being multi-stage stratified sampling. In agricultural censuses and surveys, multiphase and successive sampling designs are also used.

The proper sample size to use in a given situation depends on the purpose and the desired accuracy of information. For example, if data are needed for planning at the smallest administrative level in the country, a much larger sample is needed, proportionally, than for larger units. A critical examination of the sample size should be made at the time of the pilot survey.

6.2.6 Questionnaires and Tabulation

The success of agricultural censuses and surveys depends on the proper design of the questionnaire. The framing and wording of questionnaires should take into consideration the calibre of enumerators and respondents and should be simple and clear. Before designing a questionnaire, data requirements of different users must be ascertained and the extent to which they can be accomodated in the questionnaire or covered by separate surveys should be determined. The advice of a data processing expert in designing a questionnaire can be of immense value in facilitating later tabulation of the results. In fact, the tabulation plan should be drawn up along with the design of the questionnaire to ensure that items of information needed in the tabulation programme are included in the enquiry.

6.2.7 Data processing

Data processing is currently one of the most limiting factors in the statistical programme of most developing countries. The data processing capability should be planned, implemented and tested before field enumeration is begun and, generally, data should be recorded in machine readable form early in the development cycle.

The organization of computer data processing activities depends on the computer facilities available. There are, however, certain operations to be conducted before computer work can begin. One very important operation, which will help rectify omissions and other errors, is checking the completeness of the census and survey enumeration and questionnaires. In addition, field supervision will reduce the burden of checking at the central office. Other important operations are coding, punching and verification, for which it is important to establish appropriate quality control procedures.

A comprehensive, consistent data base management system is also necessary to check, update, store, and retrieve data from various sources and measurement instruments. For statistical purposes, such a system is important to generate additional tabulations not published initially, for cross-section analyses based on data at the level of the statistical unit, and for later analysis of the data. Access to data from different sources so they may be combined in various ways is needed for policy analysis. The computer programmes and equipment which house the data and operate the data base management system must be designed to be as easy or easier to use for non-computer people as traditional desktop calculators and printed publications.

6.2.8 Quality Checks and Post-Enumeration Surveys

Various factors affect the quality of data in different ways. Errors always exist in data whether based on a complete enumeration census or a sample survey. It is therefore necessary to check the quality of data collected. In the case of a sample survey, results are accompanied by what are known as sampling errors, which can be controlled to any desired degree by using proper techniques and by enlarging the sample size. However, there are other errors, called non-sampling errors, which are difficult to eliminate. The technique practised most often for checking the quality of census data is the comparison of that data with information available from independent sources. Another useful technique in many cases involves examining the consistency of data with respect to a priori knowledge. Post-enumeration checks through sample surveys are also a very common method of assessing the accuracy of survey and census results.

6.2.9 Dissemination

A publication programme for disseminating the results of agricultural censuses and surveys is the traditional link between producers and users of statistical information. Census and survey results and analyses need to be properly organized, tabulated and published in a report or series of reports and made available to users as soon as possible. Therefore, at a minimum, it is essential that a programme of publications be carefully planned and implemented with adequate resources.

The utility of statistical information decreases in direct proportion to the time it takes to become available to users. As a consequence, on-line data bases are growing in importance relative to statistical publications, thus increasing the importance of an efficient data processing and data base management capability.

6.3 Organizational Considerations

Three classes of organizational issues important to food and agricultural statistical programmes are discussed in this section: institutional structure, human resources, and supporting infrastructure.

6.3.1 Institutional Structure

There is wide variation among countries in the structure of government agencies responsible for food and agricultural statistics (FAO 1974/75). Typically, several agencies, often even more than one ministry, may be involved. For example, administrative record keeping and technological research are carried out by many different agencies. Two types of organizational set-ups can be distinguished for censuses and surveys. In some countries, all censuses and surveys are centralized, i.e., under the responsibility of a single, centrally located statistical office, while in others they are decentralized. In a decentralized system, coordination among statistical agencies -- possibly through the establishment of a central statistical coordination office or an interministerial or interagency committee with effective executive authority and responsibility -- is essential to maintain consistency with respect to conceptual definitions, timing, data processing and other technical and analytical aspects of the information system.

6.3.2 Human Resources

Personnel requirements to execute the various measurement instruments should be considered in light of the types of activities to be carried out, which, in broad terms, can be distinguished as follows: (a) administration, (b) planning, (c) data collection, (d) data processing, and (e) support services. Administration refers to the overall management of a census or survey, while planning involves its design. The design of a census or survey describes the scope and coverage and includes the forms and questionnaires to be used, definitions of concepts, sampling plan (if one is to be used) and instruction manuals for data collection and processing. Data collection, then, is the actual conduct of interviews, measurements or record keeping, as the case may be, while data processing involves the editing, coding, classification, publication and storing of data and is generally computerized. Finally, services necessary to support the statistical personnel in the conduct of their activities include transport, maintenance, data entry, computer programming and secretarial and office services.

For each type of activity, personnel may be required, both full time and part time, at various levels of professional experience, training and competence. Proper personnel coordination and scheduling among activities and among data sources/measurement instruments will avoid problems of some areas being overstaffed while other areas may be short. This is particularly important for professional statisticians and data processing experts whose supply is limited in most developing countries and also in the case of a decentralized statistical programme. Cooperation among agencies in the utilization of available manpower will not only be cost effective from the standpoint of the national statistical budget but also promote the consistency of the data being generated by the various instruments and sources.

Since the institutional structure of statistical programmes varies widely from country to country, it is not possible to formulate detailed personnel requirements which would be appropriate for all of them. The following list does indicate, however, general personnel requirements which are relevant to all countries:

(a) high-level government administrators of statistical activities;
(b) experts trained in statistical theory and practice;
(c) experts trained in computer operations, programming and data base management;
(d) junior staff capable of supervising enumerators; and
(e) sufficient numbers of enumerators and data processing clerks.

Some countries employ full-time field enumerators, but many developing countries may prefer to reduce costs by utilizing part-time and temporary enumerators. For example, agricultural extension workers are frequently assigned data collection duties during what would otherwise be slack seasons for them. In practice, however, the training and experience of the enumerators and supervisory staff and the smooth functioning of the field organization in general are critical to the success of statistical activities --signalling the importance of a stable, permanent staff (at least a small cadre) and organization.

Training of statistical personnel should be organized in a planned and coordinated way for all data collection activities. Different types of training programmes should be devised so that the training is appropriate to the trainee's level as well as the task the trainee is expected to perform in the statistical operation. Training may have to be organized at international or regional centres for senior staff, at national training centres for middle-level staff, and at various places within the country for field staff. The requirements for training professional and supporting statistical and data processing personnel could be determined as part of the pre-programme plannning phase of a long-term statistical programme (see Chapter 8, Section 8.2.1).

With respect to staffing statistical projects, it is increasingly recognized that resident foreign experts should be utilized only when absolutely necessary. Rather, limited project funds are better used for formal training of country personnel and for temporary technical backstopping by consultants and staff of international organizations.

6.3.3 Supporting Infrastructure

As mentioned above, a number of services and facilities are necessary to support the direct statistical activities. Among these are computer, printing, transportation, maintenance, secretarial and office services and equipment. Transportation and data processing equipment require particularly close coordination with the various statistical activities, especially in developing countries where they are in short supply. Transportation equipment is also important in situations where reliable public transport is not available, especially for field work. The sharing of data processing facilities is another area where economies of scale can be gained. Data processing requirements should be carefully planned and coordinated to avoid underutilization of expensive equipment while still processing the data in a timely manner.

With careful planning, advantage can also be taken of linkages between the statistical and analytical programmes not only for supporting staff, facilities and equipment but also with respect to institutional structure in order to facilitate and ensure the necessary working relationships between the two programmes.

Basic data development, data processing and statistical analysis are three equally important cornerstones of a successful national programme of food and agricultural statistics. With respect to analysis, it is essential for an effective analytical programme that statisticians and economists work together along with appropriate technical subject-matter scientists and decision makers. The analytical programme component of an information system is described in the next chapter, Chapter 7.

CHAPTER 7

THE ANALYTICAL PROGRAMME

The statistical and analytical programmes are the two major components of an information system for food and agriculture decision making. The statistical programme is primarily responsible for planning and conducting field enumeration of basic data, data processing and statistical analyses. The analytical programme, while also performing some observation and measurement, concentrates chiefly on interpreting and analysing data and on communicating results to decision makers. However, the distinction between data processing for statistical as opposed to analytical purposes and the border between statistical and economic analysis is somewhat arbitrary.

Policy analysis is typically carried out, frequently on an ad hoc basis, by staff analysts located in various ministries, divisions, and bureaus; by government or semi-autonomous research institutes; and with contributions from universities, consultants, and other sources of subject-matter expertise.

This chapter begins with a description of the policy analysis process and its role in decision making. Remaining sections define and discuss models and the modelling process and their roles in support of both analytical and statistical programmes.

7.1 The Policy Analysis Process

Policy analysis is the process of producing information to improve policy decisions. Policy analysis is oriented to some objective. The ultimate value of analysis may be to improve well-being of people but the proximate objective or end-in-view for the analyst is to provide information to managers and policy makers to help them make better decisions in allocating scarce resources to meet objectives.

Section 3.2.2 described the seven stages of the decision cycle: problem definition, synthesis of options, analysis of options, decision, implementation, observation of results, and evaluation. Here, the discussion focuses on application of the cycle to solving problems at the policy, programme, and project levels of decision making to guide the food and agricultural socio-economy.

The analytical programme is intimately involved with all stages of the decision cycle but especially in problem definition and synthesis and analysis of options. The analytical programme may entail ex post evaluation of on-going programmes and projects, such as agrarian reform and rural development efforts (FAO, 1985b). In other cases, the analytical programme may emphasize ex ante feasibility of a price intervention policy or an infrastructure project.

The analysis to support a decision will be made within a specific time frame. Decisions made in the course of policy implementation tend to have short-term focus, while policy formulation typically takes a longer-term view. For example, adjustments in on-going measures to regulate rice prices may only be concerned with programme performance over the next few days or weeks. On the other hand, investments in crop improvement research and irrigation infrastructure will need to consider a much wider range of consequences distributed over several years.

In the synthesis of options stage, analysts and decision makers work together closely to formulate alternatives which can fill needs. The analysis stage then projects the likely consequences of the options and evaluates them in terms of feasibility and relative desirability. Close interaction and effective communication is essential between decision makers and analysts to determine economic feasibility, social desirability, and political acceptability of policy options.

7.2 Models and Modelling

Grasping the totality of a country's food and agricultural system is impossible for anyone who would monitor and evaluate the current situation and analyse policy options. Models are a necessary abstraction of the real system. Analytical models serve as filters to screen out non-essential elements and to retain elements essential for food and agricultural decision making. A formal model often integrates statistical data with a conceptual framework (theory), assumptions, and objectives. These elements may come together in an algorithm such as simulation, linear programming, or other mathematical device to provide a framework for generating predictive or prescriptive information of value to decision makers.

7.2.1 Classification of Models

Analysis ranges from informal or intuitive judgement taking little time to highly complete and complex plans laying out a detailed blueprint for the course of an entire economy. Analysis may be predictive, forecasting the likely future course of one or more variables of interest in the absence of new policy interventions, or it may be prescriptive, showing the implications for producers, consumers, taxpayers, and society of seeking alternative objectives that decision makers have or could prescribe.

Informal or formal mental models existing in the modeller/analyst's mind tend to be vague, implicit, and even subconscious images or concepts of how the world works. A decision maker deriving most or all of his analysis from his own mental models is said, in colloquial English, to be making "seat-of-one's-pants" or "intuitive" decisions. In the face of severe constraints and analytical resource time, such judgements by an informed and experienced analyst can be appropriate and useful.

This chapter mainly deals with formal models. Formal models exist in concrete, explicit form outside the modeller's mind. Being explicit, they are available for critical scrutiny and evaluation and thus for conscious improvement and modification.

Mathematical models can never be the sole information source for complex socio-economic decision making. Informal and formal models, including mathematical models, are used in combination with each other to generate information needed to support decision making. Mathematical models can increase the information quality (in terms of consistency and precision) and the quantity of information as the measured capacity for analysing a number of complex policy options.

Mathematical models frequently require data which do not exist, are expensive to acquire, or are of questionable reliability, especially in developing countries. The quality of information generated by quantitative models is critically dependent on structure (variables and relationships). Poor data with good structure may yield more useful information than good data with poor structure. A model with a reasonably valid structure is a valuable aid in checking data consistency and setting priorities for data collection. Such a model can be used to make estimations to fill gaps in published data. While mathematical models can handle more complex structures more consistently than can verbal or mental models, there are, nevertheless, limits on the feasibility of finding general mathematical solutions.

7.2.2 Some issues for models

A presentation of analytical models is incomplete without placing them in the context of issues which they address. Issues addressed in policy analysis are numerous but policy analysis tools illustrated in this chapter relate mainly to three prominent issues:

(1) Economic efficiency. Obtaining maximum useful output or real national income from given resources is a major policy objective. Issues of economic efficiency arise when policy makers decide whether to rely on the private market or to supplement or replace it by public interventions. Taxes, subsidies, exchange controls, import quotas, price supports, regulations, and other means are often used to intervene in markets. At issue is whether they raise or lower the real volume of goods and services available to society. Policy makers are concerned with economic growth, and economic growth depends on how efficiently output and resources, including savings and investments, are allocated.

(2) Distribution. Policy makers are concerned not only with the size of national or sector income but also with how it is distributed. To make decisions, they frequently desire information on the distribution of costs (and benefits) of programmes among producers, consumers, and taxpayers by level of income.

Poverty, underemployment, and access to means for generating a livelihood are policy issues in nearly all countries. Policies to promote more equal income and resource distribution frequently reduce economic efficiency and hence aggregate income and economic growth. The policy analysis can provide information not only on distribution of costs and benefits but also on the trade-off between equity and efficiency. Price ceilings and targeted food assistance influence not only income and nutrition of the poor, they also infuence other income groups and sectors by changing producers' prices and government costs. Policy makers can make better decisions if they are aware of these impacts.

(3) Stability. Food supply and price stability is often of major concern to policy makers. A policy that increases average income and distributes it more equitably may be undesirable if it subjects producers and consumers to high risk of low income or short food supplies in some years. Price controls, commodity stocks, or a cash reserve fund are examples of policy options to reduce instability. The policy analyst can provide useful information to policy makers regarding the likelihood and magnitude of food shortfalls and the economic costs and benefits of policy options to reduce instability, including the option of relying on the private market versus public interventions to reduce instability.

Some governments pursue policies to achieve self-sufficiency in staple commodities. Sometimes such policies reduce food security because they increase reliance on uncertain domestic output, reduce efficiency, and reduce national income to purchase food supplies from abroad when domestic production falls because of unfavourable weather, pests or diseases. In some instances, food security and economic efficiency can be simultaneously improved by raising income through producing commodities in which a country has a comparative advantage. The higher income permits purchase of commodities from abroad as necessary when domestic supplies are short.

In the following sections, specific analytical tools addressing the above and other issues, are presented and discussed. No one tool is applicable to all situations and any tool must be tailored to the needs of the specific situation. The tools presented have been proven through wide use. References are listed for analysts who wish to obtain more background in the theory and application of the various procedures. It is assumed that the statistical programme has provided needed information for the analytical programme. However, it must be recognized that the analytical programme provides feedback to the statistical programme regarding data needed.

7.3 Simple Tools for Analysing Trends

The commodity balance equation provides a useful initial framework to illustrate simple policy analysis tools. The balance identity for a commodity in year t is

(7.3.1) $S_{t-1} + O_t + M_t = C_t + X_t + S_t.$

Carrying of stocks from last year S_{t-1} plus output (production) O_t plus imports M_t equal consumption (including waste) C_t plus exports X_t plus carryout of stocks at the end of the year S_t.

An experienced analyst can make many inferences of value to decision makers simply by observing trends in the commodity balance sheet over time. And more formal policy analysis tools can extract even more information from the statistics. A graph of each of the variables, easily constructed with high quality microcomputers, can vividly illustrate trends in data and alert decision makers to emerging developments which they may judge warrant a policy response.

Regression analysis, using statistical procedures now possible at low cost and with precision by computer, can provide additional information. Policy makers may wish to predict production and consumption for next year or further into the future. The analyst might use a ruler and pencil to extend a line from the past into the future, but the result would depend on the analyst's judgement: any two analysts would not draw the same line to predict future values of O and C.

A more systematic and objective procedure is to estimate an ordinary least squares regression equation from the time series of past data. One of several possible forms might be appropriate to predict output O_t:

(7.3.2) $O_t = a + bT$

(7.3.3) $O_t = aT^b$ or $\ln O_t = \ln a + b \ln T$

(7.3.4) $O_t = ae^{bT}$ or $\ln O_t = \ln a + bT$

(7.3.5) $O_t = a + bT + cT^2$

(7.3.6) $O_t = a + bT + cT^{.5}$

where T is a time trend variable arbitrarily constructed as the last two digits of the current year, e is the base of natural logarithms and ln refers to variables coded in natural logarithms. Each equation provides a different trend line; the statistical results can help to decide which equation to select. Equation 7.3.2 assumes that output increases by the same quantity b each year. Equation 7.3.3 assumes that a 1 percent increase in T always results in a given percentage increase b in production. Equation 7.3.4 forces production predictions to increase by the same percentage b each year. Equation 7.3.5 allows the production to follow a "U" shape, either upright or inverted. Equation 7.3.6 allows production to increase (or decrease) at a decreasing rate. If all b and c coefficients in the above prediction equations are not statistically different from zero, the analyst may conclude that the best prediction is a simple average of past production.

Functional forms such as a linear, log-log, semilog, square root, or quadratic equations might be fitted and one selected for prediction based on the proportion of variation explained (R^2), the sign and statistical significance of coefficients, and consistency with the conceptual framework (an equation predicting negative or infinite future values might be ruled out). The standard deviation of the estimate could be used to define the range within which O or C would be expected to fall in any particular future year with specified probability.

Other statistical techniques could be employed to analyse commodity balance sheet data. A simple correlation coefficient could be used to express the degree of linear association between production and consumption if policy makers are concerned whether food consumption is influenced by variation in food production. Simple correlation coefficients of production 0 between crops would indicate whether production is highly correlated and hence similarly influenced by weather (positive correlation) or whether low production of one staple tends to be offset by high production of another staple (negative correlation).

The standard deviation provides a measure of variability, and may estimate dispersion around the mean or around a trend. If the distribution is normal, two-thirds of the outcomes are expected to fall within one standard deviation above and below the mean (or trend).

In general, the standard deviation increases as average production increases. A measure of relative variation is the coefficient of variation, the standard deviation expressed as a percent of the mean. Coefficients of variation are often used to compare relative variability among crops. Policy makers may wish to explore means to reduce variability in production of a staple crop, and it may be useful to compute coefficients of variation for yield as well as area to determine which is contributing most to variation in output.

Commodity consumption trends may be predicted from population trends and the income elasticity of demand E_y. If the population growth rate is expected to be r_n percent per year, if consumption per caput is expected to be constant (except for the influence of income), if the annual percentage rate of growth in real income per caput is expected to be r_y, and if the income elasticity of demand (percentage growth in consumption C associated with each 1 percent growth in real income per caput) is E_y, then the annual percentage rate of growth in consumption r_c can be expressed as

$$(7.3.7) \quad r_c = r_n + E_y r_y.$$

Thus, if the population growth rate r_n is 3.0 percent per year, the income elasticity of demand E_y is .5, and real income annual growth rate per caput r_y is 2.0 percent, then demand for commodity C is expected to grow r_c = 4.0 percent per year.

If some of C is exported and equation 7.3.7 expresses growth only in domestic consumption, the total rate of growth in C from all sources r_T may be expressed as

$$(7.3.8) \quad r_T = w_c r_c + w_x r_x$$

where w_c is the proportion of C consumed domestically, w_x is the proportion of C exported, and r_x is the predicted rate of growth in exports. If three-fourths of C is consumed domestically so w_c is .75 and w_x is .25, if r_c is 4 percent per year, and if the expected rate of growth in exports r_x is 8 percent per year, then the total rate of growth r_T in utilization of C is .74(4.0) + .25(8.0) = 5 percent per year. The weights will change over time if r_c differs from r_x so the formula in 7.3.8 with fixed weights is only valid for short periods.

7.4 Demand and Supply Models

In market economies, it is useful to supplement less sophisticated analysis described above with a more complete accounting for variables that influence consumption and production. The supply curve is a schedule of relationships between real prices of a commodity and quantities supplied by producers at each price for a given market per unit of time, other things equal. The demand curve is a schedule of relationships between real prices of a commodity and quantities taken by consumers for a given market per unit of time. The supply curve and demand curve together determine market price and quantity and can be used by analysts to study a wide range of policies as noted in this section.

7.4.1 Supply and production analysis

Many variables such as technology, weather, investment in infrastructure, and prices of related commodities and of inputs shift the supply curve. A supply function contains all of these variables and can be used to estimate the supply curve and sources of shifts in the supply curve.

Earlier, production O was viewed as a function of only a time trend variable. The supply function expresses supply quantity as a function of several variables:

$$(7.4.1)\quad O_{it} = f\left(\frac{P_i}{PP}, \frac{P_j}{PP}, I, T, G, W\right).$$

O_i is production of commodity i; P_i is own-price of i; P_j is the price of competing or complementary commodities (which may be represented by an index of prices received by producers or by separate price variables for each commodity); PP is prices paid for inputs (which may be represented by an index of prices paid for all inputs or by separate prices of fertilizer, machinery, labour, pesticides, and other inputs); I is fixed capital inputs or infrastructure such as public irrigation capacity; T is technology such as high-yielding varieties or productivity which is often represented by a time trend; G is government programmes such as extension education or supply controls; and W is weather and other factors such as pests over which the producer has little or no control in the short run. Other variables such as the variation in past prices may also influence the supply quantity.

Elasticities are frequently used for convenience to express the supply response to price. The elasticity E shows the percentage change in one variable associated with the percentage change in another variable and hence is independent of the units of measurement. For example, the own-price elasticity of supply response is

$$E_{ii} = \frac{\Delta O_i}{O_i} / \frac{\Delta P_i}{P_i} = \frac{dO_i}{dP_i}\frac{P_i}{O_i} = \frac{d \ln O_i}{d \ln P_i},$$

the cross-price elasticity for related commodities is

$$E_{ij} = \frac{\Delta O_i}{O_i} / \frac{\Delta P_j}{P_j} = \frac{dO_i}{dP_j}\frac{P_j}{O_i} = \frac{d \ln O_i}{d \ln P_j},$$

and the elasticity of response to input prices is

$$E_{ip} = \frac{\Delta O_i}{O_i} / \frac{\Delta PP}{PP} = \frac{dO_i}{dPP}\frac{PP}{O_i} = \frac{d \ln O_i}{d \ln PP},$$

where Δ is the change in price or quantity and d refers to a very small change. In theory, the sum of these elasticities is zero. That is, a proportional increase in all prices does not change output if farmers react to real (relative) prices as shown in equation 7.4.1 rather than to absolute (nominal) prices.

Supply response elasticities can be estimated empirically by multiple regression statistical analysis utilizing data over time on the variables in equation 7.4.1. In doing so, it is important to recognize that when producers plant they ordinarily do not know what actual price will be when they sell their commodity. They plan based on expected prices. Producers' expectations of price in year t may be formed from a weighted average of prices in previous years. For example, the expected real own-price $(P_i/PP)^*$ for commodity i may be represented by

$$(7.4.2)\quad (P_i/PP)_t^* = .50(P_i/PP)_{t-1} + .33(P_i/PP)_{t-2} + .17(P_i/PP)_{t-3}$$

which can be constructed from time series of past prices. Once producers are subjectively certain of price, they may adjust output slowly because of caution, inertia, or costs of making adjustments. The actual adjustment of supply quantity in one time period may be some proportion g of intended full adjustment to 0_i^* as expressed below (Nerlove, 1958):

$$(7.4.3)\quad 0_{it} - 0_{it-1} = g(0_{it}^* - 0_{it-1}).$$

A typical linear equation of long-run supply is of the form

$$(7.4.4)\quad 0_{it}^* = a + b(P_i/PP)_t^* + cH_t + eT$$

where H is high-yielding varieties and the expected price is from equation 7.4.2. Substituting equation 7.4.4 into equation 7.4.3 yields the Nerlovian short-run supply equation.

$$(7.4.5)\quad 0_{it} = ag + bg(P_i/PP)_t^* + cgH_t + geT + (1-g)0_{it-1}.$$

This equation can be estimated by the ordinary least squares multiple regression procedure from time series data. The adjustment rate g is calculated from the coefficient 1-g on the lagged variable 0_{it-1}. The short-run supply response to P_{it-1} is .5 times the short-run coefficient of bg from equation 7.4.5. The long-run response b to price is the short-run coefficient bg in 7.4.5 divided by the adjustment rate g. If the equations are in original values, the marginal response to price can be converted into elasticities by multiplying them by the appropriate ratios of price to quantity. If the variables are in logarithms, the coefficients in equation 7.4.5 will be elasticities. A typical empirical supply elasticity is .1 in the short run and 1.0 in many years if the price increase is maintained. Supply elasticities have been estimated and reported for a number of commodities and countries (Nerlove 1958; Askari and Cummings 1976).

Figure 7.1 illustrates the use of a supply curve for policy analysis. Output initially is q_s and price is p. An increase in the price to p_1 from an increase in demand, an increase in support price, termination of a tax, or from other sources raises the supply quantity to q_{s1}. If the increase in price is 10 percent and the supply elasticity is .1 in the short run and 1.0 in the long run, supply quantity is predicted to increase by 1.0 percent in the short run and by 10 percent in the long run if the higher price is maintained. If the original quantity q_s is 150 kilos and the original price p is 20 rupees, the long-run elasticity implies that a price increase of 2 rupees increases quantity 15 kilos if the price increase is maintained for several years.

If the price is decreased to p_2 from the initial price p, the quantity supplied falls to q_{s2}. If the real price decrease from p is 20 percent and price is held at that lower level with the supply elasticity as above, the quantity supplied is expected to fall 2.0 percent in one year and 20 percent in many years.

Frequently, the analyst desires more information than just the supply response to price. Suppose it is useful to know the contributions of specific resources and of yield and area components to supply response. Supply response to price is a function of the physical response of output to use of inputs and the behavioural response of input use to price, the latter represented by the input elasticity of demand. The physical response of output to inputs is expressed by the production function.

$$(7.4.6) \quad O_i = f(X_1, X_2, \ldots, X_n)$$

where $X_1, X_2, \ldots, X_n$ refer to inputs such as fertilizer, pesticides, irrigation water, land, labour, and other inputs. The production elasticity of output O_i with respect to any input X_k is

$$E_{ik} = \frac{\Delta O_i}{O_i} / \frac{\Delta X_k}{X_k} = \frac{dO_i}{dX_k}\frac{X_k}{O_i} = \frac{d \ln O_i}{d \ln X_k}$$

and the elasticity of input demand with respect to product price is

$$E_{ki} = \frac{\Delta X_k}{X_k} / \frac{\Delta P_i}{P_i} = \frac{dX_k}{dP_i}\frac{P_i}{X_k} = \frac{d \ln X_k}{d \ln P_i}.$$

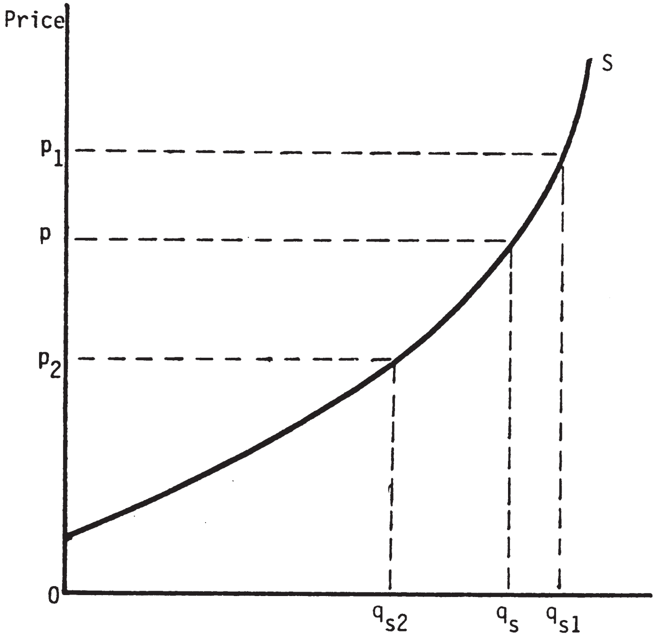

Figure 7.1 - Illustration of supply curve S