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SEMINAR SERIES – XI

Seminar on

DEMAND AND SUPPLY PROJECTIONS FOR AGRICULTURAL COMMODITIES

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THE INDIAN SOCIETY OF AGRICULTURAL ECONOMICS, BOMBAY

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APPROACHES TO DEMAND PROJECTIONS FOR FOOD COMMODITIES

P. S. George

The standard approach to demand analysis involves the estimation of a demand equation

$$(1) \quad q_{it} = F_i \, (y_t, \, P_{it}, \, Z_{1t}, \, Z_{2t}, \ldots\ldots U_{it})$$

where q_{it} is per capita consumption of the i^{th} commodity in year t, F_i is a function whose mathematical form is decided using the goodness of fit, y_t is a measure of per capita disposable income, P_{it} is the price of i^{th} commodity in period t, Z_{1t}, Z_{2t},....., are other explanatory variables and U_{it} is a random disturbance term, Long-run changes in the per capita consumption of food commodities occur as a result of individual and joint effects of many factors like changes in relative prices and income, changes in tastes and preferences, introduction of new products, changes in occupation and urbanization, and changes in the age composition of the population. In the short run, it is convenient to assume that factors other than prices and income remain the same. Therefore, short run changes in per capita consumption will be influenced by price and income changes.

Single Equation Approach

In single equation approach, a mathematical form of demand equation is specified and the parameters in the regression equation are estimated. Often, it may be difficult to provide proper <u>a priori</u> specifications of the demand functions. Therefore, in practice, the following five forms have been used, and a choice among them is made based on the goodness of fit and the nature of individual coefficients.

(a) Linear $q_t = a + b\,y_t + c\,p_t$

(b) Semi-logarithmic $q_t = a + b \log y_t + c \log p_t$

(c) Double logarithmic $\log q_t = a + b \log y_t + c \log p_t$

(d) Inverse logarithmic $\log q_t = a + b\,y_t + c\,p_t$

(e) Log-difference $\Delta \log (q_t) = a + b\,\Delta \log y_t + c\,\Delta \log p_t$

Once the parameters of the regression equation are estimated, the equation can be used for short-run forecasts of commodity demand. However, there are a number of limitations of this approach:

(1) The explanatory variables, income and prices, are not truly exogeneous. Often quantities and prices are jointly determined. In other words, the demand equation, expressed as above, is really only one in a system of equations which are to be estimated simultaneously.

(2) The decision regarding the predictors appearing explicitly in a regression equation may be arbitrary in the absence of a widely accepted criterion. In regression analysis, a regression coefficient is treated as insignificant if it is less than approximately twice its standard error. However, the omission of such regression coefficients may bias the estimates of the remaining parameters.

(3) The standard approach to demand analysis specified above is static in nature. Over a period of years, apart from changes in the tastes, preference and similar other factors, there may occur changes in the regression coefficients. In certain other cases the response may tend to be distributed over a period of years. Distributed lag models have been used to estimate regression coefficients when the response is spread over a number of years.

Here it is not possible to review all refinements introduced by demand theory and statistical estimation procedures. We shall restrict the discussion to show how demand interrelationship can be incorporated in the projection framework and to indicate how trend factors can be accounted.

Suppose that the consumer's choice function involves n commodities. Let $q_1, q_2, \ldots q_n$ represent the quantities chosen at price $p_1, p_2, \ldots, p_n$ and the consumer income y. The consumer's choice from the commodity space will be influenced by certain behavioral characteristics. We can define a number of preference axioms such that there exists an order-preserving, quasi-concave utility indicator which is monotonic and continuous. The consumer's choice of $q_1, q_2, \ldots, q_n$ will be such that the utility indicator is maximized subject to the availability of resources (income y). Under given prices and income, the quantity purchased of each commodity can be expressed as a function of its price, price of other commodities and income.

$$(2) \quad q_i = q_i (p_1, p_2, \ldots, p_n, y) \; ; \; (i = 1, 2, \ldots n).$$

If we assume that the relationship is linear, the demand function can be written as:

$$(3) \quad \begin{aligned} q_1 &= a_{11} p_1 + a_{12} p_2 + \ldots + a_{1n} p_n + b_1 y \\ q_n &= a_{n1} p_1 + a_{n2} p_2 + \ldots + a_{nn} p_n + b_n y \end{aligned}$$

In matrix notation, the system of equations (3) can be written as (4) $Q = M.P.$ where Q is a vector of quantities, M is a matrix of price and income slopes and p is a vector of prices and income. Equation (4) involves $(n \times n)$ price coefficients and 'n' income coefficients. In order that the model may be estimated by known techniques, it is required that the number of observations should be at least equal to the number of parameters to be estimated, which in this case is n (n + 1). When there is a larger number of commodities to be considered, it is not possible to satisfy this condition, and thus we run into the so-called "problem of degrees of freedom."[1] However, the "integrationist's approach" recognizes the inter-relationship among all commodities, so that it is possible to estimate the demand inter-relationship matrix M.[2]

Linear Effects of Time on Consumption

The specification of demand functions in terms of price and income excludes many possible continuous systematic variations in the demand as a result of factors other than those specified. Limitations of data and imperfections in our understanding of the factors that influence consumption decisions may often contribute to and enhance the possibility of some systematic variation in the quantity demanded. Often, in demand analysis, such variations are handled by incorporating time as a variable with linear or non-linear effects. If the purpose of the analysis is only for making projections, inclusion of time may result in more reliable projections than when time is excluded. However, it may be

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1. A.C. De Janvry and J. Bieri, "On the Problem of Degrees of Freedom in the Analysis of Consumer Behaviour," American Journal of Agricultural Economics, Vol.50, No.5, December, 1968, pp. 1720-1736.

2. See W.K. Boutwell, Jr.: 'Estimation of Consumer Demand from Ordinally Separable Utility Functions, Unpublished Ph.D. Thesis, North Carolina State University, Raleigh, 1965; G.E. Brandow:"Interrelationships among Demands for Farm Products and Implications for Control of Market Supply, Pennsylvania Agricultural Experiment Station Bulletin 680, 1961; and P.S. George and G.A. King: "Consumer Demand for Food Commodities in the United States with Projections for 1980, University of California, Davis, 1969.

possible that variables like income and prices are highly correlated with time so that introduction of time as a variable may result in estimation problems. An estimate of the coefficient associated with time may often be an over-estimate since most unexplained variations might be absorbed by this coefficient in addition to the effect of time. Further, it will be hard to provide an interpretation for the coefficient associated with time. Therefore, in many cases, it may be advantageous to exclude time as a variable in the demand equation.

At the same time, use of first difference of the variables in the demand equations provides an opportunity to test the presence of linear effect of time. A demand equation of the following form can be used:

$$(5)\quad \Delta \log q_i = a_i + e_{i1}\, \Delta \log p_1 + \ldots\ldots + e_{in}\, \Delta \log p_n + e_{iy}\, \Delta \log y.$$

when there is no change in the independent variables (price and income) over the years, (5) reduces to $\log q_i = a_i$.

If the value of a_i is significantly different from zero, it implies that some change in consumption will take place from the preceding year, even if there was no change in prices and income.

Foote[3] suggests that the percentage effect of time in each year can be obtained by taking the antilogarithm of the constant term plus 2, if all variables in the first difference analysis are converted to logarithms and if the constant term differs significantly from zero. For example, if the estimated value of a_i is equal to .0172, we take the

3. R.J. Foote: Analytical Tools for Studying Demand and Price Structure, United States Department of Agriculture, Agriculture Handbook No.146, 1958, p. 43.

anti-logarithm of 2.0172 as 104.20. So we could say that time trend alone would increase consumption of the commodity by 4.20 per cent annually.

Projections with Constant Demand Matrix Plus Time Trend

As mentioned earlier, the demand interrelationship matrix, M, was developed under conditions of static equilibrium. Further it was shown that time trend of consumption could be obtained from the constant coefficient of the first difference of logarithmic estimating equation. One approach to projecting consumption in a future period is to use the demand matrix plus the time trend. When estimates of prices and income are available for a future period, say 1980, an estimate of quantities demanded can be obtained from (4) under the assumption of constant demand elasticities (when Q and P are expressed in logarithms). Let the annual time trend for the i^{th} commodity be S_i, expressed as a per cent change per year. If the projection is for K periods ahead of the present period, the time trend alone will introduce a multiplier of $(1+S_i)^K$. This multiplier together with the projected static level of consumption $(\hat{q}_i)$, provides the following estimate for consumption for K periods ahead.[4]

$$(6) \quad \hat{q}_{iK} = \hat{q}_i \, (1 + S_i)^K$$

Projections with Changing Demand Matrix

Another method of incorporating dynamic elements into the projection framework is by assuming a varying demand inter-relationship matrix. Here, it is possible to assume that the elements in the matrix M vary over time in a certain manner. For example, consider the

4. Estimates of consumer demand for many food commodities in the United States are given in P.S. George and G.A. King: op.cit.

demand equations:

$$(7) \quad \Delta \log q_i = \sum_{j=1}^{n} a_{ij} \Delta \log p_j \quad e_{iy} \Delta \log \bar{y} \quad (1, j = 1,2,\ldots,n)$$

where

q_i = quantity of the i^{th} commodity demanded,

p_j = price of j^{th} commodity, and

y = a measure of real income.

Let $\bar{y}$ denote the income at current prices. Then the expenditure proportion on the i^{th} commodity is given by

$$(8) \quad W_i = \frac{P_i q_i}{y}$$

Multiplying (7) by (8) we obtain

$$(9) \quad W_i \Delta \log q_i = \sum_{j=1}^{a} W_i e_{ij} \Delta \log p_j + W_i e_{iy} \Delta \log \bar{y}$$

$$= \sum_{j=1}^{a} \pi_{ij} \Delta \log p_j + \pi_{iy} \Delta \log \bar{y}$$

where

$\pi_{ij} = W_i e_{ij}$ and

$\pi_{iy} = W_i e_{iy}$

If a regression equation of the type (9) is fitted, using time-series data on quantities, prices, income, and expenditure proportions, it is implied that π_{ij} and π_{iy} remain the same over the years whereas, in (7), it was assumed that e_{ij} and e_{iy} remain the same over the years. But π_{ij} and π_{iy} are obtained from e_{ij} and e_{iy} by multiplying with W_i. Since the budget proportion W_i varies over time, as a result of changes in the prices and consumption pattern, e_{ij} and e_{iy} also vary over time. Thus, if expenditure proportions are known for different years, it is possible to obtain an estimate of the demand matrix M for the different periods. For projection of future consumption levels, two different approaches could be used.

Estimation of Changing Demand Coefficients

Using the values corresponding to each element of M, obtain a time trend for the coefficient and use this trend to project the value of the coefficient for a future period. That is, if M_{ij}^{t} corresponds to the $(ij)^{th}$ element of the interrelationship matrix for the period t (i, j = 1,2,....., n; t = 1,2,.......n), the s values of M_{ij} could be used to establish a trend equation for M_{ij} and this could be used to obtain M_{ij}^{s+K}, where K is the desired number of years for which projection is required. Having obtained the value of M_{ij}^{s+K} for all i and j, equation (4) can be used to project the value of q if the price and income levels are known.

Estimation of Expenditure Proportions

Instead of obtaining a projection for M_{ij}^{s+K} directly, it is possible to estimate the expenditure proportions and to derive the value of M_{ij}^{s+k}. From the estimation procedure used, Π_{ij} is assumed to be the same for all time periods or

$$\Pi_{ij} = W_i^{(t)} M_{ij}^{(t)}$$

Therefore, (10) $$M_{ij}^{(t)} = \frac{\Pi_{ij}}{W_i^{(t)}}.$$

In order to use (4) for projection of prices, it can be written as (11) $\dot{P} = M^{-1}Q$.

As Sosnick[5] points out for the one good case, this transformation will be exact only if perfect correlation exists. When the objective of the study is to predict prices, it is more appropriate to fit demand equations with prices as dependent variables and to obtain a price flexibility matrix corresponding to M^{-1}. Most of the restrictions in deriving the demand inter-relationships in terms of elasticities can be derived in terms of price flexibilities.[6] However, the inverse of the elasticity matrix, M can be taken as a rough approximation to the price flexibility matrix and it can be used for projecting future prices if the quantities consumed and income are known. For agricultural commodities, however, price prediction equations generally require specification of alternative outlets (fresh, processed), stock changes, and exports.

The above discussion indicates that projections of per capita consumption levels in 1980 could be obtained either by using a projected demand inter-relationship matrix for 1980 or by using projected expenditure proportions for 1980.

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5. S.H. Sosnick; "Orderly Marketing of California Avcados," Hilgardia, Vol.33, No.14, 1962, pp. 707-772.

6. See, for example, J.P. Houck, "A Look at Flexibilities and Elasticities," Journal of Farm Economics, Vol. 48, No.2, May, 1966, pp. 225-232.

In all these approaches, it is not possible to obtain demand projections without making some assumptions. For example, while using the demand inter-relationship matrix for projection purposes, it is assumed that estimates of prices and income for the future period are available. If these estimates are interval estimates, rather than point estimates, the projections will also lie in an interval. Another difficulty regarding projection is related to the type of data available to estimate the parameters in the demand functions. Time-series and cross-section data may be available on the quantity consumed. Often income and prices may be correlated, and therefore, it may be difficult to obtain both price elasticity and income elasticity from the same equation. This problem can be solved if a combination of time-series and cross-section data is used, such that estimates of income elasticity obtained from cross-section data can be used as an extraneous estimate. Here another difficulty is that income elasticity obtained from cross-section data may sometimes be expenditure elasticity, instead of income elasticity. Also it may be necessary to choose between quantity consumed and expenditure on food items.