation of the product supply functions, consumer demand functions, and factor demand functions for each major agricultural product and resource. Carried to logical extreme, a model of this sort would include relevant equations for each distinct product in agriculture and the rest of the economy. Such a massive general equilibrium model exceeds the resources of research economists and probably the time span for which the estimates would be most useful for agriculture. To be useful for important policy formulation and guidance of individuals over the next dozen years, a model of this general nature would need to include only agriculture and separate equations for the important product aggregates (those interrelated in surplus accumulation, low prices, and resource adjustment requirements) within the industry.

Even then, as those who have tried can testify, a regression system such as that implied and reliable for predictions is not generated with ease, nor always with signs and error terms for coefficients which cause the investigator great pleasure. Beyond these difficulties are those of formulating general equilibrium models which have utility beyond short-term forecasts and which incorporate the appropriate "shifters or adjusters" as reflected in degrees of fixed resources, in technological change, in uncertainty and knowledge conditions, or other variables which cause response elasticities to change over time but are not observed in the neat units of isolated economic theory. To be most useful in prescribing policies, educational and guidance programs relevant to specific geographic sectors of agriculture, product supply and factor demand equations would need to be estimated by major geographical regions. But again this degree of detail, incorporated into a model which surrounds only the products of the feed grain-livestock economy, becomes computationally complex.

Much can be contributed to knowledge on extent of adjustments needed in agriculture and action and educational programs to facilitate them with much less complicated and sophisticated models. Additional supply or response functions estimated separately by least squares methods for several major agricultural products, or groups of them, could serve for general guidance of policy and educational programs. Issues and policy directions would be clarified considerably if we had greater knowledge of supply elasticities for these products. Not only have agricultural economists expressed conflicting hypotheses about magnitudes of supply elasticities, but conflicting policies have been and are being proposed because different assumptions are implicitly made about these elasticities. For example, proposals for a free market at one extreme and rigid output quotas at the other extreme imply different elasticity magnitudes. The free market policy would suppose elasticities of product supply and factor demand to be large in the short run. Supposition evidently is that a new structure of prices would lead to rapid adaptation of agricultural output and resource employment and, therefore, that the burden of adjustment would be relatively short in duration and light in impact. In contrast, policies of restricting output or of providing price supports with no restraints on output evidently assume these elasticities to be extremely low. Educational programs which emphasize increased farming knowledge for a greater number of rural youth, without parallel opportunities in counseling or vocational education for other occupations, would assume high demand elasticities or low supply elasticities, or both, for labor in agriculture. Quite obviously, the outcome of a particular action or educational program depends on the supply functions for factors, as well as on the supply functions for those commodities which move directly into the consumer market.

What is needed or wanted is change *per se* in the structure of agriculture and supply. Accordingly, research into supply-related quantities must be much broader than the restraints imposed by past regression models. Research directly aimed at changing the parameters of supply is probably more important than that aimed at estimating the parameters of the past or present. For example, analyses which might estimate the rate or quantity by which labor now on farms would be furnished to agriculture or to nonfarm industries under various price relationships would provide useful information for some purposes. But if problems in particular areas of agriculture are to be solved more rapidly or permanently (or, even if our criterion is simply one of giving low-income persons in these areas greater opportunity for higher paying opportunities in rapidly growing sectors of the economy), we need research and services changing the relative supply of labor to agriculture under a given set of price ratios, other things remaining equal.

Conceptually, of course, all variables relevant to such change could be incorporated into a regression model. Practically, however, we must confess that observations and measurements are not available for quantitative operation of such models. To change certain of these parameters, supply-oriented research will include estimating the effects of investment in alternative forms of education and vocational guidance to increase the occupational and geographic mobility of farm people. Prediction of the effects of the variables involved is hardly possible from regression models based on time series data and will need to rest on other approaches. These will often involve greater judgment and less sophistication, but will still represent estimates in supply.

Similarly, other realms of needed information are not likely to be filled by conventional time series approaches. One example is in supply problems relating to interregional competition. If we knew more about the supply functions which will prevail over the future, or the relative changes which will take place among regions, we could do much better in counseling farmers on investment and occupational choices. We could provide improved credit, educational, and compensation programs in areas where production will either grow or decline. But insights into these relevant supply quantities again are not possible from conventional regression models. Broilers provide an example. Regression analysis of time series data prior to 1941 would not have provided much insight into the extent of postwar change in supply functions among areas. As a basis for occupational and investment decisions, many farm people ask whether the regional supply functions will change similarly among regions for hogs, beef, and cotton. Answers, refined or highly approximate, may need to be given by programming or budgetary approaches. Nevertheless, the empirical efforts which provide insights and answers to these changes and questions will still be those of supply analysis.

ALTERNATIVES AND REFINEMENT IN EMPIRICAL TECHNIQUES

We have tried to emphasize that an extremely wide range of information relating to supply functions is needed, both for policy formulation and educational guidance. A wide range of empirical techniques will have to be applied in providing these predictions. They will include regression analysis of time series and cross-sectional samples, mathematical programming, budgeting, less formal models for forecasting output, and others. They also will need to include analysis of national and regional aggregates of outputs and inputs, individual firm functions, and even relationships inherent in such "fixed plants" as an animal or acre. But these numerous alternatives in mathematical technique and degree of aggregation serve as supplements and complements rather than as rivals. The question is not a discrete one of which technique will prevail. Instead, it is a question of which technique is most appropriate for a particular purpose or set of estimates.

All techniques available to us at the present time have extreme limitations for particular purposes. Methodological implications and improvements relative to the data available have been fully explored for none. While the economic, statistical, and mathematical theory underlying the major empirical techniques is relatively satisfactory, the situation in respect to data availability and measurement is indeed different. If our only purpose were to find isolated bits of data to illustrate that certain facets of econometric technique can be applied to actual observations, we would be in fair position. But if we direct our research at the major relationships and problems of agriculture, the data and empirical problems take on quite a different dimension. The empirical approach will have to be decided as much or more on the data which are available or can be synthesized than on theoretical appeal.

Modifications and improvement of quantitative models will need to come especially from those who operate on data, because they are faced directly with the unique problems of aggregation, multicollinearity among variables, and others of available agricultural data which prevent coefficients and quantities from rolling out in neat form. Because many of these problems are inherent in the data rather than in the theory, we can find out what can and will work only by operating on the data available and shifting to another set of variables, degree of aggregation, or source of information if the first is not successful. Certainly, an important amount of effort must go into this trial and error phase of supply research methodology and a major portion must be done by those concerned with quantitative analysis and applied predictions.

MAGNITUDE OF RESEARCH AND DISCIPLINES INVOLVED

Research relating to product supply and its complement of factor demand has not been entirely lacking for agriculture. Many types of information are necessary for a moderately complete knowledge of supply. Much of this knowledge will come from research conducted several steps away from estimation *per se* of supply functions. Perhaps the greatest void over the past two decades has been that the several types of research which contribute to knowledge of supply have not been organized more systematically in this direction, or have not had the supply estimation or contribution as a more precise objective.

The economists who have worked most with the variables or phenomena underlying product supply and factor demand are those in farm management and production economics. Their central task has been analysis of the quantity and mix of the commodities farmers do produce and those which they should produce. Similarly, they have analyzed how these firms do use resources and how they should use them. They have estimated firm and technological production functions. They have analyzed farmers' expectations and planning procedures and the technologies used by farmers. At times they have aggregated food production possibilities and resource requirements for agriculture of the states and of the nation. They have studied decision-making processes of farmers and the effects of uncertainty and alternative economic goals on choices. These are basic data in knowledge of supply and factor demand. Basically, supply rests on these very micro relationships within agriculture. The foundation of product supply and factor demand is the firm's production function. But given knowledge or expectations of it, the commodities the farmer will produce and the resources he will use in any specified period are tempered by the nature of the farm family's economic goals, capital position, investment in fixed factors, expectations of prices, risk aversion, and related quantities or conditions.

The crucial supply information leading to improvement in agricultural policies and educational guidance must come in macro form, by important regional and national aggregates. We need to study the relationships and decision processes underlying individual output choices if we are to understand fully supply phenomena. Eventually, the quantities so derived must be aggregated or lead to improved procedures for estimating supply quantities from aggregate data. Farm management and production economists, the specialists most centrally concerned with the variables and phenomena leading to manifestation of agricultural supply, also have worked on aggregate supply response as much as three decades back. Such contrasting techniques as budgeting and regression analysis have been used, but micro and macro analyses must be related and integrated to improve knowledge of supply structure and improve forecasts of output and resource use.

In a sense, the entire social investment in biological and physical research for agriculture leads directly to the complex of commodity supply and factor demand. The quantities generated here stand at a level with, or beyond if degree of knowledge and uncertainty is considered, market forces in specifying the variables and quantifying parameters which are important in output and input responses. This statement is made not to suggest that economists need simply to count and measure physical scientists and incorporate them as a variable in their models to predict supply functions and resource demands, but to indicate that the group contains persons contributing information basic to supply knowledge. Should we be able to increase substantially our knowledge of conditions surrounding decisions on various types of innovations (e.g., choice of a new production function and expression of new factor demand functions for the farm firm), we could usefully and more readily project from discovery of a new innovation to future output quantities. In any case, the technologist provides necessary information in respect to supply and factor demand quantities for models which provide estimates of normative character. His efforts and cooperation will need to be enlisted for studies which probe supply relationships and prospective outputs beyond the extreme short run or those which deal with major change and interregional competition.

Sociologists, more than any other group of social scientists, have attempted to describe the processes involved in farmer adoption of innovations. Sociological and psychological sciences are importantly involved in providing information on how choices actually are made. Personnel from these fields should be encouraged to intensify their efforts, but they also should be encouraged to cooperate further with economists and vice versa. The sociologist perhaps needs to consider an innovation less as a discrete production function characterized by pure technical complementarity and unrelated to input and output and prices, uncertainty, and the investment period. Under this implicit assumption, adoption of innovations (e.g., selection of a new production function and choice of a different set of inputs and outputs) comes to rest too much on status, leadership, and similar roles and too little on prices and other important quantities.

Historically, other research and operations contributing to knowledge of supply, factor demand, and output have existed and contributed importantly to knowledge. The series of indices dealing with output, resources used, and employment initiated in the Division of Farm Management and Costs and continued under the Farm Economics Research Division of the USDA has provided certain aggregate measurements for these purposes, as well as projections or expectations of these quantities in the future. Estimates of ultra-short-run output responses have long been provided by the Crop and Livestock Reporting Division of A.M.S. These estimates and forecasts are only one step away from formal supply analysis. Dealing some with intentions to plant, farrow, etc., certain of these estimates are macro quantities paralleling the micro quantities provided in analyses of individual farm decision making and plans. Largely, the forecasts during the growing season are *ex poste* to the time of actual decision making and reflect the effect only of weather variables. Forecasting for these particular purposes would provide better farmer guidance if it could be incorporated into an extended time period and decision framework. At levels of national aggregation, demand studies of the past decade also have included supply equations in simultaneous models. Supply relationships have been included mainly for purposes of identification and specification in estimating demand relationships and structure. They have, however, had but minor emphasis and apply more nearly to an extremely short period wherein price and quantity variables are jointly determined. Finally, numerous interpretative analyses of American agriculture have included less technical approaches to agricultural supply, output, and factor demand. Generally, they have been quite usefully related to agricultural policy voids and needs.

This inadequate historic summary of research relating to supply has been included to indicate that our knowledge underlying agricultural supply is not totally lacking, although it is far from complete. Some major efforts, in terms of stage in development of estimating procedures and data, were invested in supply analysis more than three decades ago. Perhaps the lack has been more nearly one of systematic orientation of these various phases of research toward the supply pole. Needed in the future is more comprehensive and systematic research on the facets of production and choice which have supply relationships as their foci. Some of this research is not simple or it would already have been accomplished. Complex problems exist in (1) using aggregate time series data to provide more than a description of past relationships and a basis for short-run predictions (even with so-called long-run models) under technological and other revolutions in structure, (2) meaningful aggregation of estimates from firms and samples, and (3) establishing correspondence between normative and positive estimating procedures. The "shifters" in supply differ greatly from those in demand. Even population growth, per capita income, and income elasticities of demand do not have parallels in supply which can be measured and quantified in a simple, useful manner. It is unlikely that anyone will ever estimate an average price elasticity in supply which will have the same utility and degree of permanence as those which have or can be estimated for demand. To suppose that this can be done is either wishful thinking, hoping for the impossible, or assuming unlimited research resources. Yet it is extremely likely that much more useful quantitative knowledge can be derived with available time series data and empirical tools than has been accumulated to date.

THE PRODUCTION FOUNDATION

As mentioned previously, the production function is the foundation of supply. Under conditions of perfect knowledge in respect to all variables, a firm's static supply function could be derived directly from the production function, given a goal of profit maximization for competitive firms. Using the algebraic form in equation 1 for simplicity, we can illustrate the relationship of the production function to both the static short-run and long-run supply functions and the factor demand function. For the short run, we have the production function in equation 2 where $c = aX_2^{b_2}$ and X_2 is fixed at some specified level. The long-run total cost function is equation 3 when both factors are variable and p_1 and p_2 are prices of the respective factors. Substituting $k = p_2X_2$, the value of the fixed quantity of X_2, into equation 3, we obtain the short-run total cost function (equation 4).

(1) $Y = aX_1^{b_1}X_2^{b_2}$ (2) $Y = cX_1^{b_1}$

(3) $C = p_1X_1 + p_2X_2$ (4) $\bar{C} = k + p_1X_1$

Returning to the short-run production function (equation 2) and expressing input as a function of output, we obtain equation 5 where $n = b_1^{-1}$. Substituting the value of X_1 from equation 5 into equation 4, we obtain the short-run total cost function in equation 6. The marginal cost equation, the derivative of $\bar{C}$ with respect to Y from equation 6, thus becomes equation 7 and is a function of output. Equating equation 7 to p_y, the price of the product, and solving for Y, we obtain the form of the short-run supply curve in equation 8 when X_2 is fixed in magnitude.

(5) $X_1 = c^{-n}Y^n$ (6) $\bar{C} = k + p_1c^{-n}Y^n$

(7) $\frac{d\bar{C}}{dY} = np_1c^{-n}Y^{n-1}$ (8) $Y = \left(b_1c^n\frac{p_y}{p_1}\right)^{\frac{1}{n-1}}$

The magnitude of output is a function of the production coefficients b_1 and b_2, given the magnitudes of X_2, and the commodity prices.

Deriving a short-run factor demand equation, we can multiply equation 2 by p_y, the price of the product, to obtain a total value function (equation 9). Taking the derivative of V with respect to X_1, we obtain the equation of marginal value productivity in equation 10. Setting equation 10 to equal the price of the variable factor, p_1, and solving for X_1, we obtain equation 11, the static demand function for the factor.

(9) $V = p_ycX_1^{b_1}$ (10) $\frac{dV}{dX_1} = b_1p_ycX_1^{b_1-1}$

(11) $X_1 = \left(b_1^{-1}c^{-1}\frac{p_1}{p_y}\right)^{\frac{1}{b_1-1}}$

Returning to the long-run production function (equation 1) and cost function (equation 3), we can derive the long-run static supply function. First, we obtain the marginal rate of substitution of X_2 for X_1 in equation 12. Equating this to the ratio of factor prices, $p_1^{-1}p_2$, and solving for the expansion line for the given price ratio, we obtain X_1 as a function of X_2 in equation 13. Substituting this value of X_1 into equation 3, we obtain the long-run total cost equation in equation 14. Substituting the value of X_1 from equation 13 into equation 1, we obtain the long-run production function in equation 15 which supposes X_1 and X_2 always in

$$(12) \quad \frac{dX_1}{dX_2} = \frac{b_2 X_1}{b_1 X_2} \qquad (13) \quad X_1 = \frac{b_1 p_2}{b_2 p_1} X_2$$

$$(14) \quad C = \left(\frac{b_1 p_2}{b_2} + p_2\right) X_2 \qquad (15) \quad Y = a \left(\frac{b_1 p_2}{b_2 p_1}\right)^{b_1} X_2^{\,b_1+b_2}$$

proportions which minimize costs. From equation 15 we express X_2 as a function of output in equation 16 and substitute the latter value into equation 14 to obtain the long-run total cost equation in 17 where cost is expressed as a function of output. Now, taking the derivative of equation 17, the long-run marginal cost equation is 18. Setting equation 18 equal to p_y, the price per unit of product, and solving for Y, we obtain the form of long-run supply equation in 19.

$$(16) \quad X_2 = \left[a^{-1} \left(\frac{b_2 p_1}{b_1 p_2}\right)^{b_1} Y\right]^{\frac{1}{b_1+b_2}}$$

$$(17) \quad C = \left(\frac{b_1 p_2}{b_2} + p_2\right) \left[a^{-1} \left(\frac{b_2 p_1}{b_1 p_2}\right)^{b_1} Y\right]^{\frac{1}{b_1+b_2}}$$

$$(18) \quad \frac{dC}{dY} = \frac{1}{b_1+b_2} \left(\frac{b_2 p_2}{b_2} + p_2\right) \left[a^{-1} \left(\frac{b_2 p_1}{b_1 p_2}\right)^{b_1}\right]^{\frac{1}{b_1+b_2}} Y^{\frac{1-b_1-b_2}{b_1+b_2}}$$

$$(19) \quad Y = a^{\frac{1}{1-b_1-b_2}} \left(\frac{b_1}{p_1}\right)^{\frac{b_1}{1-b_1-b_2}} \left(\frac{b_2}{p_2}\right)^{\frac{b_2}{1-b_1-b_2}} p_y^{\frac{b_1+b_2}{1-b_1-b_2}}$$

The optimum long-run output, Y, supposing that price and the production function are correctly anticipated and the farmer maximizes profits, then is determined by the price of the two factors, p_1 and p_2, and the price of the product, p_y.[2]

[2]Given interest in elasticities of product supply and factor demand in relation to product price and factor price, respectively, we could compute the short-run elasticity of supply and demand, respectively, from equations 8 and 11. The long-run supply elasticity could be derived from equation 19. Similarly, we could derive a long-run resource demand function paralleling equation 19 and compute elasticities accordingly. However, we do not do so in order to conserve space and because their derivation is obvious.

Point of Departure

The static supply function above, derived from the relevant production function and set of commodity prices, thus provides a conceptual starting point in analysis of farmer output responses. By incorporating variables to represent new innovations, the knowledge of productivity coefficients for very particular resources previously thought to be zero, we could account for technological change. Of course, the assumptions implied in deriving supply and demand functions such as equations 8, 11, and 19 from the production function (equation 1) hardly square with decision-making conditions of the real world. If they did, we would only need derive production functions for farms of a sample, aggregate them by appropriate weights, and produce the regional or industry supply function. Or, under certain conditions, unlikely ever to be completely fulfilled, we could estimate the production function from an interfarm sample and derive a single supply function directly from it. Yet even though empirical operations of the latter type are not directly possible, the equations 1 through 19 generally provide the inventory of types of variables and parameters we try to use and estimate in deriving actual output response functions by means of regression procedures or in projecting possible responses by programming, budgeting, or related techniques. In fact, the normative supply functions derived by budgeting and linear programming generally employ the same assumptions as implied in going from equation 1 to the supply and demand equations in 8 and 11, respectively. However, they also include, as well as a moderate dose of subjective judgment, certain other assumptions about the nature of fixed resources and form of the production function. Use of normative procedures such as programming or budgeting does not obviate need for knowledge of the production function.

Complexities Relating to the Production Function

As stated above, supply functions could be derived directly from production functions if uncertainty, capital rationing, lack of knowledge, nonmonetary goals, and lumpiness of fixed factors did not exist. Absence of these and related conditions would allow us to estimate production functions first, then derive the product supply and factor demand functions. Even in the absence of these conditions, we would still be faced with empirical difficulties in estimating the underlying production functions from which the supply and demand equations must be derived.

One difficulty is that relatively few firms in agriculture produce single products. This fact would not bother us if (1) all products were competitive technically, produced together only because of the relationships between prices and substitution rates, and (2) the inputs used for each could be measured accurately and independently. But in most farming regions, commodities are produced in combinations because they are complementary and supplementary over some range. Too, services of many resources cannot be allocated very precisely among the several products into which they are transformed. This is true for durable types of assets which give rise to flows of input services regardless of the quantity of use for a particular product. Then, too, the degree of multicollinearity, difficulties of measurement, and inability to incorporate a large number of unique input categories into a satisfactory set of regression estimates necessitate aggregation of resources into a few gross categories for farm production function studies. The fact that some important resource categories are neither pure complements nor substitutes but serve as both, within the input magnitudes usually encountered, also complicates problems of estimation. Similarly, except in a few highly specialized and peculiar climatic areas, outputs must be aggregated by value transformations. These aggregation requirements themselves prevent derivation of clear cut commodity supply functions from production functions.

Many other measurement difficulties also prevent us from deriving production functions which can be used for computing clear cut normative supply functions. For this reason, economists have turned to budgeting and programming to estimate what farmers might produce under pure goals of profit maximization and perfect knowledge of production and price parameters. (These alternatives do not, as mentioned previously, eliminate need for knowledge of production functions.) Particularly bothersome are errors stemming from specification biases and inability to measure inputs such as management, information, and related items (cf. 6, 10). For resources clearly used up in a single production period, as seed for annual crops, measurement is simple. Slightly more difficult is measurement of inputs of fertilizer where some residual remains. At a higher level of difficulty are semidurable capital items such as machines and buildings which may provide service in proportion to some uses but which also depreciate even under nonuse. In the case of seed and, even though imperfectly, fertilizer, we measure capital input by value or input of the resource itself. We cannot measure input for machines and buildings similarly. We can attempt to measure input by services or depreciation during a particular production period. Yet given the mixture of stocks and flow services representing these assets, these efforts will usually lack complete accuracy. If interfarm differences in technology could be adequately identified and measured by input categories, farm production functions could be estimated, and product supply and factor demand equations derived from them much more readily and meaningfully.

Obviously, additional investigations are needed to establish a closer and more useful empirical linkage between production functions and supply. The major portion of public investment in physical and biological research relates to fully discovering or changing the production function. One major attempt to link knowledge of the agricultural production function and supply or output was the agricultural production capacity studies conducted in 1951 by agricultural economists and technologists (1). Black and Bonnen used essentially these data in projecting output to 1965, without measurement of possible effects of prices and other relevant variables in altering the mix over the next two decades, to point up the likelihood of a continuing surplus problem (3). Certainly, we could use a much more formal and systematic linkage between these major research efforts in the general realm of the production function and supply.

POSITIVE AND NORMATIVE APPROACHES

The slight excursion into the realm of output and supply has already brought us into contact with concepts of what farmers do and what they can, might, or should do. These are the two poles from which agricultural supply has been attacked in the past. They will continue to provide the two major directions from which empirical estimates are approached. Whether the one or the other approach is used will and should depend on the nature and purpose of the estimates. Each has its limitations, as well as advantages, for particular purposes and in respect to particular estimational objectives.

Terms which have come to broadly categorized the two separate approaches are positive and normative. This distinction stems partly, but not entirely, from J. M. Keynes' early discussion of methodology in political economy (13). Positive analysis has come, especially in considerations of supply by the North Central Farm Management Research Committee, to mean prediction of quantitative relationships among variables as they actually do exist at a point in time, or have existed over a period of time. Other terms sometimes used to describe this same type of empirical effort are descriptive and predictive. Within the limitations of technique, the analysis describes structure as it actually exists, and, hence, can be used to predict the magnitude of one variable from the magnitudes of others. In contrast, normative analysis refers to what ought to exist, under certain assumptions. The term normative departs from the Keynesian concept in the sense that it is not an ethical or value consideration, but simply an indication of what might be expected to happen if decision makers possess certain goals and knowledge and are free from certain resource and institutional restraints. Both the positive and normative approaches entail formulation of empirical models for use in predicting or estimating real world quantities. The efficiency of either thus depends on whether the relevant variables are included and accurately measured in the empirical model and how well they correspond with the real world conditions as they will exist during the period for which predictions are to be made.

The major tools for positive analysis are regression procedures, less refined methods of projection or others which attempt predictions from observations drawn out of the "actual operating world." The major tools for normative analysis include budgeting, programming, judgment, and related techniques. Here, certain assumptions are normally made about goals and actions of decision makers. Quantities consistent with these are derived. A somewhat pure example of this approach is illustrated in certain linear programming analyses of supply where the resource restraints are defined to represent different degrees of fixities and lengths of run, with programming used to specify optimum or profit-maximizing outputs at different levels of factor or product prices. Budgeting procedures such as those used by Mighell and others (14) are similarly normative, except that the estimates arising were more tempered, as one subjective linkage with positive aspects, with judgment of what farmers would do. How closely programming results parallel actual outcomes will depend, just as is true for budgetary analysis, on the manner that restraints are built into the model to correspond to the real world inflexibilities. Normative product supply and factor demand functions also can be derived from statistical production functions. The steps outlined in equations 1 through 17 illustrate the method.

Both positive and normative approaches have been and are being used because of the limitations of the estimates derived by each. Our conscience could rest if positive approaches existed enabling us to use coefficients generated in the actual process of farmer choice and decision in more accurately predicting production response at relevant periods in the future. But here is the major limitation of regression studies. Regression models based on time series observations cannot predict in light of new variables and structures, previously unencountered but known to exist for the future. They are necessarily tied to the past and are reflections of historic relationships. No satisfactory method is in sight for incorporating major changes in technology, institutions, and government policy into regression approaches. In supply, it is the quantity of the future, rather than the record of the past, that is important. The linkage is much weaker and less important in producer response than it is in consumer demand. True, most regression models of supply functions, of either the so-called short-run or long-run types, are useful and quite accurate for short-run predictions of aggregate outputs. This is particularly true for models where output in period t is regressed on output in t-1. Because of statistical necessity, regression models are highly aggregate in respect to inputs and cannot reflect quantitative effects of many specific variables of interest.

These limitations of regression models have caused research workers to turn to budgeting and related techniques. Models of the latter type allow analysis of the possible effect of new variables on the horizon and more detailed examination of specific variables. Estimates of product outputs and factor demands for more individual commodities can be analyzed. They also provide a method for estimating supply for firms where time series observations are not recorded or available and samples for cross-sectional analysis can provide only a set of mongrel relationships among short-run and long-run functions over an extremely small range of prices and similar parameters. Normative programming models also have an advantage over descriptive regression models in dealing with length of run as it relates to supply. Magnitude of output can be related quite precisely to extent and kind of fixed assets with programming, but not with regression models.

However, normative procedures, in turn, have had limitations not associated with the major positive procedures. One of these limitations concerns spatial aggregation. While national or regional aggregates can be handled quite readily by regression models, the same is not true with a programming model, for example. A programming model, using a single region or the nation as the aggregate producing unit, could be easily devised to meet all mathematical requirements of the technique; but the results might have little meaning. If restraints of sufficient quantity and variety are included, it might generate quantities paralleling those realized in the past. Yet these same restraints, devised to tell the historic story, would have the same limitations as a regression model in predicting a future subject to important technological or institutional changes. A regional or national model, formulated to represent a single producing unit and to allow a new environment of technology, institutions, and response, would be unlikely to provide a supply function approaching one representing the aggregate for individual firms producing under a variety of conditions in respect to soils, capital, tenure, fixed resources, and other variables which modify farmers' response to product and factor prices.

In contrast to a programming model for a region as the producing unit, one can be derived for individual farms of a regional sample. A normative supply curve then can be computed for each farm, either separately or as part of a single computational model. If a representative sample is used and programming functions are computed for each farm, these can be aggregated directly, either after programming computations or in the computational process, to give a normative supply function for the region. (Use of "typical" farms gives rise to aggregation problems of greater complexity.) However, even though approaches such as these can be used in estimating an aggregate supply relationship of normative nature, the computational and financial burden would be great for aggregates at the national level.

While all normative and positive approaches have limitations unique to their type, each can add something to knowledge about product supply and factor demand in agriculture. Our current knowledge in respect to the effect of numerous variables on product supply and factor demand and use is relatively small. Even though they are tied closely to history, regression and other positive approaches are useful in giving some indication of the quantitative relationship between price and related changes and supply as they exist under actual decisions of farmers. Predicted for relatively small homogeneous regions, problems of the product and factor aggregation can be partly overcome. Similarly, a material increase in the magnitude of normative analyses may well provide means for overcoming difficulties inherent thus far in the procedure and for relating predictions from this method with those of regression estimates.

Additional Approaches and Comparisons Needed

Studies at various levels of geographic, product, and factor aggregation are needed, regardless of whether positive, normative, or related methods are used. Firm studies which can better quantify the decision-making process of individual farmers in respect to uncertainty, fixed assets or investment policy, technical innovations, and nonprofit goals also can lead eventually to greater knowledge of aggregate product supply and factor demand. Generally, these will need to be made over a considerable number of years with farm samples constructed to account for firms which both enter and leave the supplying scene. Such samples have been used for periods of 2 or 3 years (11, 17), but they will need to be extended over much longer periods if they are to provide detailed and dependable findings relating to the dynamics of supply. The decision-making processes of farmers and their plans in view of price and other expectations need to be linked more closely with their actual plans and outputs. On an aggregate and short-run basis, a partial linkage has been made in planned and actual inputs (and, hence, indirectly in outputs) through the crop and livestock estimates of the Agricultural Marketing Service. Data for intended and actual farrowing and planting are available as time series observations. However, these have not been sufficiently analyzed to indicate the quantitative effect of prices and other variables in causing deviation between plans and commitments or actual inputs and outputs.[3]

Linkage between normative firm supply functions derived by programming and statistical (sample) studies of farmers' intentions (decisions on inputs and outputs in respect to price and other expectations) and actual investment and outputs also is needed. Given this connection, we would have knowledge of the extent to which normative quantities must be discounted or otherwise modified to conform with (1) farmers' planned inputs and outputs and (2) actual investments and production response. This knowledge would provide an improved basis for projecting from major structural changes on the horizon to investments and supply or output over the longer run. Models based on inventory (2) and decision theories (5, 12, 16, 18) may have some utility in making this linkage. Finally, as mentioned earlier, the normative supply functions which can be derived from statistical production functions and the supply functions derived from programming models need to be linked with actual decision-making processes of farmers.

DYNAMICS OR CHANGE IN SUPPLY

The major challenge in empirical supply analysis is to identify, measure, and express the quantitative effect of variables which cause

[3] These data, although extremely useful for the short-run projections intended, extend over a period which is too short for determining the quantitative importance of variables relating to longer-run investment decisions and the dynamics of supply.

agricultural supply to change with time. Some agricultural economists regard this, aside from short-run outlook projections which need be little concerned with the dynamics of supply and which can be based more on historic estimates of structure, as the only justification for large outlays for supply analysis. They would classify regression analysis of aggregate time series data largely as empirical doodling to illustrate certain logical arguments in mathematics and economics. Certain micro programming analyses would be similarly classified. The situation of agriculture and the pressing problems of the industry, they contend, call for "forward analysis," since past elasticities or the difference between short-run and long-run elasticities over past decades have little import for the future. They would emphasize that solutions of agriculture's problems depend on the changing structure of markets and supply, and on control in these structures by agriculture.

This writer would agree generally with this concept of the agricultural supply problem, particularly as one of projecting into the future and having weak links with data and coefficients of the past. Technological change, developments in market institutions and structure, government programs, increased educational and informational services leading to greater on-farm and off-farm mobility of resources, and related phenomena limit the usefulness of coefficients based on time series data. Yet it is largely by analysis of data available in this form that we can more fully understand the dynamics of supply — the change in supply over time or the relation of output in one period to the magnitude of variables (which can be measured) in earlier periods.

Fixed Resources

The existence of fixed resources, as simple as the concept might seem, poses important estimational problems in supply analysis. We are acquainted with the orthodox concepts of short-run and long-run supply, and the fan family of supply functions over different time periods as the restraints of fixed resources are lifted. Yet, to date, we have been unable to incorporate these types of relationships into regression analyses at either the macro or micro level. We can handle these relationships better with programming models, but we are still confronted with difficulties in deriving aggregate output responses for different periods corresponding to levels of fixed factors. The latter models are no better in supply prediction than the assumptions made in respect to fixed resources and technical coefficients. The usefulness of programming models in supply projections approaching reality will depend not only on the extent to which (1) appropriate statistical distribution of resource fixities has been used over time and among firms and (2) inputs of one period can be related to outputs in later periods, but on the extent to which (3) the effects of other considerations that place differential restraints on production over different time periods can be incorporated.

Fixity is a problem, especially because the period over which services are provided differs greatly among resources. Even fertilizer, a resource which would appear to have little fixity, applied at one time has residual response effects for different months within the season and between production years. Some resources consist mostly of flow services provided at particular rates in given time periods regardless of whether products are produced. Within the period, the prices of the resources or their services have little relationship to production response. Outputs of one period are supplementary to outputs of another period, and product prices between periods may have little relationship to the distribution of outputs over time. Services of buildings, machines, and labor with low mobility fall in this category, as do other resources in the extreme short run.

Other fixed resources represent stock services, with the amount available in one period depending on the amounts of services used and products produced in another period. Harvested feed for cash sales or livestock production is an extreme example, but certain of the services of machinery and land also fall in this category. The outputs of different periods, then, are competitive and can be related to prices of the same product in different time periods. The space services of land are so represented, and soil may be fallowed or cropped depending on the price in one year as compared with two years ahead. In contrast, other products may be complementary in respect to use of a resource or its services. Corn output, summed over a period of years, can be greater if the land is used for legumes this year because nitrogen and soil structure produced by hay become inputs for grain. Or, complementarity may surround the moisture services of a fixed farm acreage, with wheat output greater in t because land was fallowed in $t-1$ (8).

Even aside from other complexities surrounding changes in output response with time, we have few empirical measurements relating supply functions of different periods and their change with fixed resources. Of course, we have knowledge of the contrasting response of output to price within breeding and planting periods, when brood animals and planted acreage are fixed, as compared with interyear differences for individual commodities. But we have not yet been able to use regression analysis to penetrate much further into this general problem of time and fixed resources in relation to supply elasticity, especially in respect to agricultural output in aggregate. Some major conflicts in policy elements to remove surpluses and low incomes rest on suppositions in respect to the degree of fixity of resources, the nature of price alternatives for their services, and the corresponding output response in agriculture. The hypotheses which might be generated from Cochrane's work (4) as compared with current proposals of free market prices is an example.

Expectations and Uncertainty

Little connection also has been made to date between studies of farmers' expectations and uncertainty and the dynamics of supply. Starting at the other end, in his pioneering empirical work Nerlove has interestingly introduced concepts of distributed lags into aggregate regression analysis of supply to indicate how change in price in one period might be reflected in lagged producer behavior in later periods. Here the realistic assumption is used that farmers do not make full adjustments within a discrete period, but instead distribute their adjustments among future periods until they finally approach some optimum or maximum position. The supply elasticities are based on a model assuming certain characteristics of price expectations for farmers. Uncertainty surrounding price expectations provides one reason or basis for using a model supposing distributed lags in response.

Expectations in one period relative to prices in the following period might be held with great uncertainty and discounted accordingly. Hence, adjustment of production to this "expected" level would not be as complete as in the next period for which the same "most probable level of expectation" might be held but with less uncertainty because of knowledge gained over time. Hence, adjustment of production toward a given "most probable" or "normal" expected level of price should continue with time as knowledge is gained and uncertainty declines.

This approach appears especially appropriate for changes in plans prior to a response period. Assume for example, that a hog producer begins formulating his expectations for hog prices in May of year t in July of t-1. He is preparing plans for breeding in November of t-1, with farrowing and sale in March and September, respectively, of t. If the expectation of "normal" or "most probable" price formulated in July of t-1 is surrounded with great uncertainty, his adjustment in planned breedings and farrowings may be small. If he holds the same normal or most probable expectations of price in August, his planned breedings and farrowings may be adjusted nearer to a possible optimum or maximum. September, October, and November may lead to further adjustments toward this optimum if his knowledge increases and uncertainty declines regarding the same expectation of normal or most probable price. Similar adjustments may be highly realistic between years in building up dairy or beef herds where more time is required; knowledge may increase and uncertainty may decrease with time and the normal or most probable price expected remains similar between years.

But where prices fluctuate considerably and an entirely new normal or most probable magnitude of expected price arises frequently or before each period in which resources are recommitted, as continued or lagged adjustment toward a possible optimum or maximum probably does not occur. Hence, a similar degree of uncertainty may arise each year, rather than decrease over several years with further adjustment to the optimum ordered accordingly. Finally, adjustments which do take place for many products are not made against a price expectation in a single period but against those of several periods over which new investments must be made.

Some important new ideas relating to expectations and dynamic supply adjustments have been injected into the empirical streams by studies such as Nerlove's. However, much or most of the warp and woof of expectations and producer response is left to be unraveled. The task is difficult and may well be accomplished first at the micro and less aggregate level of analysis.

Technological Change

The truly important economic and adjustment problems of commercial agriculture revolve around the national aggregate of output. The important dynamic foundation of changes in aggregate output is the numerous variables encompassed by the phenomenon termed "technological change." These variables are difficult to measure and express in direct quantitative and logical relation to supply. New resources arise as specific capital items or innovations, and they do not have price observations tying them with time series observations of other variables. Even if they did, they are numerous and cannot be introduced separately in a model of modest aggregation. The production processes (research in private and public institutions) which give rise to them logically fit into the framework of supply and factor demand, but true quantitative relationships are thus far lacking. We have employed models with catch all variables such as time and lagged output (largely a substitute for time in input, output, and consumption series of the types typically analyzed by economists), but we have accomplished little in relating inputs and outputs of this general process and category to agricultural outputs in later periods.

SUPPLY OF FACTORS

The three considerations mentioned above (fixed costs, expectations and uncertainty, and technological change) provide the most important areas for research relating to producer behavior in different periods and change in supply over time. Perhaps equally important in explaining other unique characteristics of agricultural supply is study of the supply of factors to agriculture. When we can better explain the supply functions and reservation prices for such factors as labor, land, and capital improvements in farming, we will have gone most of the way in getting at some of the elasticity quantities which give rise to surplus and income problems within agriculture (and to debates among agricultural economists). We know so little about supply relationships for farm labor that we cannot predict the timing and income levels under which different price schemes would eliminate the surplus problem.. We do not fully understand why such large quantities of labor can be withdrawn from agriculture, as during the last decade, without decreasing total output, or why the process of migration and farm consolidation does not occur more rapidly. Similarly, we know little about price levels which would cause land and auxiliary resources to be shifted from crops in surplus to grass, forestry, and recreation areas. Neither do we know anything of importance about the dynamics of this supply situation and the lag with which shifts would take place, or the lag in labor migration and the persistence of income depression. Even though we are investing large quantities and directly paying prices to build up a supply of land in nonagricultural uses (land withdrawal and soil banks), we know practically nothing about the supply function of land in particular regions or the relationship of labor supply to land supply within this complex. Knowledge in these areas of factor supply can serve as the basis for guiding individual farm adjustments. Given more information on labor migration and land availability, we would know more about opportunities and costs and timing for farm consolidations and capital acquisition.

From the standpoint of major national farm problems, supply knowledge at the level of aggregate output for all commodities is more important than detailed knowledge of elasticities and coefficients for a large number of individual commodities. This aspect should not be forgotten, as it might, as momentum in supply analysis and producer behavior increases. Certainly, refined statistics for individual commodities and farming areas will increase our knowledge in the general area of supply. We need them for both individual guidance and policy. But unless an elaborate model of computational feasibility containing the appropriate numbers and forms of equations can be formulated, we will still know little about the forces molding the aggregate agricultural output. Our start here is probably in factor supply and its dynamics.

THE NEED

We have pointed out only a few of the major concepts, problems, and social implications relating to increased knowledge of agricultural supply and producer behavior. While the area of research is receiving increased attention, much is left to be done. This conference represents an attempt to focus emphasis on this need. It should serve as an aid in exchange of knowledge and hypotheses, as well as an interpersonal stimulation of imagination. This is the purpose for which it was designed, and its product should certainly flow forth in future years, even if only in distributed lag fashion.

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Discussion

HEADY'S PAPER provides an excellent springboard for this workshop on "Estimating and Interpreting Farm Supply Functions." It provides a comprehensive framework for an understanding of both the nature and the urgency of some of the improvements needed in analyses of supply response; the critical relationships between supply response and resource inputs, prices, and related factors; both the history and the current state of the arts as well as some of the obstacles which confront us in our efforts to unravel these relationships; and the advantages, shortcomings, and needed adaptations of the analytical tools generally in use in this broad area of research. That I have no major quarrel with the paper will be readily apparent.

Heady seems to agree with one of the conclusions of the conference on "Adjusting Commercial Agriculture to Economic Growth" called in Chicago in 1957, by the North Central Farm Management Research Committee namely, that instead of attempting to manipulate food demand, it is "the mechanism associated with achieving adjustment of farm production which should be analyzed in our efforts to solve the farm problem and achieve future economic adjustments." He does stress, however, the importance of factor demand and prices, and suggests that the basic problems of American agriculture have their roots in the demand and supply of resources used by the industry.

Our fundamental need is represented as the need for basic knowledge which will relate product output to factor inputs and provide a framework for altering the supply structure by adjusting production and resource employment with economic growth. Societal concern, rather than the individual firm, and forward-looking appraisals, rather than those of historic relationships, are stressed. A wide range of information relating to supply functions is said to be needed, as is a wide range of empirical techniques, with data characteristics and limitations frequently the major determinants of the most appropriate techniques to be used. The latter point, I think, is especially important today with all of the gaps and inadequacies in our data; but I hope the day is not too far away when we can have access to the data required to utilize fully our most appropriate techniques.

The production function is deemed to be the foundation of supply, but product supply and factor demand functions cannot be derived directly from production functions because of uncertainty, capital rationing, imperfect knowledge, lumpiness of fixed factors, nonmonetary goals, and various measurement difficulties. Normative analyses, that is, analyses of what producers would do if they had certain goals and knowledge and were free from certain resource and institutional restraints, have been developed in an effort to circumvent some of these difficulties. Inherent in such analyses, however, are both an aggregation problem and, even more important, a problem of relating normative supply functions to actual response. In contrast, positive or predictive analyses using regression procedures to quantify relationships among variables as they have existed or do exist at a point in time have their major limitation in the fact that they cannot predict effects of new variables and structures not encountered in the basic time series observations. Such models also are highly aggregative in respect to inputs and, as such, have limited ability to reflect quantitative effects of very many specific variables.

Heady concludes that despite their limitations, both normative and positive approaches can add something worthwhile to our knowledge about product supply and factor demand in agriculture. He suggests, and certainly I concur, that we need to increase our analyses of producer panels in which we attempt to link normative firm supply analyses with studies of farmers' actual response and thereby develop a basis for discounting normative quantities to conform with production decisions. He suggests the need for increased effort to relate normative predictions with those of regression estimates, and for increased attention particularly to the nature and effects on supply functions of fixed costs, uncertainty, and technological change. He especially emphasizes the need for analyses of factor supply. I have no quarrel with these suggestions.

Throughout his paper, Heady's emphasis is almost wholly on commercial agriculture and societal interest. However, we must continue to consider the interests of the individual producer. I question, for example, whether time-series analyses which allow forecasts for a single production period may be adequate as a guide for the year-to-year production decisions at the firm level. Despite the overriding importance of policy decisions requiring positive analyses, I suggest that we should not abdicate our responsibility to the individual firm, and that the individual producer has a real need for normative analyses indicating the economic consequences of alternative production decisions. I also believe that analyses of normative supply functions for representative firms and of means of quantifying the effects of various causal factors on variations between normative and actual response by such firms are among our most promising avenues to a better understanding of supply response.

The implied emphasis on commercial agriculture in Heady's paper also seems warranted. In this day of surpluses, we should probably concentrate on learning what makes the commercial farmer tick, or cease to tick. But does not the increasing importance to commercial farmers of income from employment at nonfarm jobs suggest that we need to make specific provision in our models for the modified and additional motivations and restraints inherent in this trend?

Similarly, do we not need to give a great deal more attention to economic conditions and to changes in the nonfarm sectors of the economy in our efforts to analyze the supply of factors to agriculture? For example, what effect does the business cycle have on labor transfers out of agriculture? More people have left farms since 1930 than now remain on farms, but how many would have left if business activity had been relatively limited throughout this period? What about the effect of nonfarm capital, our tax structure, and the business cycle on factor values? I am sure Heady would include such inquiries in his analyses of factor supply, but it seems to me that they need greater emphasis if we are to extricate ourselves from some of the traditional ruts inherent in overemphasis on intrafirm analyses.

Among other points that appear to need additional emphasis are those relative to the importance of cooperation with physical scientists in probing supply relationships and prospective outputs, and with sociologists and social psychologists in probing decisions. There also is need for emphasis on analyses of changes in the supply structure, by regions, and on the limitations imposed on our programming models in dealing with regional and national aggregates by a variety of conditions with respect to soils, capital, tenure, fixed resources, and other variables.

Finally, one might read into Heady's paper an implied need for a "bank" of production functions representing significantly different production situations, assembled and kept up to date over time as pertinent analyses are made, and available to all whose analyses strive to facilitate the adjustment of production and resource employment with economic growth. Certainly, others have expressed such a need as they have discovered the dearth of usable data, resulting in part from the fact that data simply were not assembled and retained in a form usable by others. Perhaps a part of our discussion should focus on the feasibility and the means of maximizing the product of the resources required in the tremendous job of assembling basic data.