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PREFACE

Most governments intervene in the price-setting mechanisms and distribution systems for food and other agricultural products in many different ways and for various reasons. In developing countries, governments often follow policies that lower the relative prices of agricultural products and increase the relative prices of industrial products. Tax, trade, credit, and exchange-rate policies are commonly used instruments along with direct agricultural price and market-control measures. A study of price distortions in the Ivory Coast in the 1967-72 period concluded that government policies: 1) discouraged agricultural output, 2) encouraged capital-intensive agricultural production techniques using imported machinery, 3) caused private profitability of new industrial activity to diverge substantially from social profitability, 4) resulted in negative value-added in the processing of agricultural exports, and 4) favored production for domestic and West African markets over international export markets. (Pursell, Monson and Stryker)[1/]

In contrast, developed countries often use product and trade policies to benefit farmers. The typical result is to create surpluses that have often found their way to developing country markets and further depressed domestic prices there. Peterson found that real farm prices received by farmers in LDCs have been substantially lower than those received by farmers in

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[1/]For a review of other studies, see Lutz, E. and P. Scandizzo, "Price Distortions in Developing Countries: A Bias Against Agriculture." Euro. Rev. Agr. Econ. 7-1(1980):5-28. (All references used in the preface are contained in the list at the end of Chapter 1.)

developed nations.[2/] He showed that differences in product/fertilizer price ratios on the order of four to five times or more existed in 1968-70. With few exceptions, price relationships were more favorable to farmers in developed countries than in the LDCs he studied.

The industry-urban biased development strategies adopted after WW II in many countries were based on several assumptions:

1) that industry provided a more rapid means of growth, and that achieving that growth depended upon large transfers of investible resources from agriculture to industry;
2) that higher food prices lead to higher urban wages and lower profits for manufacturing firms; and
3) that agricultural production is not very responsive to changes in intersectoral terms of trade.

Lagging agricultural production, food shortages, and rising food prices in many developing countries have led to increased concern over policies that reduce production incentives and lower food output. It is obvious that in many countries there is not enough food and that many physical, biological, and economic factors constrain agricultural production. At the same time, large sums of domestic and external capital are being allocated to raise food production in these countries. Schultz has been in the forefront of economists who believe that many low-income countries are foregoing needed and possible increases in agricultural production as a consequence of economic policies. He has recently written:

[2/] To avoid exchange-rate distortions, Peterson divided wheat-equivalent prices in domestic currency by the domestic currency price of commercial fertilizer. Thus, "real" prices reflected product-fertilizer price ratios.

"It is my contention that the unrealized economic potential of agriculture in many low-income countries is large. The technical possibilities have become increasingly more favorable, but the economic opportunities that are required for farmers in these countries to realize this potential are far from favorable. Thus, for want of profitable incentives, farmers are not making the necessary investments, including the purchase of superior inputs. I argue that interventions by government are the primary cause of the lack of optimum economic incentives. Although it has not always been by design, the state of incentives in many low-income countries suppresses the economic opportunities of farmers." (Schultz, p. 7)

Greater emphasis by donor agencies and LDC policy makers on rural-oriented development strategies that meet basic needs, provide employment, and benefit the lowest income population strata, has also shifted interest to policy interventions more favorable to agriculture. The focus of this manual, however, is neither on the evolution nor the effects of recent pricing policies in developing countries. Rather, its purpose is to provide an overview of the role of analysis in formulation and implementation of pricing policies, and a general survey of approaches that can be used to analyze the impacts of market and price interventions. Chapter 1 contains a general review and discussion of policy analysis within the planning process and data and information systems. Chapter 2 deals with the analysis of stabilization and price-support programs. Chapter 3 considers input subsidies. Chapter 4 analyzes trade and exchange-rate policies. Chapter 5 concerns food subsidies and food distribution policies. Basic econometric concepts and procedures are reviewed in Chapter 6.

The manual is designed for use in short-term training and self-study for staff members in planning and policy analysis offices and agencies in Latin America. The emphasis is on basic economic concepts and econometric tools that can be utilized to evaluate the effects of existing policies and predict the consequences of alternative policy choices. It is meant to be useful in practical policy analysis, and thus sacrifices some theoretical rigor in favor of simpler, more straightforward analytical approaches.

In addition to chapter references, annexes at the end of Chapters 2 - 5 contain annotated bibliographies. These are designed to provide convenient access to selected sources for those using the manual who wish to pursue the topics covered in more depth.

CHAPTER 1

ANALYZING PRICE AND MARKET--
INTERVENTION POLICIES

Policy Analysis Within the Planning Process

In a general sense, planning can be conceptualized as a process for controlling public-sector and private-sector actions that determine a country's economic and social development. The outputs of the planning process are public sector policies, leading to the definition of planning as a continuous policy-producing process. (IICA, p. 3)

The main agents within the planning process are the planners and the policy decision-makers. Planners are responsible for policy analysis, decision-makers for policy decisions.

Policies represent the application of all instruments available to the public political-administrative system for influencing the socioeconomic performance of the economy. Since agricultural development must be viewed within a context of national multisectoral development, agricultural policies include all the instruments that affect the performance of that sector.

The political-administrative system, composed of polciy decision-makers and executor agencies, is responsible for the formulation, implementation and evaluation of policies oriented toward influencing actions of socioeconomic agents to accelerate achievement of desired goals. Although planners are not responsible for policy decisions and administrative actions to implement policies, they have an important role to play in support of these actions. (IICA, pp. 12-36)

In a broad sense, policy analysis refers to all activities that generate and present information to improve the basis for decisions by policy-makers and implementation actions by executor agencies. Analyses can range from informal advice, possibly based on nothing more than intuition and opinion, to formal studies requiring extensive data gathering and processing. Policy analysis, therefore, is the process that produces analytical information for the purpose of improved public policy decision-making and implementation.

Policy analysis has an important role to play in each stage of the planning process. Its use is most familiar within the formulation stage, where its main contribution is to identify and compare policy alternatives. The elements of the policy analysis process can be identified as: 1) determining objectives, 2) designing alternatives, 3) comparing alternatives, and 4) interpreting and presenting results. These elements are discussed in more detail later in this chapter of the manual.

In the implementation stage, the primary role for policy analysis is in the specification of concrete policy measures. These measures represent specific actions to be carried out by the executor agencies of the political-administrative system. Their role is to operationalize the policy decisions made by policy-makers.

The function of evaluation is to review and assess the policies and policy measures formulated and implemented by the political administrative system. The purpose is to feed back information on the positive and negative impacts of policies such that specific policy measures can be revised, corrective policy modifications can be instituted, or new policies can be formulated.

While policy analysis within the formulation, implementation and evaluation stages can be presented as conceptually distinct, in practice it is more of a continuous activity. The same analytical framework and techniques used for the comparison of policy alternatives are also used to analyze the specific policy measures for the selected policies. Similarly, the evaluation of policies can be thought of as an *ex post* verification of the *ex ante* comparisons of policy alternatives.

As an example of these abstract ideas applied to price policies, many countries have public policies for basic foodgrains that are supposed to balance the needs and interests of consumers, producers, middlemen, and the government itself. The design of a policy regime for foodgrains, for example, is what is meant by "formulation." The year-to-year application of specific policy measures within that regime is "implementation." The measurement of impacts leading to revised policy measures or reformulation of the policy regime is "evaluation." Policy analysis refers to all the activities within the planning system that provide information to policy decision-makers and executor agencies in the political-administrative system useful for formulating, implementing, and evaluating price policies.

The approach advocated here does not mean that policy analysis is a panacea for all defects in public decision-making. Decisions on government policies are fundamentally political, not analytical; decision-making at the public level is the responsibility of politicians, not policy analysts. The goal of policy analysis is to help a policy-maker make a better decision than he otherwise would have made. But analysis is limited in many ways--by concepts, data, time, human resources. It can never provide a complete understanding of real-world phenomena nor consider all factors that a decision-maker may take into account.

Moreover, there are sources other than analysts for assistance to policy-makers in choosing among alternatives. The decision-maker's own intuition and judgment, for example. Asking experts for opinions. Getting advice from interested parties. Bargaining with other officials and pressure groups. It is not necessary to believe that analysis can solve all public policy problems to claim that there is a definite need for it. It is sufficient if identifying policy alternatives and analyzing their various impacts can contribute significantly to the improvement of public policy decisions.

Diagnostic Assessments

A policy analysis is generally initiated after someone perceives a problem exists. A policy-maker, for example, may feel that the performance of the economy is deficient in terms of priority socioeconomic goals and request assistance in defining remedial policies. Or, an official in an executor agency may have noticed that something is wrong with a program and request help to decide how to improve it. Frequently, special interest groups may suggest to public officials that a policy be initiated, modified, or discontinued. The latter may then decide to have an analysis carried out.

When beginning to work on a problem, a desirable first step for analysts is to prepare a diagnostic assessment to define the problem and describe the problem area. (Quade, pp. 67-70) The purpose of the diagnosis is to answer the following kinds of questions:

1) What is the problem and how did it arise?
2) Which officials or agencies will make decisions and implement corrective actions?
3) What are the goals and objectives of relevant decision-makers?
4) What impacts and measures of effectiveness are important?
5) What groups or institutions will receive benefits from, or bear costs of, a solution to the problem?

With respect to market interventions, the diagnostic study should first concentrate on a qualitative description of the actual regime of trade, tax, subsidy and market control policies, with emphasis on the nature, extent, and administration of the interventions. Next, the study should undertake meassurement of distortions created by the policies by comparing actual domestic prices to international alternatives through estimating producer and consumer "subsidy/tax equivalents." (Josling) Through this procedure, it is possible to estimate the distribution of costs and benefits and the effects on government expenditures from price policies affecting food and agricultural markets.

Fox has recently made a qualitative assessment of Brazil's minimum price policy, which operates through a set of minimum prices announced before the planting season. That study contains a review and analysis of the program particularly as it works in Northeast Brazil. The program's background and history were reviewed. Performance of the program was evaluated in largely descriptive terms. The primary focus was on the effects of the program in terms of stabilizing prices and expanding output. Little evidence that the program has functioned as a positive instrument of agricultural and economic policy was presented.

In a comparable study of Portugal, the World Bank went beyond a descriptive review of the extensive price controls throughout the Portugese food and agriculture sector to estimate producer and consumer "subsidy/tax equivalents." This procedure views the overall effects of various policies in two categories: those that act as a tax/subsidy to producers, and those that act as a tax/subsidy to consumers. In deriving these measures, border prices (c.i.f. import prices and f.o.b. export prices) are compared to domestic prices. Thus, the difference between an export price and a higher (lower) producer price measures the implicit producer subsidy (tax). Similarly, the difference between a final good's import price and a lower (higher) domestic market price is the implicit consumer subsidy (tax). The sum of the implicit subsidies (taxes) give an estimate of the net impact on the government budget.

The table below contains calculations for wheat in Portugal for 1976 using this methodology. It shows that the government was subsidizing both wheat production and consumption, but that wheat producers received the heaviest subsidy in that year.

Table 1-1

PORTUGAL: WHEAT PRODUCER AND CONSUMER SUBSIDY EQUIVALENTS

		1976
Producer Subsidy Equivalent	mil esc.	720
(As % of Total Producer Value)		(19)
Consumer Subsidy Equivalent	mil esc.	340
(As % of Total Consumer Exp.)		(8)
Net Subsidy	mil esc.	1060
	(US$ million)	(35)

Source: World Bank, Prices and Subsidies in Portugese Agriculture, Report No. 2380-PO, Washington, 1979, p. 16.

Elements of Policy Analysis

Objectives, Criteria, and Impacts

In choosing policies or making policy decisions, goals are most often multiple and likely to be conflicting. This complication exists even for an individual decision-maker, and is practically unavoidable where several officials or institutions have a voice in a decision.

It is also the case that the goals may not be clearly stated or even fully perceived. Apparently, there are political advantages in being ambiguous about goals and stating objectives as broad statements of direction rather than as precise targets. In stating objectives, officials may not reveal what they really want, either to maintain an ideological position or because they are unsure about what they want. (Quade, pp. 86-6) Analysis can be of some assistance in reaching policy decisions even when the objectives are not agreed upon but the key to good analysis is a clear statement of goals. Until the goals a policy or program is supposed to accomplish are specified, information about alternatives and impacts has, at best, limited value.

In the case of price policies, governments often establish such vague and poorly defined objectives as consumers' welfare, producers' income, distribution of income, price stability, self-sufficiency, stable market supplies, and lower public expenditures. In this case, it is first necessary to establish with much more precision:

1) what objectives policy-makers want to achieve,
2) specific measures of performance for each objective, and
3) whether "more" or "less" of each measure is desired.

As an example, consider that a government specifies these five objectives for its foodgrain price policy: 1) attain self-sufficiency in foodgrain production, 2) stabilize market prices of foodgrains, 3) increase consumers' welfare, 4) increase incomes of foodgrain producers, 5) hold down government expenditures. Similar objectives have been reported in several case studies of price policies. (Mangahas, Timmer)

For each objective, alternative performance measures can be defined. In the case of farm income, for example, several concepts could be proposed. And after an income concept has been selected, questions about the distribution of the income impacts would arise. Thus, it may be much more important to know how income changes are distributed by size of farm, tenure type, and region rather than just know that farm income rose or fell in total.

The loss of welfare, defined as a loss of social real income (net social loss), is often calculated by the summation of changes in producers' and consumers' surplus (deadweight loss). This approach is derived from standard static partial equilibrium analysis based on the Marshallian economic surplus concept. (This concept is reviewed in Currie, et al.) It is used in the analysis of market interventions to provide an approximate measurement of allocative inefficiencies and welfare transfers between producers and consumers due to price distortions. Typical causes of price distortions are producers price supports, tariffs, quotas, export taxes, input subsidies, retail price ceilings, etc. These policies distort domestic producer and consumer prices away from international import (cif) or export (fob) prices (border prices). International prices at the same point in the marketing chain are used as reference points on the assumption that they represent a valid measure of the social opportunity costs of the commodities to the economy.

The basic analytical structure of the partial equilibrium evaluation of price distortions can be concisely stated. For a "small" country, whose terms of trade are beyond its control, the loss of welfare (real income) from price intervention policies is calculated as follows:[3/]

net social loss in production (NSL_p) (1)

$$= 1/2(Q_s^b - Q_s^p)\ (P_b - P_p) = 1/2 t_p^2 \eta_s V_p$$

net social loss in consumption (NSL_c) (2)

$$= 1/2(Q_d^b - Q_d^c)\ (P_c - P_b) = 1/2 t_c^2 \eta_d V_c$$

welfare gain of producers (G_p) (3)

$$= Q_s^p(P_p - P_b) - NSL_p$$

welfare gain of consumers (G_c) (4)

$$= Q_d^c(P_b - P_c) - NSL_c$$

change in foreign exchange earnings (ΔF) (5)

$$= -P_b(Q_s^b - Q_s^p + Q_d^c - Q_d^b)$$

change in government revenue (ΔF) (6)

$$= NSL_p - NSL_c - b_p - b_c$$

where:

Q_s^b = domestic production at border prices

Q_s^p = domestic production at domestic producer price

P_b = border price

P_p = domestic producer price

[3/] For the "large" country case, whose terms of trade are dependent on quantities traded, border prices would be replaced by marginal revenues.

P_c = domestic consumer price

t_p = tariff as proportion of domestic producer price

t_c = tariff as proportion of domestic consumer price

η_s = price elasticity of domestic supply

η_d = price elasticity of domestic demand

V_p = value of domestic production at domestic price

V_c = value of domestic consumption at domestic consumer price

Q_d^b = quantity consumed at border price

Q_d^c = quantity consumed at domestic consumer price

This static framework and the simple formulae can be used to estimate the following effects of price interventions:

change in domestic production

change in domestic consumption

change in imports/exports

net social loss in production

net social loss in consumption

total net social loss

income gain (loss) of producers

income gain (loss) of consumers

change in government revenue

change in foreign-exchange earnings

In general terms, the agricultural sector in developing countries often is being taxed through the price distortions that result from market intervention measures. As a result, these countries produce less and consume more than they would in the absence of the price distortions.

Trade and foreign-exchange effects depend on the combination of production and consumption effects. In the case of food commodities in developing countries with nominal protection coefficients (NPC) less than 1, imports are increased by the sum of the absolute values of the production and consumption effects.[4/] In this case the government is providing an implicit subsidy for domestic consumption. Similarly, for exported commodities with NPCs less than 1, exports are reduced. In contrast, for export commodities with NPCs greater than 1, export subsidies are necessary to bridge the gap between the higher domestic price and the export price.

The estimated net social losses in production and consumption depend linearly on the price elasticities of demand and supply and quadratically on the domestic-border price distortions. These effects can be large, as high as 10 percent of GNP (World Bank, Price Distortions in Agriculture).

Frequently, the internal income redistributive effects are even larger and possibly of more direct concern to policymakers. The framework sketched above gives estimates of the redistribution of income between producers and consumers and the impact on government revenue (eqs. (3), (4), and (6)). Consumers in developing countries generally gain from the price interventions. The losses to producers can be regarded as implicit taxes on agriculture.

The effects on government revenue and foreign-exchange earnings are also important to governments. If the government-revenue effect is positive, then an objective of government revenue generation is implied. If it is negative, pressure to design a price/trade policy regime to lower governments costs may

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[4/] $$NPC = \frac{1 + P_p - rP_b}{rP_b}$$

where P_p = domestic price, P_b = border price, and r = official exchange rate.

arise. If foreign exchange is being lost, a foreign-exchange constraint on overall investment and development policy may be aggravated.

In considering goals, it must be remembered that costs and benefits of price interventions are not shared equally by all producers and consumers. Where food production is taxed, thus subsidizing consumption, the income-transfer effect represents a larger percentage change in the real income of low-income families but a larger absolute change in the real income of higher-income families. (Mellor) Where producers receive income gains via such devices as price supports, input subsidies, government purchases, and tariffs, large farmers utilize most of the subsidized inputs and market most of the price-supported output. Thus, price interventions not only transfer income between producers and consumers as a group but also affect income distribution within groups.

The partial-equilibrium framework presented in this paper does not consider the effects that price distortions have on agricultural productivity, capital formation, adoption of technoloby, employment, and migration. These longer-term, dynamic effects are possibly even more critical to the compatibility between instruments and objectives of government policy than the impacts identified earlier. Through the growth process, they have many profound influences on the evolution of the economy. Extension of policy analyses to these long-term objectives is necessary to present a partial, confusing, and conflicting set of policies from emerging over time but difficult with existing theoretical tools and data availability.

Choosing goals and specifying operational measures for goal achievement, therefore, is seldom an easy task. It is unlikely for most policy problems that the objectives are simply and directly given. And when different officials disagree, the analyst must help the decision-makers clarify their objectives before he can assist them in determining which policy to select. Analysis can contribute to goal clarification in several ways:

1) by showing whether or not some objective is feasible,

2) by revealing conflicts among objectives, and

3) by identifying policy means that favor several objectives.

Indeed, this process of goal clarification may even help firm up goals. As noted by Quade, "...knowing what can be done may be extremely helpful in deciding what one should try to do." (p. 84)

As previously stated, policy analysts are most often faced with multiple objectives rather than a single objective whose obtainment is the unique measure of success of the policy. The multiplicity of objectives poses no additional problem only when the goals can be compared through the use of a common unit of measurement of achievement. For example, if all objectives can be related to money costs and benefits, then a cost/benefit analysis is feasible. Otherwise, the noncomparability of multiple objectives must be dealt with in some other way.

The approach most directly comparable to optimization with a single objective is to establish a system of weights and structure the problem as one of vector maximization. Multiattribute utility analysis is an example (Keeney and Raiffa). Construction of multiattribute utility functions involves: 1) identifying objectives, 2) defining performance measures for each objective, 3) deriving a univariate utility function for each performance measure, 4) determining the relationships among the performance measure, 5) specifying the functional form of the multiattribute utility function, and 6) solving for the scaling constants associated with each attribute. The result is a utility function of the form

$$U(X) = \sum_i k_i u_i(X_i)$$

where U(X) is the multiattribute utility function that depends on the utility functions, u_i, for the performance measures, X_i, and k_i are scaling constants. This function incorporates the subjective risk perceptions of decision-makers and uses their preference structure to enforce comparability among the multiple objectives. Thus, the tradeoffs among various objectives are implied by the form of the utility function that emerges.

A second approach is to order the objectives lexicographically and then optimize in sequence. After the objectives are ranked, an "optimal" solution is obtained with respect to the highest-ranked objective. Next, an "optimal" solution with respect to the second objective is sought under the constraint that the first objective is held at its optimal level, and so on for the other objectives. This approach assumes that after the higher-order objectives are satisfied to the fullest possible extent, there is still room for choices that contribute to lower-order objectives. If this flexibility does not exist, then the analyst can only explore the tradeoffs that are possible by deviating from optimality with respect to the priority objective. For example, a policy-maker might be told that a country's self-sufficiency in foodgrains would have to fall by X percent and prices to consumers rise by Y percent if government expenditures on its grain management program are to be held to Z dollars per year.

A third approach is to specify minimum levels of performance for certain objectives and use those levels as constraints while searching for optimal policies with respect to one or more other objectives. This approach at least keeps some objectives from simply being ignored without making the analysis hopelessly complex.

As a general rule, the more objectives that are considered and the more that distributional implications of policies are taken into account, the more difficult it is to obtain practical and acceptable weights to use in resolving conflicts among objectives. A solution is to simply present a "scorecard" of significant policy impacts, each measured in its natural scale. In this way, a broad spectrum of good and bad impacts can be provided, along with an indication of which groups get the benefits and which ones pay the costs. This method for presenting results is discussed more fully later in this chapter.

Identifying the Alternatives

If the goal of policy analysis is to help a decision-maker choose a policy, then it follows that identification of the set of alternatives is of considerable importance. No process of analysis will lead to the best alternative if it is not included in the feasible set! Thus, an important responsibility of the analyst is to search out or design a broad set of alternatives for analysis.

The search for alternatives is a creative act not subject to hard and fast rules. No general answers are possible to questions about how alternatives can be identified or designed. Or, how many should be analyzed in depth and in what sequence?

Several factors tend to restrict the range of alternatives that decision-makers may wish to consider. The first is the conservative and parochial attitude of many officials and institutions. Maintaining the status quo and not considering alternatives that actively involve other institutions both serve to limit possible courses of action.

Another quite possibly serious limitation on the range of alternatives has to do with ideological considerations and political feasibility. Decision-makers may simply refuse to consider certain alternative on ideological grounds, or feel that others are politically unacceptable to higher-level decision-makers, pressure groups, or the electorate. It can be unrewarding--even hazardous--to analyze unacceptable alternatives. Yet, what is not acceptable today may become the priority policy tomorrow! Moreover, without considering infeasible alternatives now, how will the social costs of the political restrictions ever become known? (Quade, p. 30)

These problems are part of the broader dilemma over role facing policy analysts. Should they only analyze marginal changes in policies within a given political/institutional context? Or should the basic socioeconomic structures also be considered as policy instruments? Most of the tools available to analysts operate on the basis of given technological and institutional structures. These tools are only able to estimate the effects of changes of policy instruments within the given structure. Only rarely can they handle questions of structural or institutional changes. For this reason, policy analysis is likely to have an inherent conservative, status-quo bias. The result may be that analysts consider only limited policy alternatives and neglect the very structural and institutional changes that may be required for equitable agricultural development and reduction of rural poverty.

Comparing the Alternatives

The core of any policy analysis is the prediction of the consequences that follow from the choice of various policy alternatives. For this purpose an analytical framework, or model, is needed to tell us what impacts will result, and to what extent the objectives will be realized, if a given alternative is chose for implementation.

On the question of models, modesty is most appropriate! No model, nor any series of models, can incorporate all aspects of real world situations that are of interest to decision-makers. The validity of predictions from models depends on crucial uncertainties and unforeseen exogenous circumstances. Our current capability to design reliable models that can accurately predict consequences of policy choices is limited, especially where long-term dynamic impacts are at issue.

Models used for policy analysis range from verbal to mathematical, from simple to complex, from micro to macro, from static to dynamic, from deterministic to stochastic, from accounting to optimizing. Agricultural production processes have several well-known characteristics that complicate the modelling process. These include spatial dispersion, biological and weather dependence, and a large number of small-scale decision-makers. Such a complex interactive and interdependent system obviously operates dynamically and stochastically--a model that fully represents such a system is necessarily a dynamic and stochastic systems model. Continued efforts to construct and apply large-scale sector-wide simulation models are feasible and desirable. They are likely to be fruitful as sources of knowledge about the operation of socioeconomic systems, as fertile seedbeds of improved methodology for smaller scale modeling, and ultimately as useful simulators for direct policy applications. This conclusion, however, does not imply that large-scale computer models of some type should be the immediately utilized in all LDCs. Their high cost in terms of human, financial, and time resources--and they are expensive tools--must be given explicit recognition in undertaking policy analysis work. Choices of approach and models should reflect:

1) clear formulation of problems to be analyzed and specification of purposes for which the model will be used;

2) quantity and quality of human and financial resources available;
3) quantity and quality of data available or feasible to collect for verifying and validating the model; and
4) needs and requirements of decision-makers intended to be aided or influenced by the analysis.

Models, then, are the means of generating information about the consequences of choosing a policy alternative. In trying to explicitly examine multiple and conflicting objectives, a wide range of policy alternatives, distributional effects, and uncertainties, the danger is that the model will become distressingly complex. To avoid this pitfall, some decision analysts suggest that decision-makers be led through a sequence of models of increasing scope and complexity. The problem is to balance simplicity and realism. If a model is too simple, it may lack credibility and explanatory power. If it is too complicated, it may no longer be a useful aid to understanding by decision-makers. In practice, it will often be desirable to use a series of models, each increasingly complex and realistic. In this way, a decision-maker may be motivated to respond to the output of a simple model by asking just the types of questions that can only be answered by more complex ones.

The basic purpose in using models in policy analysis is to assess the effects of a changed policy situation so that predictions can be made about the likely consequences of the policy action. A "comparative statics" approach is the most common. This type of analysis involves three steps:

1) obtain a model solution under the existing policy situation,
2) introduce a policy change and obtain a new solution, and
3) compare the two static solutions to determine the impacts of the policy change.

The two main problems with this approach are first, the validity of the model in capturing the main aspects of the real-world situation, and second, the extent to which relevant impacts are reflected in the model results. This means that it is important to construct a model that is both sufficiently realistic with respect to the modelled economy and sufficiently comprehensive in terms of modelled impacts.

If the purpose of policy analysis is to provide quantitative measurement of the effects of policy alternatives on multiple economic and social objectives, then there is need to capture the socioeconomic relationships in the sector in formal analytical models. Notwithstanding this need, time and resource (both human and financial) limitations often do not permit the immediate development of a formal model. As a result, analysis may involve short-term, policy-oriented studies based on limited data and heavy dependence on qualitative approaches. Alternatively, partial approaches may be taken that increase the use of quantitative methods but limit the scope of the studies to specified products, regions or economic impacts.

Where policy studies of limited scope and quantitative content are undertaken, their relationship to a long-term analytical approach to the entire sector could be established from the very beginning. Thus, each partial or qualitative analysis can be oriented to an overall sector-analytic framework so that relationships and interdependencies can ultimately be identified and quantified. Short-term and subsector studies, then, could lead in time to a model of a sector that defines the economic structure and relationships of the system, introduces policy instruments, and evaluates alternative policies, programs, and projects in terms of multiple economic and social goals. In this way analysts can slowly increase their capacity for assisting policy-makers in selecting the policy alternatives that contribute most to priority goals.

Interpreting and Presenting Results

In a simple world, decision-makers would be faced with choosing one alternative from a limited and explicit choice set based on a single criterion. Under those circumstances, analysts could easily rank the alternatives according to the agreed-upon objective. The approach of constrained optimization would be applicable. This could involve either fixing the level of goal achievement and ranking alternatives according to their cost or fixing a level of cost and ranking them by their degree of attainment.

Benefit/cost analysis can be viewed as an example of this approach. The use of monetary values provides a unit for quantifying benefits and costs. The comparability of benefits and costs makes it possible to trade off one benefit for another and look for the "best" alternative. The main difficulty, of course, is in capturing the relevant costs and benefits in monetary terms.

Even where benefits and costs can be successfully quantified, the ranking of the alternatives may not be straightforward. Assume that the benefit/cost comparisons for two alternative policies are as shown in Fig. 1-1. In this example, point A cannot be attained and point D is inefficient in benefit/cost terms. Which policy is "best?" That depends on other considerations. If B_2 is specified as the minimum acceptable level of benefits, then Policy II is the only feasible choice. Similarly, if C_2 represents a fixed budget, then Policy II will provide more benefits for this expenditure than Policy I. However, if the objective is to maximize the ratio of benefits to costs, then Policy I is preferred (point E).

In practice, however, goals are usually multiple and not all costs and benefits can be expressed in dollars values. Moreover, as the analysis becomes more comprehensive, more decision-makers, executor agencies, and socio-

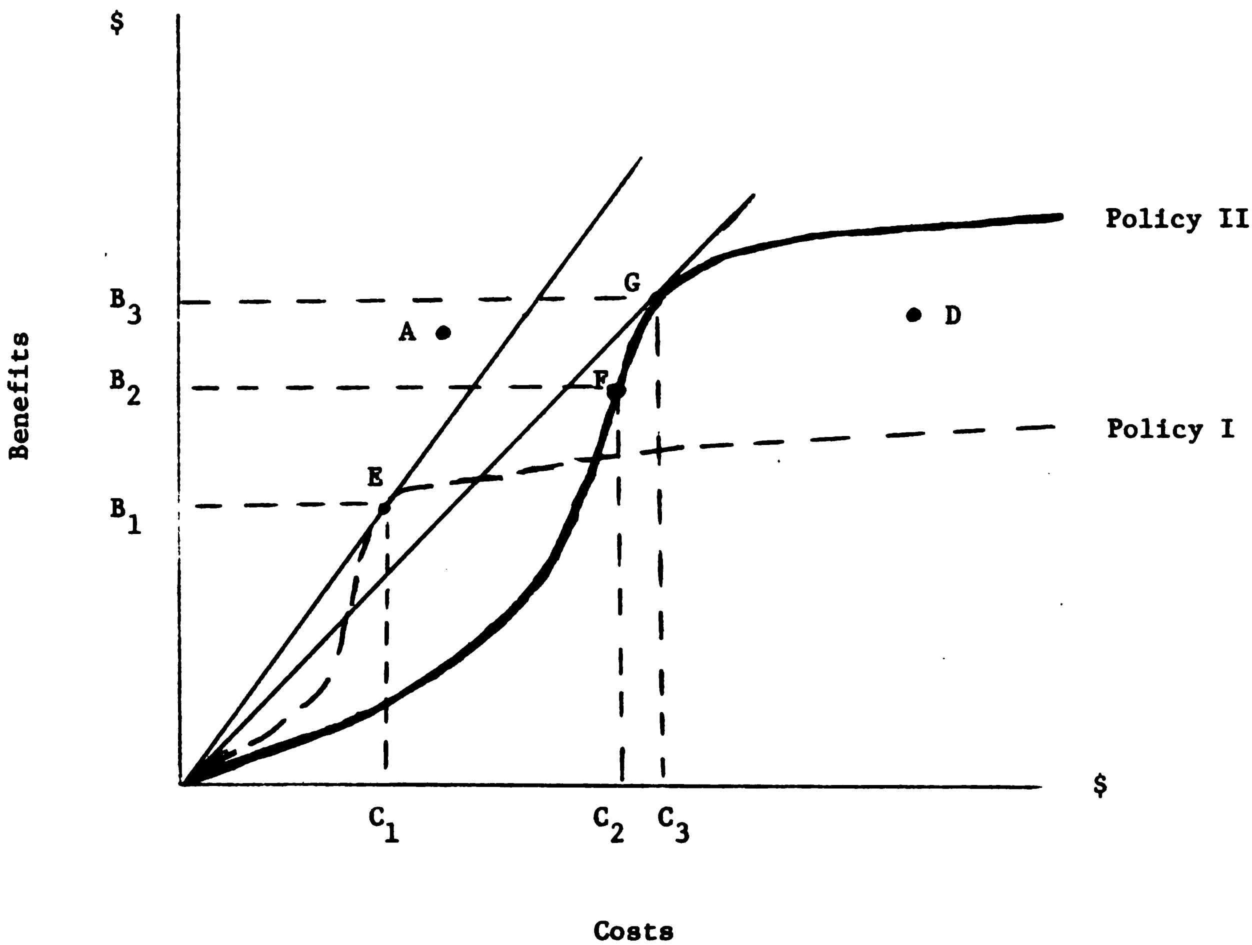

Fig. 1-1. A Benefit-Cost Comparison of Policy Alternatives

economic groups become aware that they have an interest in the decision to be made.

For this reason, and also to guard against recommendations that are biased by what the analyst feels should be done, the best scheme may be to present a "scorecard" of the impacts of the alternatives and leave the ranking problem to the decision-makers. A matrix like the following could be utilized for this purpose:

	Policy Choices			
Impacts	No Change	Alternative I	Alternative II	Alternative III
Production				
Imports/exports				
Consumer prices				
Producer prices				
Government expenditures				
Producer income				
Consumer expenditure				
% change expenditure of low-income consumers				
% change income of small farmers				
Government costs				
Ease of implementation				
Employment				
Nutrition of low-income strata				

This approach places the emphasis on a full display of the consequences of the policy alternatives--costs, benefits and their distribution, qualitative as well as quantitative. It should be accompanied by a frank indication of how uncertainties could affect the various impacts. This will permit decision-makers to ask "what if" questions which, when answered by the analysts, may lead to the design of other alternatives for analysis.

Uncertainty is an aspect of policy analysis that is both prevalent and hard to handle. It is usual to distinguish between uncertain events that are stochastic, for which all possible outcomes are known together with the probability that each will occur, and those for which the probability distributions are unknown. In the latter case, even the full set of possible outcomes may not be known.

Another useful distinction is between environmental uncertainties--those under the control of nature--and strategic uncertainties--those due to ignorance about the actions of decision-makers. (Quade, pp. 214-7)

Formal techniques for decisions under uncertainty are described in an extensive literature. For purposes of this manual, three admonitions are offered:

1) Make extensive use of sensitivity testing to examine the effects of ignorance about response parameters, environmental factors, and preferences.
2) Provide information from a "maximin" perspective; that is, what will happen under the assumption that the least favorable outcome occurs in every case; and
3) Look for alternatives that have a clear advantage over a range of uncertainties and strategic considerations rather than concentrating extensively on how much better one alternative is than another.

Given the limitations of the models, data problems, and the many uncertainties, there are important interpretations that must be made after solutions are obtained before results have information value for decision-makers. Analysts must make these interpretations in terms such as, "This is what the model predicts will happen if this policy is adopted, and this is why. On this basis, these are my conclusions about the alternative policy choices."

Decision-makers bring their own judgment and experience, their responsibilities, their institutional perspectives, and other information available to them, to their evaluation of their decision alternatives. If they desire accurate information on the likely effects of policy changes, how will they decide whether or not to accept the information provided by their analysts?

Generally, decision-makers cannot be expected to have a technical understanding of the structure of a model, the theory and assumptions on which its structure is based, or the methods by which predictions are made. Consequently, the policy-maker is more likely to evaluate the analyst than the analysis. It is for this reason that a careful interpretation of the results of the analysis is required. Since policy-makers are likely to rely on sources that have proven reliable before, analysts who want their results accepted should avoid acknowledging unrealistic assumptions, unreliable data, and untested results only in footnotes, thereby passing the responsibility of validating the results to the users.

Implementation

Even when the alternatives have been compared and a decision made to adopt one, considerable analysis may be needed in readying the chosen alternative for implementation.

For example, once a decision to implement a price guarantee-purchase program has been made, questions about the level of the minimum price guarantee, how purchase will be made, availability and cost of storage, and many other factors, will arise. For some of these questions, further analytical work will be required. Moreover, careful thought should be given before implementation to collecting baseline data that can be used later for evaluation of the policy.

Analysts may also be called upon to assist the decision-maker in inter-institutional negotiations required for getting his policy choice accepted. In this context, information may be used by a decision-maker more to strengthen his bargaining power with higher authorities or related agencies than as a basis for deciding which policy to choose.

Implementation does not follow automatically once a policy has been formulated. Indeed, problems with policy implementation are widespread. In many countries, for example, price guarantees are announced but actions to implement the required purchases are insufficient. As a result, prices at harvest fall well below the announced level. Or, retail price controls are placed on a food commodity. If implementation is inadequate, actual prices may go up when they are controlled.

How and to what extent should policy analysts consider likely difficulties in gaining acceptance for, or implementing, a given alternative? Clearly, some policies have a better chance than others of acceptance and implementation, another important category of uncertainty to take into account in evaluating alternatives. Analysts may not be in the best position to assess that uncertainty. But as a minimum, if the analyst believes that a policy will encounter trouble in being accepted and successfully implemented, he should point that out.

Evaluation

The purpose of evaluation is to measure the extent to which an existing policy is fulfilling the objectives for which it was chosen. However, the concern is less with a purely ex post assessment than to suggest changes in implementation or that a new policy be formulated.

The ideal evaluation is to be able to say what happened that would not have happened if the policy had not been implemented. A "before vs. after" comparison is a common way to approximate the policy impacts. However, to establish cause-effect relationships, it is necessary to compare what actually happened to what would have happened had the policy not been implemented. If a model was developed for the ex ante policy analysis, then actual ex post data can be compared to estimated data predicted by the model run without the policy change. A major problem with this method is how the influences of changes in other factors than the particular policy choice can be taken into account.

Analysts may encounter resistance from executor agencies in the evaluation process. Most administrators will agree that the principle of evaluation is good but many feel threatened when their own operations are evaluated. Even when the stated purpose is to improve policy formulation and implementation, the mere mention of evaluation can cause difficulties in obtaining access to data. This, plus the perception of many administrators that evaluation uses scarce resources that are needed for implementation, may well explain why evaluation activities are almost always behind schedule and frequently superficial. They often amount to little more than a comparison of planned vs.

actual performance. Such evaluations describe the policy implementation process but reveal little about the impacts of the policy--the extent to which it is attaining its goals and what other spillover effects are occurring.

Summary: The Process of Policy Analysis

The main elements in policy analysis discussed in this paper are summarized in Fig. 1-2. Analysis moves logically from goals to alternatives to consequences to choices. Because goals are so often multiple and ill-defined, and because there are so many possible impacts, the ones to be considered must be clearly identified. Then, once a reasonable set of alternatives has been defined, the idea is to predict their impacts. This may lead to redesigning the alternatives among which the decision-maker will choose.

Once a policy choice is made, analysts can assist in getting it accepted and instrumented for implementation. Evaluation feeds back into each previous element. Its most immediate application is to improve policy implementation. But evaluation may reveal dimensions of policy performance that alter the comparison or design of alternatives. Indeed, as a result of improved understanding as to how policies influence the socioeconomic system, it may become feasible to estiablish goals or identify additional impacts to take into account.

In reality, the process is seldom as orderly as presented here. Successful analysis is less of a discrete activity than a continuous cycle of selecting objectives, designing and comparing alternatives, building better models, etc. The extent to which the quality of the information produced over time by this process improves will be determined by the degree to which policy analysis capabilities are developed, supported and maintained.

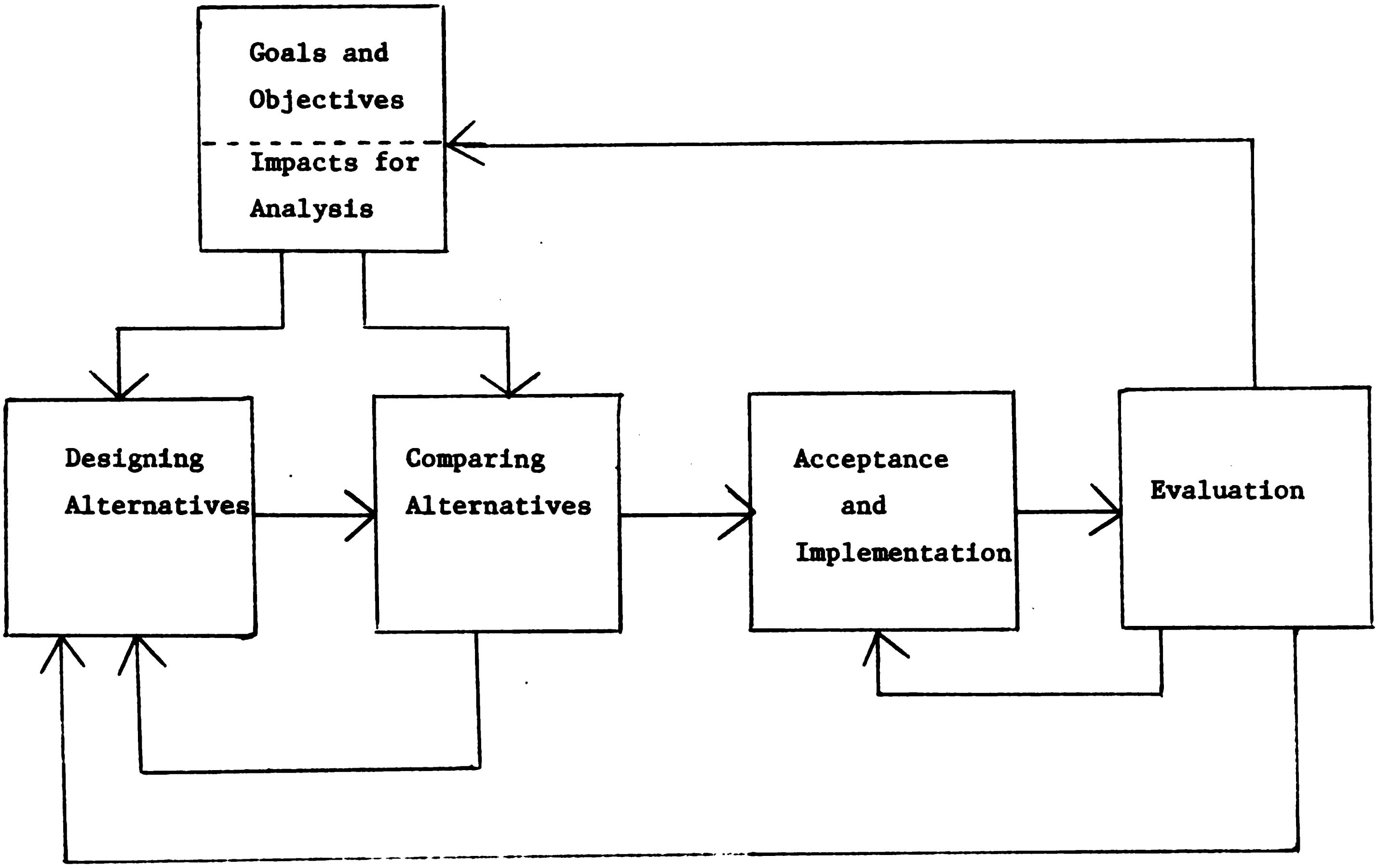

Figure 1-2. Process of Policy Analysis

Data and Information Systems for Planning and Policy Analysis

Information about food, agriculture, and the rural economy is needed in all countries to formulate and implement government policies and programs and to manage public and private resources. Public data collection is as old as institutionalized governance. Census-taking has been common since early civilizations. The use of formal statistical methods for data gathering goes back at least to the second half of the 19th Century.

As governments have extended the scope of their interventions in the economy and set diverse and more ambitious goals for socioeconomic development, demands for more extensive, relevant, and reliable information have grown. In response, data collection activities have proliferated in every country. The data produced, however, are not necessarily information. All measurement of real-world phenomena produces data, but these data are rarely of much direct use for decision-making and managing resources. For those purposes, data must be transformed so that it is useful in a particular context. Data, therefore, are not information in themselves, but rather raw material from which information can be produced. Many statistical techniques are used to transform data from its raw form into information that can be used for decision-making and management.

To be useful, information must be timely, reliable, and relavant to an identified problem or decision at hand. The assumption that more information will lead to better decisions is implicit in this statement.

Collecting data and producing information are expensive processes. Personnel required include statisticians, enumerators, coders, programmers and analysts. Computers and other hardware are needed to process the raw data. Transforming the data into information can be costly in terms of human and financial resources. Dissemination of the information to users can also be difficult. The aggregate of all resources required for gathering the data and providing information can be considered at the cost of the information.

It is less simple to clearly identify the value of the information. The goal of information is to improve decision-making. That is to say, decisions are more likely to be "right" or more apt to produce desired results. Conceptually, the value of a unit of information is the improvement in decisions attributable to its use. (Operationally, neither the units nor the gains are easily evaluated). As such, the benefits of information are related to its relevance, its reliability, and its timeliness.

The collection of data and production of information that is not relevant to decisions wastes resources. It uses resources without returning any gain in terms of improved decision-making. Reliability is also important. Unreliable information does little to improve decisions. Finally, information must be timely. It loses value if made available only after a decision has been made or a management option implemented.

In all countries resources that can be devoted to data collection and information generation are limited. It is important, therefore, to consider which types of information are needed by whom and for what, so that the information with highest value can be produced. Furthermore, since absolute accuracy is impossible, decisions must be made on the degree of reliability needed in relation to the cost of achieving it.

Information and the Planning Process

In the previous section information has been linked to policy and management decision-making in an input-output sense. Decision-making in an economy is both public and private. In a management context decision-making is concerned with the formulation, implementation, and evaluation of policies, programs, and projects. It is the responsibility of the decision-making members of the political-administrative system (Fig. 1-3). Decision-making within the socioeconomic system (i.e. the economy) is largely private. It is carried out by firms and households, the economic units responsible for production and consumption.

The main product of the planning-policy analysis system is information for use in public and private decision-making. In the public sector this includes identification of alternatives, the likely consequences of those alternatives, and information to support the implementation of selected alternatives. Implemented policies, programs and projects are the means by which political decision-makers influence performance of the socioeconomic system. (IICA)

In generating information, the planning system uses data gathered from the socioeconomic system and ideological guidance on relevant alternatives obtained from the political decision-makers. These data will also contain normative information on values and goals within the socioeconomic system, which is communicated directly to policy-makers through political pressure and participatory activities. The extent of this communication, and the degree to which it influences the ideological position of the government, de-

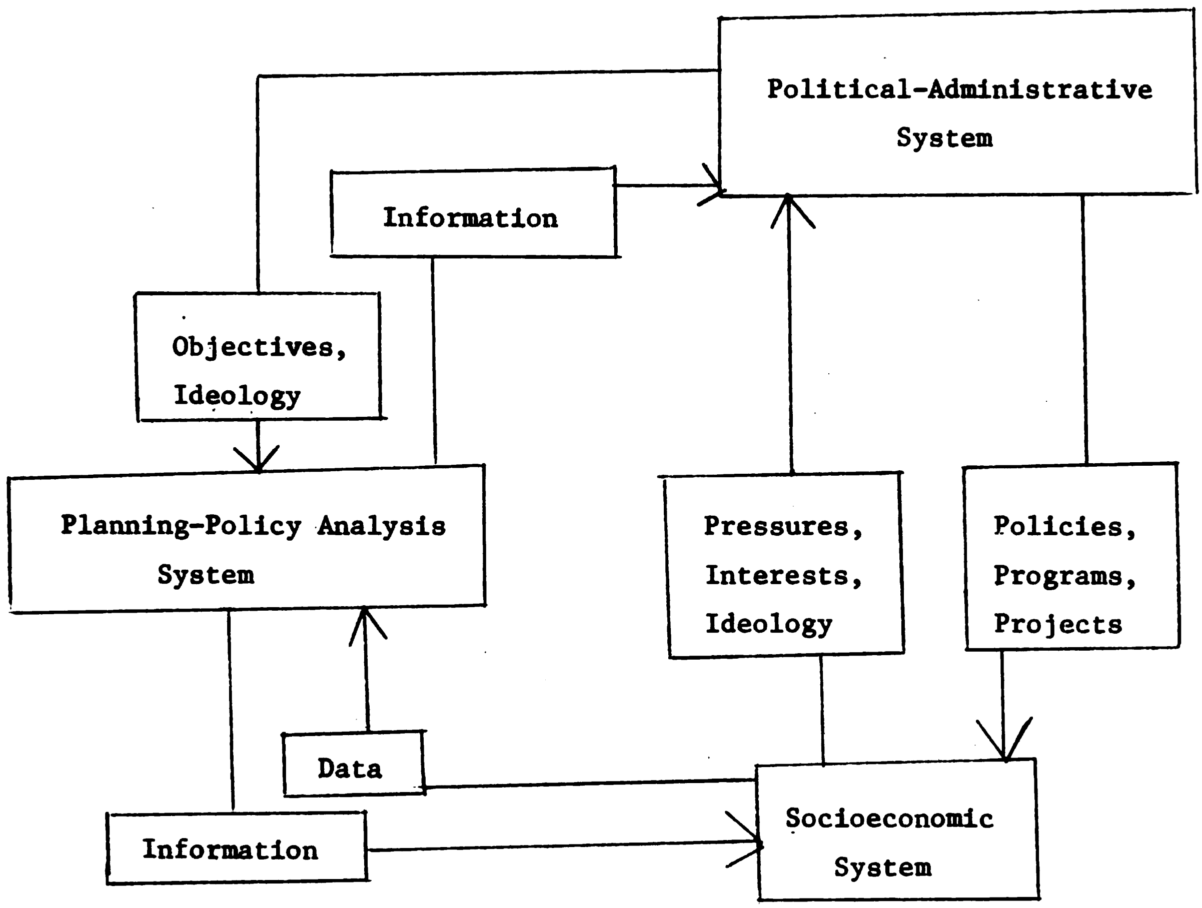

Figure 1-3

Conceptual Role of Information in Decision-Making pends on the political system of the country. The main point made here is that the central role of the planning-policy analysis system is the creation of information for decision-making. The myriad of data gathering and analysis activities in any country are the means by which these information flows are created.

Data Systems

Choices of variables to be measured and the units they are to be measured in are a prerequisite to measurement. The direct product of the measurement process is data. As previously discussed the quality of data can be evaluated using criteria of accuracy (reliability), relevance, and timeliness. Another important data quality characteristic is consistency.

Data are said to be consistent:

1) When a variable is measured in the same way over time:

2) When different measures of the same variable give comparable results; and

3) When measurement of the individual components of a variable equals the total as measured directly.

Each of these aspects of consistency are important but not easy to achieve in practice.

As previously noted, perfect accuracy in data collection is not possible. Bias and precision are two dimensions that determine data accuracy. Bias is defined as the difference between the statistical expected value of a measurement process and the unknown actual value of the variable. The measurement procedure is said to be unbiased if that difference is zero. Thus, bias deals with the conceptual outcome of a repeated measurement process in comparison to unknown true values, and says little about a single measurement. Indeed, if the true value is known, an estimate is unnecessary and bias is not a problem. Precision refers to the variability in repeated measurements of the same variable. High precision indicates that repeated measurement will give values that cluster closely around the average, which, if there is no bias, is equal to the actual value. In this case, the greater the precision, the less an estimate is likely to diverge from the actual value of the variable.

Timeliness and relevance are less statistical in nature but no less important for the usefulness of the data. In most countries, the value of data could be greatly enhanced by more attention to these two criteria.

Data systems are increasingly subject to obsolescence where the data being collected no longer give realistic or relevant information about real problems of the economy. Obsolescence may arise either from changes in the variables being measured or from shifts in problems and policies. If the variable change but no changes are made in the operational definitions of measurements being made, the data system will be reflecting a reality that no longer exists. Each time a policy-maker is faced with a new problem or considers a new policy option, it is essential to determine whether the present data system is supplying the raw data needed for analyzing it. The process of adjusting the data system to make it more relevant to current policy concerns and contemporary socioeconomic reality is a continuous and unending one. In a world of change, data needs also change rapidly. For this reason, it is just as important to keep an eye on the changing nature of the questions as to focus on information needed to answer yesterday's problems.

Data, Analysis and Users

As emphasized earlier, data are not information. Information generation is a process that impose form and gives meaning to data. Data becomes operational as information only in the context of some analytical information process.

An information system not only produces a data base through a coordinated statistical servicing system but also analyzes and interprets the data for purposeful problem-solution and policy decision-making purposes. The demand for data is generated by the need for information for use in making decisions. Policy-makers seldom use raw data. Rather, there are intervening acts of analysis and interpretation by policy analysts. It is the data needs of these analytical activities that should guide the design and production of data, for the empirical content of the policy analysis depends on the availability of appropriate data. Statisticians alone cannot design the data system if it is to be responsive to the analytical framework used to help solve decision problems.

What information does a country require to implement policies, programs, and projects that will increase agricultural production, incomes, foreign exchange earnings, and contribute to other objectives? What facts do planners and policy analysts need to generate information for decision-makers and how can these facts be gathered in a continuous, consistent, and timely way? More precisely, when the purpose is to improve existing data collection activities, the most important question is about <u>minimum</u> data needs of the analysts and the most <u>cost-effective</u> ways of meeting those needs. It is easy to determine the many needs of planners and analysts, but less simple to assign priorities to different types of data and alternative actions to improve the data system.

In the information system, the users of the data are the planners and policy analysts. In turn, the users of the information produced by the analysts are the decision-makers--individual, local, regional and national. The most effective route to the better production and utilization of information lies in developing improved capacity for information generation and delivery, i.e., capabilities for planning and policy analysis. This requires staff, facilities, and stronger linkages between analysts and decision-makers. It is a long-term process involving training that must take into account the national institutional framework, human resources, and technical capabilities for data handling and analysis.

LDCs already spend large sums for this purpose often encouraged by international agencies and other donors as well as by internal needs. Costs for large-scale data collection are rising rapidly. Unfortunately, much of the data collected is not very useful for the pursuit of development goals. The elaboration of analytical frameworks that indicate the specific kinds of data that are needed to produce the analyses required to support decision-making would permit LDCs to pinpoint more precisely their data requirements. This could increase the actual yield from expenditures on data.

Comparable to the data case, LDCs (and aid agencies) utilize surprisingly large amounts of money in a discrete series of poorly related, low quality, one-shot, start-and-stop analysis and planning efforts. Policy-makers tend to demand quick answers to policy and program option questions, which is often necessary but which almost as often produces inadequate answers due to a lack of a systematic analysis of the pertinent factors by personnel trained to do it well. Usually this analytical capacity cannot be created quickly, or even in several years, so that highly subjective methods are applied by inadequately prepared LDC personnel. This description too often applies to much of the analysis done for project selection as well as other policy work. The reliability and usefulness of the results are often comparatively low, even when professionally competent foreign advisors are involved. As a result, the support for policy analysis, and sector planning in general, is damaged so that it becomes more difficult to obtain resources for the longer term and the more systematic analytical approach that is needed. By gradually building up, keeping current, and improving a suitable array of data sets and models of agricultural sector and rural development processes, the costs of responding to short-term analytical requirements of policy-makers and planners can be reduced and the quality and consistency of responses much improved. Costs are reduced because duplication of efforts to build the data base for each analysis is avoided, the analysts themselves are better prepared for their task, and the results are not left aside after their immediate use but contribute to later analysis in a cumulative fashion.

Data Needs for Planning and Policy Analysis

Planning and program management activities in the public sector rely heavily on quantitative information about the socioeconomic system. Thus, the extent and quality of statistical information is particularly important to those responsible for constructing development plans, conducting policy studies, and implementing public sector interventions.

Often, the planner, analyst, or manager is not in a good position to evaluate critically the data that he uses. Certainly his concentration on his immediate responsibilities, time limitations placed on his work, and lack of specialized expertise and experience make it difficult to carry out detailed evaluations of quality of the data he uses. Nevertheless, the validity of his results will be strongly influenced by this quality. This implies a need for the users to be as familiar as possible with the source and character of available data, major problems that can arise from using them, and techniques useful for overcoming those problems.

The search for relevant statistical data means that the users of data usually must maintain close contacts with data producers. It is in users' interests to establish close links to data gatherers and processors not only to gain access but also to influence the development of data and information in line with their needs. Conversely, users also need to listen to the advice of statisticians and processors so that definitions, concepts, and classifications are consistent between data generation and data utilization.

Data-users can be classified in various ways. One classification is between governmental users and nongovernmental users (individuals, firms, and organizations). Another way is to classify users by the functions they exercise: planning and analysis, decision-making, implementation, and monitoring and evaluation. A third is to group users by levels in the spatial-administrative hierarchy of the economy: national, regional, and local.

The data needs of the various classes of users are naturally different. Aggregated information on production income, prices, and other variables, is essential at the national level but of limited use at the local level. Small-area data, on the other hand, may be superfluous detail for national users but highly relevant to local decision-making and management.

In shaping national data programs, it is important to consider both the overlap among users as well as the special needs of particular groups of users. In a systematic approach to data improvement, data programs may be oriented to a considerable degree to those data whose use is most widespread, while at the same time providing for the special data needs of the most important user groups. The problem is to balance the special needs of some users against those of other legitimate users.

A good place to begin is a listing of basic data series needed along with an indication of the required frequency of collection. In the case of agriculture and the rural economy, the basic data series should cover the following major categories:

1. Land and water resources and utilization.
2. Production of crops and livestock products: sales, home consumption.
3. Population and households in rural areas: employment, income, consumption, nutrition, access to social services.
4. Farm organization and resource utilization; production systems.
5. Prices of products and inputs.

6. Marketing and utilization.

7. Public sector institutions and programs.

A baseline assessment of the existing data base in each of these categories will reveal:

a) areas where insufficient or poor quality data are hindering planning efforts,

b) areas where data should be collected on a regular basis, and

c) deficiencies in analysis and dissemination of information.

The Conceptual Framework for Information Generation

It is impossible for any analyst or planner--and fortunately unnecessary--to perceive the real world in all its minute detail and complexity. Therefore, what we can know of the real world is both limited and shaped by our perceptions. These perceptions, in turn, are guided by the mental concepts we have of that real world. The collection of such concepts that we hold, often unconsciously, forms the theoretical framework which acts as a filter for our perceptions, and the process by which the theoretical framework is formulated and updated is theoretical conceptualization, a process which takes place both consciously and unconsciously. The theoretical framework for agricultural planning limits our perceptions of the real world to those aspects of the socioeconomic situation having a bearing on agricultural public decision-making, aspects partly determined by the values of the decision-makers as reflected in the government's doctrines and political ideologies.

Since theoretical concepts are largely held unconsciously by most individuals, and tend to be vague and possibly even inconsistent, it is necessary for rational and effective planning that they be operationalized in an explicit, comprehensive, and consistent framework. Such a framework represents a systematization of the information base of agricultural planning and includes three basic components.

The first component is a conceptual subdivision of the socioeconomic system into relevant subject or policy areas. A second component of an operational framework specifies the broad goals of agricultural planning and, with respect to the policy areas, the hierarchy of instrumental objectives and specific policy choices directed at the attainment of those goals. Thirdly, the framework identifies specific socioeconomic performance indicators to be measured and to form the basis for the evaluation of the socioeconomic situation, including the results of implemented policies, and for the analysis of policy options. There are many ways the conceptual framework can be defined, depending on the country's political system and the government's doctrinal position.

The conceptual framework is a prerequisite to measurement, since it specifies the variables to be measured and the units they are to be measured in. By definition, the direct product of the measurement process is data. The data system is composed of not only the measurement process with which it is usually identified, but also the processes of theoretical and operational conceptualization so fundamental to measurement.

Summary: Data and Information Systems

To summarize this discussion, the five principal criteria by which a data system can be evaluated are: relevance, accuracy, consistency, timeliness, and accessibility. The last four of these criteria refer to the three stages of the measurement process: data collection, data management, and data dissemination. The structure and quality of data collection particularly influence the accuracy, consistency and timeliness of the data, while data management and dissemination both contribute to timeliness and accessibility. The relevance of data, however, depends on how well integrated the conceptualization processes are into the data system. The most accurate, consistent, timely, and accessible data may yet be useless for policy analysis if the measurement process has not kept up to date with current data needs as reflected in the conceptual framework.

Data--the product of measurement--flow into and augment the planning system's knowledge base of positive and normative data and information. As emphasized earlier, the distinction between data and information is that, while data represent the raw results of measurement, information is the result of processing that data through interpretation and analysis . In a sense, we can conceive of a continuum of information, with data located at the lowest end and the upper end unbounded. Any piece of information, then, will fall somewhere along that continuum depending on the degree of interpretation and analysis embodied in it.

The pool of positive and normative data and information is drawn upon by other users for planning, policy analysis, decision-making, implementation, and evaluation. In particular, information from the knowledge base is a key ingredient, along with the socioeconomic situation and the government's doctrinal position, in updating the theoretical and operational conceptual frameworks which guide further perceptions of the real world and, in turn, further additions to the knowledge base itself.

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CHAPTER 2

MARKET STABILIZATION AND PRICE-SUPPORT PROGRAMS

Introduction

As noted in Chapter 1, governments intervene in the price-setting mechanisms for food and other agricultural products in many different ways and for various reasons. These interventions can cause adverse effects on prices, farmers' incomes, and export revenues especially where the primary sector is a large component of the GNP of the country. But where market instability is excessive, a lack of efficiency in the allocation of productive resources and utilization of the output can result. Uncertainty in the prices and income of primary producers can create severe problems, particularly where there are geographical areas highly specialized in one product. It affects investment decisions, family living expenses, and ultimately the level of agricultural output.

Government interventions are often designed to alter prices or quantities away from those which would otherwise occur. The context of agricultural development differs, however, in different parts of the world. Some developed countries are more concerned with problems of low demand and excess supply, while some developing countries are more concerned with the need to increase output and food consumption.

Most policies for intervening in food markets involve multiple objectives goals. There may be dual objectives of price and income stabilization. Stable prices, however, do not necessarily imply stable incomes for individual producers. As an example, consider that a government specifies these five objectives for its foodgrain price policy: 1) attain self-sufficiency in foodgrain production, 2) stabilize market prices of foodgrains, 3) increase consumers' welfare, 4) increase incomes of foodgrain producers, 4) hold down government expenditures. Similar objectives have been reported in several case studies of price policies. For each objective, alternative performance measures can be defined. The loss of welfare, defined as a loss of social real income (net social loss), is often calculated by the summation of changes in producers' and consumers' surpluses (deadweight loss). This approach is derived from standard static partial equilibrium analysis based on the Marshallian economic surplus concept.

The social cost approach is often used in the analysis of market interventions to provide an approximate measurement of allocative inefficiencies and welfare transfers between producers and consumers due to price distortions. Typical causes of price distortions are producer price supports, tariffs, quotas, export taxes, input subsidies, and retail price ceilings. These policies distort domestic producer and consumer prices away from international c.i.f. import or f.o.b. export prices (border prices). Stabilization of product prices has the advantage that it provides a cushion from downward fluctuations, reducing the risk of low prices and incomes. As product prices increase an array of inputs can be used instead of concentrating on one or a few, as is the case of an imput subsidy. Moveover, it is possible to concentrate on a few key crops. This cannot be done with a general subsidy on inputs, since all inputs may be used on a myriad of crops.

The objective of this chapter is to review some of the main issues in stabilization and price support programs. The chapter emphasizes two main themes: 1) guaranteed price programs and 2) price stabilization programs. It begins with a review of the basic concepts of consumers' and producers' surpluses as measures of social welfare and costs. Then, the analysis of price support program includes: 1) support price programs, 2) minimum price floors, 3) government purchase-sale and import-export programs, and 4) regional price differences. The second major section consists of: 1) a welfare analysis of price stabilization programs, 2) income stabilization, 3) objectives of price stabilization, 4) food security policies, and 5) agricultural comparative advantage. All of these topics are meant to provide helpful material for policy analysts working on price programs in developing countries.

A Review of Consumers' and Producers' Surplus

The concepts of consumers' surplus and producers' surplus are extensively used as measures of welfare in this manual. Therefore, it is useful to state the meaning of these two concepts and their implications for the different price policies in agricultural markets that are discussed later.

Consumers' Surplus

Assume there are n commodities that an individual can choose and that each of them has a price. The individual has a given income, I, that can be spent in consumption. The individual's Marshallian demand function for each commodity is obtained from the "price-consumption curve", which contains the quantity of that good that maximizes utility for the individual for each price of the good, given preferences, income, and prices of other goods. Thus, the individual's demand function for the i^{th} commodity is defined as: $q_i = q_i(\vec{P}_1, I, \alpha)$ where α represent tastes and preferences, $\vec{P}$ represents a vector of price P_1, P_2 ... P_n, and I_i is the individual's income. If prices of the other commodities are given, and the income of the individual is also given, then the individual's demand curve for commodity i is a function of its price, P_1^i. Assuming q_i is a normal good, then this demand curve can be represented as:

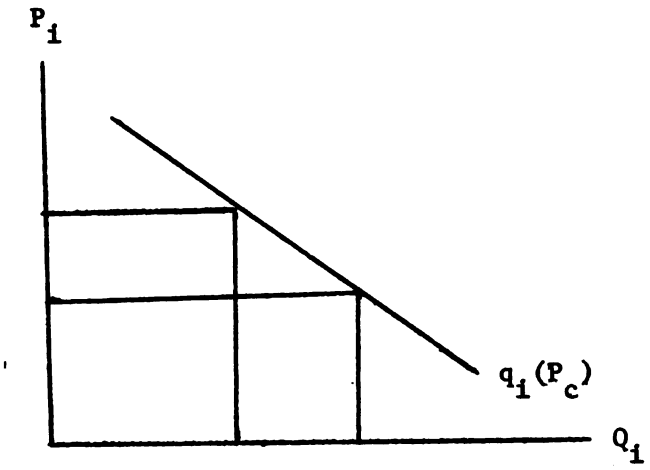


Fig. 2-1 Demand curve of an individual for good i

The demand curve is downward sloping as a function of price because of the normality assumption. An increase in the price of some other commodity j will shift the demand curve down if i and j are complements, up if they are substitutes. Similarly, an increase in the money income alone will shift the demand curve for i up.

Assuming demand curves for individuals are independent, the market demand curve D_i is obtained by the simple horizontal summation of the demand curves of the m individuals in the economy. Thus:

$$D_j = \sum_{j=1}^{m} q_{ij}(\vec{P}, I) \qquad \begin{array}{l} i = 1, \ldots n \\ j = 1, \ldots m \\ I = \text{total income for all consumers} \end{array}$$

There is some problem with this aggregation, because it assumes that each individual has given and independent preferences. However, given this assumption, the derivation of market demand curves is straight forward. Moreover, demand will be a function of the distribution of income over individuals as well as total income.

Each point on this demand curve reflects the subjective marginal value of that unit of the commodity to the individuals. Therefore, the area under this curve from 0 to a given quantity reflects the total subjective value consumers derive from the consumption of a given quantity, Q_i^0 of the ith commodity. This value is shown by the shaded area in figure 2-2.

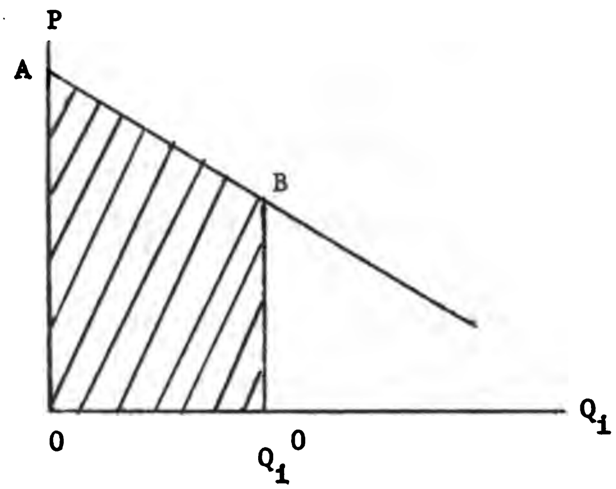


Fig. 2-2 Social value of a given quantity of a good to its consumers

The area of ABQ_i0 is precisely given by the expression: $\int_0^E D_i(Q_i)\, dQ_i$, which is the integral of the demand curve Q_i from zero to the quantity OE.

Assume the price of the good is C, then the expenditures of the consumers will be the area of the rectangle CBE $\equiv P_iQ_i$ (figure 2-3). If this expenditure is subtracted from the subjective value derived by the society from the consumption of OE units, then the area left is the triangle ABC which represents consumers' surplus from consuming OE units. This area is measured as:

$$CS = \int_0^{Q_i} D_i\,(Q)\, dQ_i - P_iQ_i$$

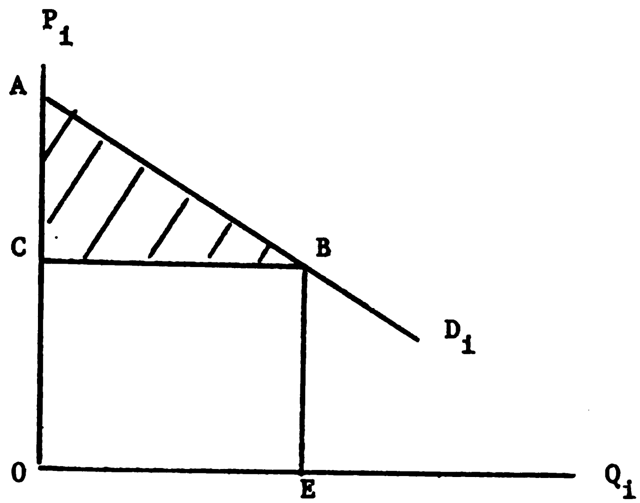


Fig. 2-3 Measurement of consumers' surplus

If the price of good i falls, as in figure 2-4, the gain in consumer surplus will be equal to the area CBGF. The area of the rectangle CBHF represents the gain in economic surplus to consumers as a result of the fall in price for the original quantity purchased. The area of the triangle BGH represents the gain in surplus associated with the expansion of quantity consumed at the new lower price. And finally the area of the rectangle $EHGE^1$ represents the cost of buying additional (OE^1-OE) units. The gain in consumere surplus is defined in general as:

$$\Delta CS = \int_{P^0}^{P^1} D_i\ (\vec{P},\ I)\ dP_i$$

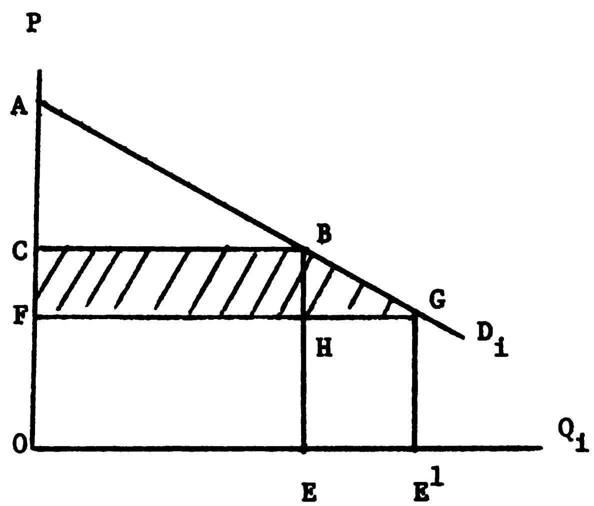


Fig. 2-4 Change in consumers' surplus

Producers' Surplus

The short run supply function for an individual firm in perfect competition is obtained from the profit maximization conditions. The first-order conditions are P = MC and

$$q_i^s = \begin{cases} Q_i & \text{if } P_i > \text{minimum AVC} \\ 0 & \text{otherwise)} \end{cases}$$

Where P_i is price, q_i^s is the firm's supply for the ith product, MC is the marginal cost of producing an additional unit of output, and AVC is the average variable cost of producing quantity Q_i.

The second order condition for profit maximization states that the marginal cost must be monotonically increasing (MC > 0). For the long run, P = min Average Cost for all firms, which reflects zero profits in the long run for all firms and hence for the industry.

The short-run supply function is often represented as:

$$q_i^s = q_i^s\ (\vec{r}, \vec{P}, \Theta)$$

where Θ is parameter which represents the technology embodied in the production process, $\vec{r}$ is a vector of factors price, and $\vec{P}_i$ is a vector of product market prices. The industry supply curve in the absence of externalities is the horizontal summation of the K-individuals firms supply curves;

$$S_i = \sum_{j=1}^{k} Q_{ij}^{S} (\vec{r}, P) \qquad \begin{matrix} i = 1, \ldots, n \\ j = 1, \ldots, k \end{matrix}$$

where curves show the quantity of good i that will be supplied at different prices of i, assuming other prices and technology are given.

Figure 2-5 represents a hypothetical short-run supply curve for the industry. Each point on this supply shows the marginal cost of producing an additional unit of output. Therefore, the area OCBM will represent the total cost for the industry of producing a level of output OM. If the market price for Q_i is A, than the total revenue for sellers is given by OABM (P_iQ_i). Producers' surplus for the industry from producing OM is measured by the area of the triangle ABC. In general, the producers' surplus is

$$PS = \int_{P_0}^{P_i} S(\vec{P}, \vec{r})\, dP, \qquad \text{or} \qquad PS = P.Q - \int_{0}^{Q} S(Q)dQ$$

If the market price for the output increases to R, then there is a gain in PS equal to the area RLBA, where area RNBA is the gain in surplus to producers as the result of the price increase for the original quantity OM, and the area of triangle NLB represents the additional surplus associated with the expansion of quantity supplied to OM^1 at the new price OR.

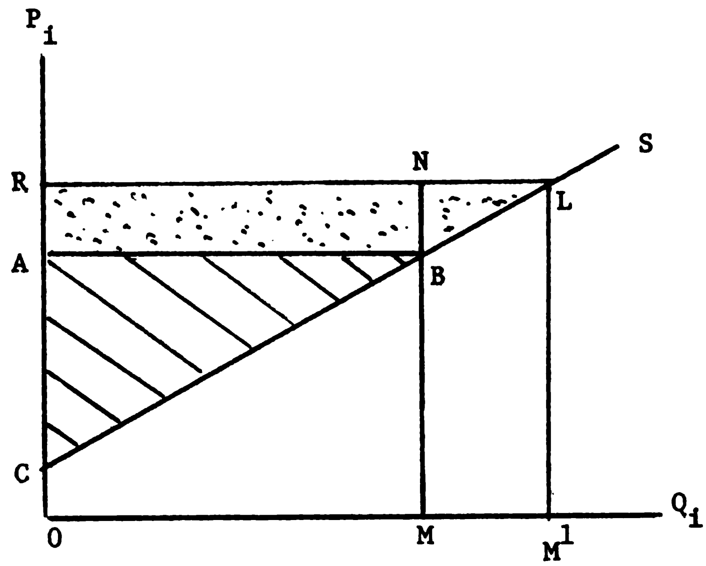


Fig. 2-5 Producers' Surplus

Producer Price-Support Programs

This section examines some stylized types of policies for guaranteed producer prices using the criteria of social cost. The method of analysis is based on Wallace (1962). Assume that the government desires to set a guaranteed price for an agricultural commodity, presumably above the market-clearing equilibrium price. Social cost is defined as any net loss in consumers' and producers' surpluses added to any net cost incurred by the government. Four types of policies are examined, which represent in a general way the policies commonly used by different countries.

Type I Program

Both consumers and producers face the guaranteed price. The quantity consumers will buy at the guaranteed price determines the new output level. This type of policy is illustrated in figure 2-6.

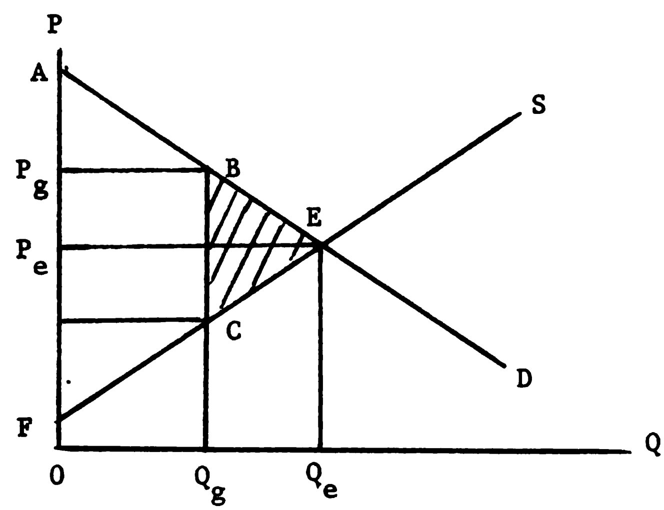


Fig. 2-6 Social costs of a guaranteed-price, controlled-output program

For the free market equilibrium, consumers' surplus is given by the area AEP_e and producers' surplus by area P_eEF, and the sum of both (CS + PS) is equal to the area AEF. As soon as this type of policy is in effect, where OP_G is the guaranteed price, the consumers' surplus will be equal to area ABP_G, the producers' surplus will be equal to area P_gBCF, and the sum of both is reduced to the area ABCF. Therefore, the net social cost will be represented by the area of the triangle BEC. The area of this triangle will depend on the relative elasticities of demand and supply. The larger the price elasticity of demand, the bigger the social cost will be, *ceteris paribus*. The larger the price elasticity of supply, the smaller the social cost, *ceteris paribus*. And, obviously, the larger is the difference between the guaranteed price and the market equilibrium price, the larger the social cost will be.

While this example illustrates the use of the economic surplus measures, it is not really very realistic. For at price OP_g producers would want to supply a large quantity, OP_g. The government would either have to buy the surplus (Q_eO_g) and remove it from the market or reduce the quantity producers were allowed to produce, possibly by some type of supply controls. The types of program discussed below take these possibilities into account.

Type II Program

For this program, consumers pay the price consistent with the quantity supplied by producers, which is determined by the guaranteed price. A direct government income transfer makes up the difference between the market price and the guaranteed price to producers.

In figure 2-7, P_c represents the consumers' price and P_g the producers' price. Given this type of policy, the consumers' surplus increases by the area P_eERP_c and the producers' surplus increases by the area P_eELP_g. The income transfer made to producers by the government is equal to the area of the rectangle P_gLRP_c. Therefore, there is a net social loss equal to the area of the triangle ELR, since the transfer by the government is larger than the combined increase in consumers' and producers' surpluses. This social cost will increase as the supply elasticity increases and as the demand elasticity decreases.

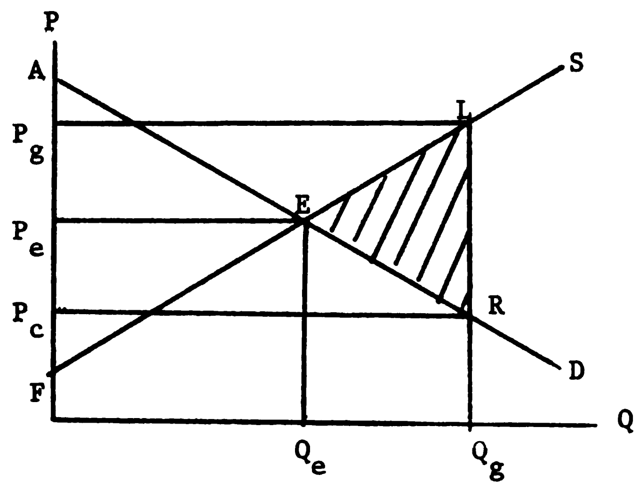


Fig. 2-7 Social costs of a guaranteed-price, income-transfer program

Type III Program

A guaranteed price is established above competitive equilibrium and acreage controls are used to reduce output by shifting the supply curve to FS^1. Policies of this general types were used for many years in the United States. As in type I programs, a social cost equal to the area of the triangle BCE is incurred. In addition, however, the social cost equal to the area of the triangle FBC arises. This happens because the PS is no longer equal to the area P_JBCF as in the Type I case. Instead, it is equal to the area of triangle P_JBF. This reflects an inefficient use of resources under the acreage controls imposed. Therefore, the social cost of this type of program is larger than for type I programs. The more inelastic is the price response of the demand, the larger the inefficiency component of social loss will become, ceteris paribus.

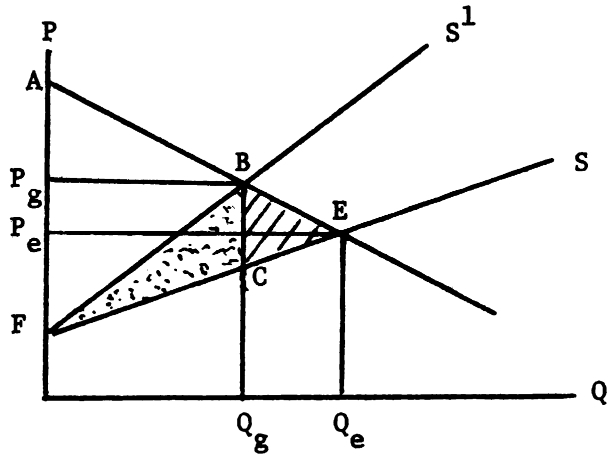


Fig. 2-8 Social costs of a guaranteed-price, import-restriction program

Type IV Program

Both consumers and producers face the guaranteed price, and the levels of output demanded and supplied are consistent with the demand and supply functions, respectively. The government buys the excess quantity supplied at the guaranteed price and sells it on the international market. (This policy could also be used for a multi-year purchase-storage-sales programs to stabilize the market as discussed in the second section of this chapter.) The effects of this program depend on the relationship between the domestic guaranteed price and the international price. The three possible cases are considered below.

Case 1) Domestic equilibrium price equals the international price. In this case, the international market price P_I equals the domestic free market price P_e. With this type of policy the producers' surplus rises to the amount equal to the area $P_J LEP_e$ and the consumers' surplus falls by the area

$P_G BEP_e$ (Fig. 2-9). Thus, there is a total gain equal to the area of the triangle BLE when PS and CS are added together. The excess output supplied, Z, is given by

$$Z\ (P_g) = Q_p - Q_c \qquad \text{and } P_g = P_c = P_p$$

where Z denotes excess quantity supplied, P_c is the price faced by consumers, P_p is the price faced by producers, and Q_p and Q_c are the quantities produced and consumed. The excess supply quantity is bought by the government at price P_G--the guaranteed price-- and sold in the international market at price P_I. Thus, there is a revenue loss to the government equal to the area of rectangle BLNK.

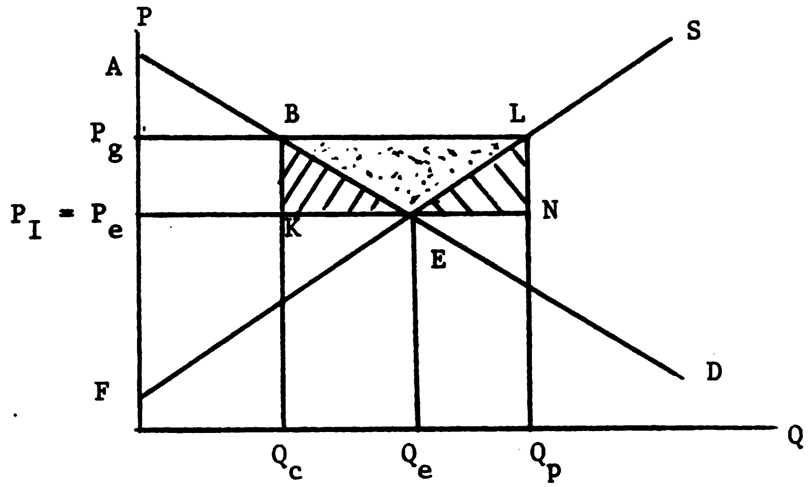


Fig. 2-9 Social costs of a guaranteed-price, export program, Case 1

The social loss of this program for this case will be given as the difference of the government loss and the gain in surpluses, which is the difference between the rectangle BLNK and the triangle BED. Therefore, the social loss is measured by the areas of the two triangles BEK and ELN.

Case 2) Domestic equilibrium price lower than the international price; guaranteed price higher than the international price.

As shown in figure 2-10, this case yields a gain in consumers' and producers' surplus taken together equal to the area of the triangle BLE, as before. However, this time the excess quantity supplied is sold by the government at price P_I, which is higher than the domestic market equilibrium price, so the loss for the government is given by the area of the rectangle BLTH. Social gains or losses in this case will depend on the relative dimensions of triangles BHM (denoted by γ_1) and LTJ (denoted by γ_2). Therefore if the prices are such that:

$$\Theta - (\gamma_1 + \gamma_2) \begin{cases} > 0 & \text{There is a social gain from this program.} \\ = 0 & \text{There is neither a gain or a loss from this program.} \\ < 0 & \text{There is a social loss from this program.} \end{cases}$$

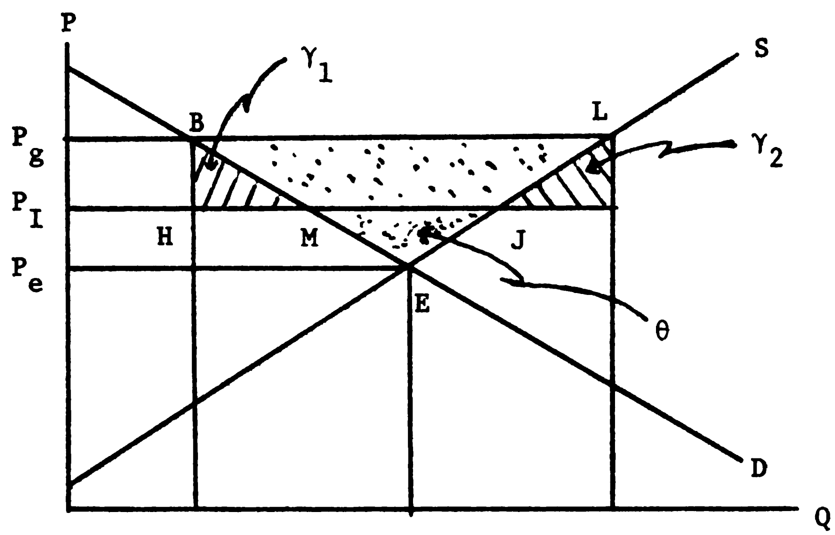


Fig. 2-10 Social costs of a guaranteed-price, export program, Case 2

Case 3) Domestic equilibrium price higher than international price.

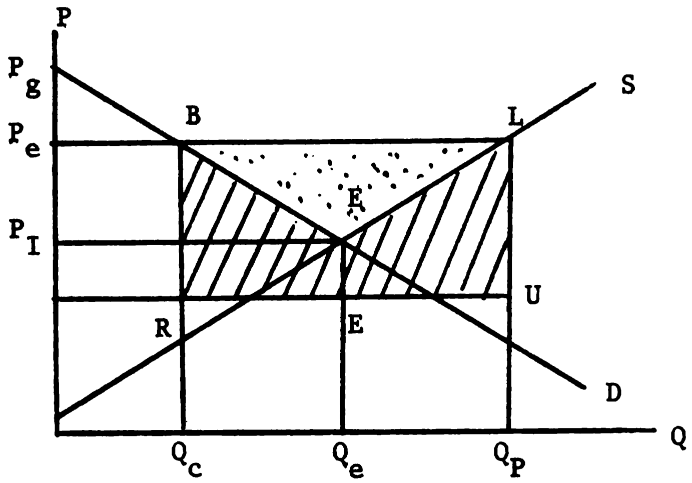


Fig. 2-11 Social costs of a guaranteed-price, export program, Case 3

In this case, the government will lose even more money than in either of the two previous cases. This loss is given by the area of the rectangle BLUR. Its difference over the triangle BLE yields the social loss, which is given by the area of the two trapezoids BETR and ELUT.

For all these cases, it is assumed that the government is the sole importer/exporter in the international market for the commodity in question. Otherwise, social losses would be much larger if, after the application of a guaranteed price above the international market price, consumers simply shift from the domestic to the international market in order to purchase at the lower price. This possibility is a reminder that government policies can create illegal sales across borders, which can sharply inflate the costs of the program.

Conclusions

1. Under type IV programs, the international market prices of the commodity in question becomes an argument in the social cost function. There is a possibility that positive social gains may result as shown in case 2. This

result is not possible with the first three types of programs. Moreover, no account has been taken of government storage, transport, and transaction costs, which may be large. Social losses would rise if these were considered.

2. If the government is interested in increasing revenues of farmers and at the same time increasing the food supplied in the domestic market and holding consumer prices down, then a type II policy seems to be the best approach available.

3. If the government, however, wants to raise prices to producers by reducing the quantity supplied, then a type I policy shows a smaller social loss than a type III, but controlling output is more difficult.

4. These four types of guaranteed price programs may be characterized as "support" programs. Another approach to guaranteed prices is to establish "shelter" or "minimum" prices to establish a floor below which the free market equilibrium price is not permitted to fall. The purpose of this type of policy is to provide protection to farmers against market uncertainty. This type of policy is reviewed in the next section.

5. Given the existence of a successful support price or guaranteed price, farmers would not only move along the existing market supply curve but that the curve would also shift to the right. Therefore supply excess would increase and so would social losses and the costs of the program to the government.

6. In the long run, public concern might well move from guaranteed price problems to the problems of price and market stability. Programs designed to stabilize markets are analyzed later in this chapter.

Minimum Price-Floor Programs

Defining the objectives of price policies should be the first step in making policy decisions on programs. Often these policies have one or more of the following objectives:

1. Incentives for production,
2. Set prices at the cost of production,
3. Provide protection to farmers against price risks and market uncertainties. (Shepherd, Sanford, and Cossio, 1969)

Incentives

One possible objective of the government is to establish prices at incentive levels. So the aim of the policy is to provide incentives to farmers to produce more of the product in question. This in turn means that the prices are to be set at a higher level than would prevail in an open market situation. There are unfavorable side effects, however. Raisng the price will also reduce the quantity demanded by consumers, therefore, the government will be left holding the excess of supply that cannot be sold without loss, which usually can mean substantial losses for the government. Many countries including the United States and the European Economic Community have found this out on a very large scale. When "support" prices have been set higher than open-market prices, large unsaleable surpluses have accumulated, causing the loss of billions of dollars. Similar situations have arisen in some LDC's that usually cannot afford losses on such large scale. Figure 2-12, describes what happens when prices are set higher than open-market prices. The demand curve, D, represents the quantities of the product that will be demanded by consumers at various prices, while the supply curve, S, shows the quantities of the product that will be offered by the producers at different prices. The intersection of the time curves defines the equilibrium price (P_o) and quantity (Q_o) in the market. Now, if the government sets the price higher than P_o, say P_1, consumers will demand Q_1 and producers will supply Q_2. This will result in an excess supply equal to the amount $\overline{Q_1 Q_2}$, which cannot be sold at price P_1. The government has to buy and hold this excess quantity off the market, which may result in a loss. In such circumstances, setting an incentive price higher than equilibrium market price is simply not a feasible solution unless the government is prepared to subsidize the producer at considerable cost to the taxpayer and permit the price to consumer to fall to P_2.

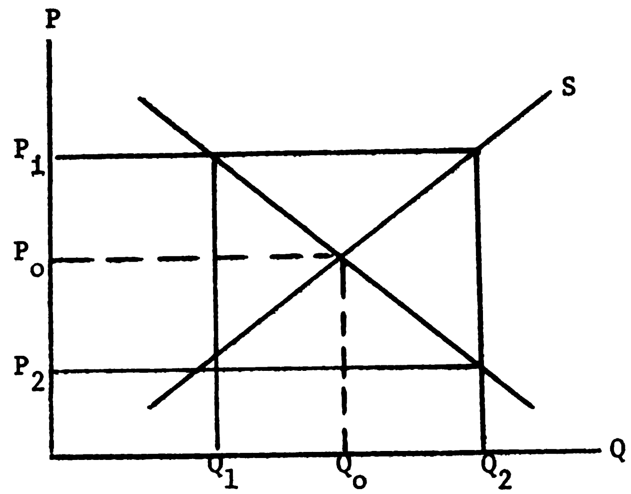


Fig. 2-12 Costs of incentive prices set above market equilibrium

<u>Set Prices at the Cost of Production</u>

Some people argue that prices should be set at a level sufficient to cover the cost of producing an agricultural product. This proposition is not as simple as it sounds. In fact, it turns out to be quite impractical.

Each farmer has his own costs of production and these costs differ from farmer to farmer. Indeed, each producer has several "costs" (i.e. short-run versus long-run, variables vs. fixed). So it is not possible to determine a single figure as the estimated cost of producing a certain product. If we take the estimated average cost of production a certain percentage of farmers will have costs of production higher than the average and can not profitably produce at a support price set at such average. Others will have lower average costs and will make excess profits at the established price.

> "The average in any case is merely an arithmetical calculation. It has no economic standing, and no logical basis in this economic situation. It is not what is needed here. If one is about to march an army across a river, it is silly to compute the average depth of the water at the crossing. The average depth may be only four feet; but in the middle it may be eight feet deep. All the men are more than five feet tall, but it would be a mistake to act on the basis of the average depth of the river and march the men across. The average cost is similarly inappropriate." (Shepherd, et al., 1969)

Price Floor

Another objective for setting a price is to provide a shelter to protect food producers against market risks and uncertainties. This type of prices constitute a minimum price floor. It has been suggested that such prices should be set a little below the equilibrium market price given by the supply and demand functions.

> "This equilibrium price is based not on dozens of estimates of costs of production, but upon supply and demand in the market; and this is based upon producers' and distributors' and consumers' actions--upon what they will do." (Shepherd, et. al., 1969)

A Procedure for Setting Prices Based on Economic Factors

Shepherd, Sanford and Cossio (1969) presented a procedure to be used for setting prices based on the economic considerations. They suggested looking at economic factors such as:

1. Probable volume of harvest;
2. Effective internal demand and trend of annual increase;

3. Present levels of productivity;

4. Reserves accumulated and facilities for adding to the stored quantity;

5. Possibility of exporting surpluses in accord with the conditions of international markets;

6. Types, varieties, and quality of the commodity in question;

7. Domestic possibilities for processing;

8. Costs of transportation and storage;

9. Importance of the product in the agricultureal sector and the economy of the country;

10. Estimation of probable net incomes that farmers will receive; and

11. Evaluation of the effects of higher food prices.

Then they suggested the use of forecasting methods for demand, supply, and price as a basis for establishing a price floor. The first step is to start with last year's prices and see how the market situation worked out. If the government purchased very little of the product, then either its purchasing procedures were unsuitable, or its prices were set too low. If, however, the government acquired a large amount of the product and could sell it only at a loss, that would mean that the price was set too high. Comparison with anticipated open-market prices would be very helpful in this analysis. The next step is to estimate how much quantity is to be produced, demanded, and exported this year drawing on all the sources of information available. Then the expected price can be estimated by using estimated price and income elasticities of demand for the product.

This price forecast could be used as the basis for setting the floor price of the product, which would act as a form of insurance to the producer against the risk of price decreases.

In 1952, F. W. Paish and P. T. Bauer presented a proposal for reducing the violence and magnitude of temporary fluctuations in the income of primary producers. They pointed out that the inelasticities of supply and demand, especially in the short-run, are the main factors responsible for the price fluctuations of primary commodities, which in turn brought wide fluctuations in the incomes of farmers. Government interventions in such a case sometimes unfortunately created, in the view of Paish and Bauer, a tendency to reduce the adjustment of supply to changes in the demand as expressed through the price mechanism. They said that in deflationary periods for agricultural commodities, governments frequently try to restrict output in order to raise prices received by farmers, results of which may affect in an unfavorable way in the long turn in the direction of adjustment of the primary sector to the growth of the manufacturing sector and population.

Some policy instruments such as straight subsidies financed out of general revenue are impracticable where the commodity is the most important cash product of the country and a unilateral stock-holding policy fails where the exporting country has no effective monopoly. The Paish and Bauer approach tries to reduce the magnitude of temporary fluctuations in the incomes of primary producers with as little effect as possible on the adaptation of supply to changes in demand in the long run:

> "The proposed method is self-adjusting in the sense that there can be no loss of contact with the trend of prices or of incomes; it explicitly aims at smothering fluctuations in incomes, rather than in prices; and its adoption would render possible more accurate forecasting of the flow of producers' incomes in the territories concerned, for a year or two ahead."

They presented a formula for fixing producers' price each season calculated as the sum of two components: 1) a fraction of the estimated market price for the current year and 2) a component which is derived from the difference between the realized payments per ton in the previous years and the amount paid in those years on account of the first component. Thus their formula is as follows:

$$S_t = \frac{\bar{P}_t}{x} + \frac{\frac{1}{n}\left[P_{t-1}\, Q_{t-1} + P_{t-2}\, Q_{t-2} + \ldots + P_{t-n} - \frac{(\bar{P}_{t-1}\, Q_{t-1} + \ldots + \bar{P}_{t-n}\, Q_{t-n})}{x}\right]}{\bar{Q}_t}$$

where

S_t ≡ is the producer price to be derived for any year t

P_t ≡ the actual price

$\bar{P}_t$ ≡ the expected price

Q_t ≡ the actual quantities purchased

$\bar{Q}_t$ ≡ the expected quantities purchased

x and n are weights.

So the first element of the RHS of the equation is the price forecast for the forthcoming year and the second element is the correction component, so that the producers' supply relationship will be given by:

$$S_t = S_c(P_t, \frac{\emptyset}{\bar{Q}_t})$$ where ∅ represents the correction factor.

The authors contend that the approach will keep the price floor in contact with the trend of prices. It will stabilize producers' incomes but will not affect price levels over time. It will provide forecasts of future movements in income and ultimately will provide no risk of damage to the long-run competitive position of the producers concerned.

P. Ady (1953) rejected this approach arguing that since the formula depends on two unknowns ($\overline{P}_t$ and $\overline{Q}_t$), the scheme itself depends on guesswork. He believes its use is impracticable. B. M. Niculescu (1954) made the same kind of argument against the scheme. Milton Friedman (1954) argued that such an approach, besides being highly arbitrary, introduces an undesirable effect on incentives, suggesting that free market adjustment is a better alternative than government market intervention.

Government Purchase-Sale and Import-Export Programs

As was mentioned earlier, governments may not be willing to subsidize either farmers or consumers directly. Direct subsidies to producer may be unsatisfactory because a large percentage of the subsidy payments would go to a small percentage of large producers. On the other hand, direct subsidies to all consumers can be very expensive. Small, indirect subsidies to both consumers and producers in the form of fixed prices at the farm and retail level may be an alternative considered by a government. Setting these guaranteed prices, however, is a very difficult task. The government needs to differentiate among farm prices, wholesale prices, and retail prices while using this kind of policy. The setting of these three prices may lead to an excess of supply or demand in the market and a need to import or export. This in itself will lead the government to a wholesale operation involving the international market. So international prices enter also as a exogenous variable that affects the government profits or losses from the program.

William C. Merrill (1967) provided a simple but useful framework to illustrate the consequence of a guaranteed price program that involves a wholesale operation and international trade in a particular crop. The model takes into account random shifts in supply and demand. A system of iso-profit and iso-import curves are used to illustrate graphically the consequence of the government price decisions.

Merrill observed that, in general, the goals of the government program are: a) to maintain low retail prices, b) to maintain "fair" farm prices, c) to break even on its buying and selling operation, and d) to minimize external dependence for the agricultural commodity by reducing imports. A conflict between these goals can easily arise because, as the farm prices of the crop increase, farmers tend to supply more of it. As the retail price of the commodity increases, consumers tend to buy less of it. The government generally sells the imported and national production at the same price in the domestic market. Therefore, imports tend to decrease as farm or retail prices increase. Wholesale and retail prices are generally increased together. If the retail price is held constant but the farm price increased, then the government makes less money or losses.

To use this model, it is necessary to know the domestic supply and demand functions for the agricultural product, the cost of buying, storing and transporting it, and international prices. With these data, it is possible to determine the farm and retail prices required to prevent government losses and/or large commodity imports.

Estimating the Iso-Import Curves

In order to estimate the iso-import curves, the price effects on quantity supplied and demanded of the crop are needed. Let the demand equation be given by:

$$D(t) = d_o + \frac{\partial Q^d}{\partial y} \cdot y(t) + \frac{\partial Q^d}{\partial N} \cdot N(t) + \frac{\partial Q^d}{\partial P_r} P_{r(t)}$$

where:

$D(t)$ is the quantity demanded in period t, and d_o is the intercept

$Y(t)$ is an index of real gross national product in period t

$N(t)$ is the population in period t

$P_{r(t)}$ is the real retail price of the commodity in period t

$\frac{\partial Q^d}{\partial y}$, $\frac{\partial Q^a}{\partial N}$, and $\frac{\partial Q^d}{\partial P_r}$ are the regression estimators, which express how much quantity demanded changes given an infinitesimal change in Y, N, and P_r, respectively.

It is assumed that the government sets the farm, wholesale, and retail prices for the supported crop shortly before the harvest time. The period term "t" refers to the marketing year for the crop. The supply equation is given by:

$$S(t) = S_o + \frac{\partial Q^s}{\partial P_x} P_x(t-1) + \frac{\partial Q^s}{\partial P_f} P_f(t-1)$$

where:

S(t) is the national supply of the commodity in period t and so is the intercept

$P_x(t-1)$ is the export price in period t-1 of a substitute commodity which can be produced with the available resources,

$P_f(t-1)$ is the real farm price of the commodity in period t-1

$\frac{\partial Q^s}{\partial P_x}$ and $\frac{\partial Q^s}{\partial P_f}$ are the regression estimators which express how much quantity supplied changes with an infinitesimal change in P_x and P_f.

Using the demand and supply equations with various farm and retail price combinations gives the iso-import curve. (Fig. 2-13) This type of curve is defined as the geometic locus of all combinations of farm and retail prices that yield the same level of import (or export) values for the commodity. For example assume that the price combination $P^0(P_r^{\,0}, P_f^{\,0})$ is such that the

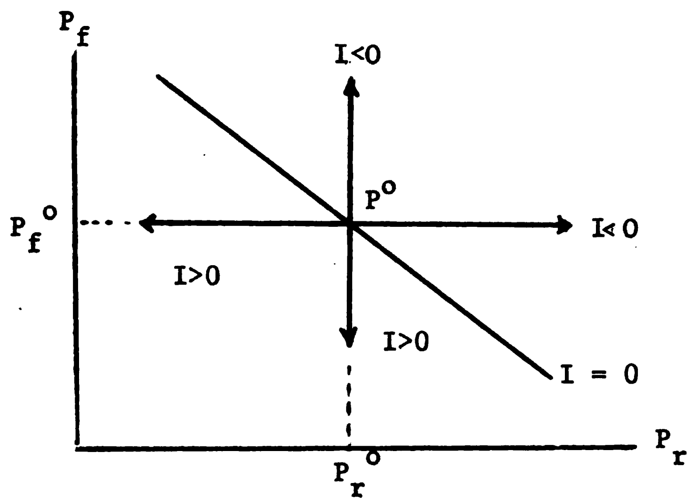


Fig. 2-13 Construction of an Iso-import curve

volume of imports/exports equal zero. Moving to the right of P^0 the retail price increases holding the farm price constant, so domestic supply will not be altered but domestic quantity demanded of the commodity in question will decrease so the excess of supply in the domestic market will be absorbed by government and will be exported in the international market. That is, there will be exports of the commodity (I<0). Moving to the left of P^0, the retail price falls while maintaining the farm price constant. This increases the domestic quantity demanded, but since supply has not been affected the government will need to import (I>0) from the international market in order to satisfy the domestic demand. Moving to the north of P^0, the farm price increases, therefore inducing a larger quantity supplied. The domestic quantity demanded, however, is not affected because the retail price has not changed. Thus, the government will absorb this excess supply and will sell it in the international market, so exports will occur (I<0). But moving in the opposite direction (to south of P^0), the farm price decreases, inducing a decrease in the quantity supplied by farmers. Since retail prices are held constant the quantity demanded remains constant. Therefore, there will be an excess domestic demand that needs to be satisfied by government imports from abroad (I>0). So the iso-import curve that yield zero imports has to pass through P^0 and have a negative slope.

Iso-imports curves that are above curve (a) represent different combinations of prices (P_r, P_f) which yield the same value of export for the product. Iso-imports curves that are below curve (a) represent different combinations of prices (P_r, P_f) that yield the same value of imports. (Fig. 2-14)

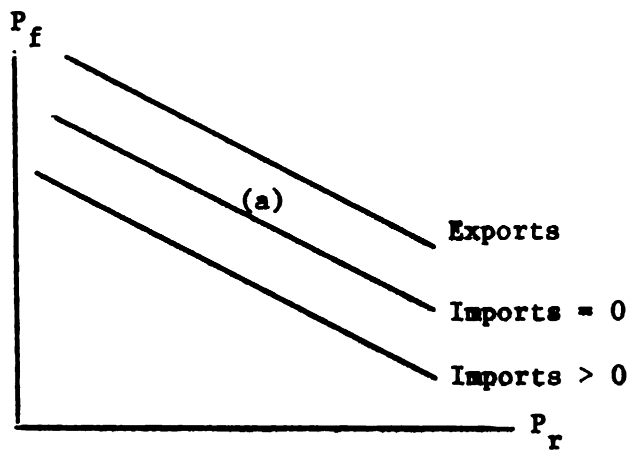


Fig. 2-14 Iso-import curves

Estimating Iso-Profit Curves

Iso-profit curves are affected by: a) The effects of prices on the quantities supplied and demanded, and b) the uncertainty about how much will be supplied and demanded. In addition, the prices of exports and imports are different.

Given that imports are required, the government's expected profit function, can be written as:

$$E(\pi) = P_W\ E(D) - (P_f + C_0)\ E(S) - FC - (P_I + C_1)\ E(I)$$

where:

π is the government's profits from buying and selling the crop.

P_w is the wholesale price.

D is the quantity of the product demanded.

P_f is the farm price.

C_0 is the variable cost of handling and storing the domestic crop.

S is the quantity of the commodity produced.

FC is the fixed cost of the government's program.

P_I is the price of imports.

C_1 is the variable cost of handling and storing imports.

I is the quantity of crop imported.

E denotes expected values.

On the other hand, exports are anticipated, then the government's profit function would be written as:

$$E(\pi) = P_w\, E(D) - (P_f + C_0)\, E(S) - FC + P_x\, E(X)$$

where:

P_x is the export price of the commodity.

X is the quantity of the product imported.

Assume that the difference between quantity demanded and quantity supplied is a random variable with a normal distribution, then $(D-S)\ \ N[E(D) - E(S), \sigma]$. The parameters $E(D) - E(S)$ and σ can be estimated from the information obtained from the demand and supply equations. But expected imports and exports are more difficult to estimate. However, the use of median imports and exports can be used in place of expected imports and exports in the profit function.

Anticipated imports are defined as:

$$A(I) = MAX[0, E(D) - E(S)]$$

Anticipated exports are defined as:

$$A(X) = MAX[0, E(S) - E(D)]$$

To estimate median imports, first estimate the probability that imports are greater than zero, say α_1. Now let A denote the event that imports are greater than zero and B denote the event that imports are greater than median imports. We know that $P(AB) = P(B) = P(B/A)\ P(A)$, where $P(A) = \alpha_1$, and $P(B/A) = 1/2$ by definition of median imports. Therefore $P(B) = 0.50\ \alpha_1$. Once P(B) is known, we can use the table of normal distribution to find the associated t value, say t_1. Median imports are then equal to $M(I) = A(I) + t_1\ \sigma$, where the second term of the RHS of this equation refers as that difference between median imports and anticipated imports, which can be labeled as d(I). The same procedure may be used to find median exports: $M(X) = A(X) + t_x \sigma_1$ where $t_2 \sigma = d(X)$.

The procedure can be illustrated using Figures 2-15 and 2-16. Suppose the retail price is set at P_r so Q_1 is the expected demand and that the farm price is set at P_f so Q_0 is the output supplied. Anticipated imports are therefore $A(I) + Q_1 - Q_0$. However, the possible variations in supply and demand are large enough so that exports could occur at this price combination. Expected imports are therefore greater than A(I) but are difficult to estimate because the probability distribution for imports would have to be integrated from zero to infinity. But if (D-S) is normally distributed, then the probability that imports are greater than zero, α_1, can be easily determined.

The probability that exports are greater than zero is $\alpha_2 = (1-\alpha_1)$. Thus median imports and exports can be determined in the manner described.

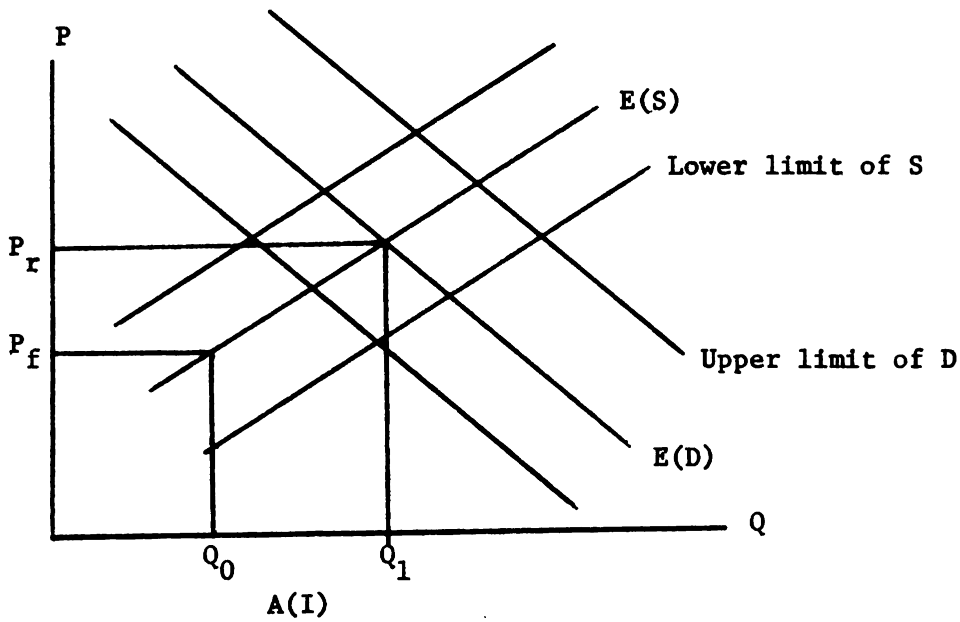


Fig. 2-15 Effects of variations in demand and supply on imports and exports

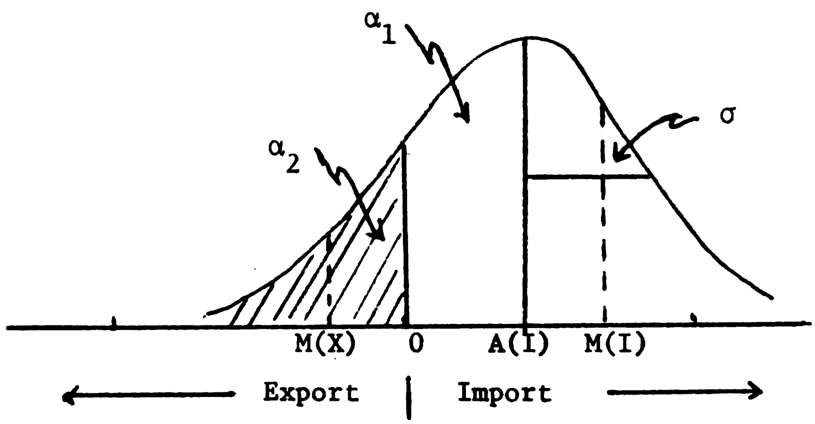


Fig. 2-16 Probability distribution for imports and exports

The government's anticipated profit function, in the case where either imports or exports may occur, consist of two parts. If anticipated imports are greater than zero, the function is equal to:

$$A(\pi) = P_w\ E(D) + \alpha_1\ P_w\ d(I) + \alpha_2\ (P_w - P_f - Co)\ M(X) - FC -$$

$$(P_f + Co)\ E(S) - \alpha_1\ (P_I + C_1)\ M(I)$$

where:

$\alpha_1\ P_w\ d(I)$ is an estimate of the expected revenue from imports above the anticipated level.

If anticipated exports are greater than zero, then the government's anticipated profit function is:

$$A(\pi) = P_w\ E(D) + \alpha_2\ P_x\ M(X) + \alpha_1\ (P_w - P_I - C_1)\ M(I) - FC$$

$$- (P_f + Co)\ E(S) - \alpha_2(P_f + Co)\ d(X)$$

where:

$d(x) = t_2\sigma$, is the difference between median exports and anticipated exports.

If a constant relationship between wholesale and retail prices is assumed, then iso-profits curves can be determined using two last equations to compute anticipated profits for various farm and retail price combinations. (Fig. 2-17)

Assume that at $P^0(P_r^{\ 0}, P_v^{\ 0})$ profits are zero. Then moving to right from P^0, will increase retail price while holding the farm price constant, thus anticipated profits are positive. Moving in the opposite direction (to the left) the retail price is reduced, and since P_f is constant, anticipated

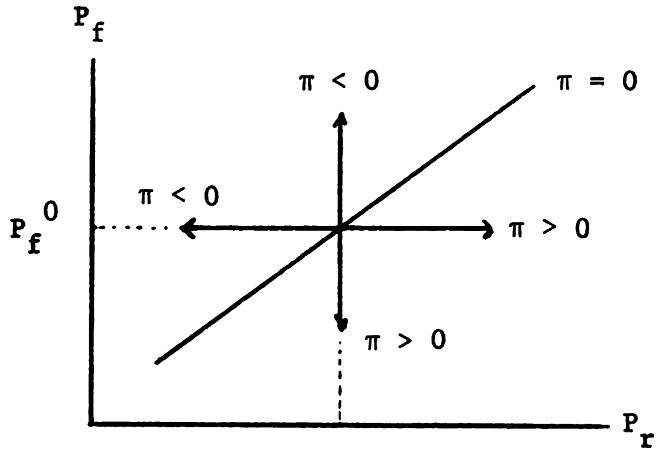


Fig. 2-17 Anticipated profits for farm-retail price combinations

profits are negative. Moving along the vertical line through P^0 the retail price is constant. To the north of P^0 farm prices are increasing so anticipated profits are negative. To the south of P^0 farm prices are decreasing, so anticipated profits are positive. Therefore the iso-profit curve that yield zero profits must pass through point P^0 and have a positive slope.

Iso-profits curves that are above curve (A) represent different combinations of prices (P_r, P_f) that yield the same losses. And iso-profits curves that are below curve (A) represent different combinations of prices (P_r, P_f) that yield the same value of positive profits. (Fig. 2-18)

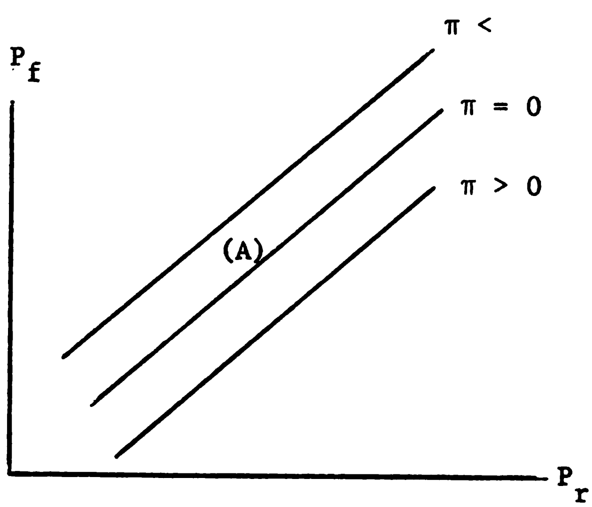


Fig. 2-18 Construction of iso-profit curves

Using Iso-Profit and Iso-Import Curves

It is now established that iso-import curves slope downward and iso-profit curves slope upward. In figure 2-19, expected imports and government's expected profits for any combination of farm and retail prices can be determined.

In reality many of the farm-retail price combinations in the figure can be ruled out. It is unlikely that the farm price would be increased (decreased) above (below) certain levels that are considered too high (too low). The same elimination is applicable to the retail price range. Decision makers can "zero in" on a "target" area by this process. The decision problem can be reduced to a single line if the government is committed to break even with the program, which in this case would be the iso-profit line $\pi = 0$.

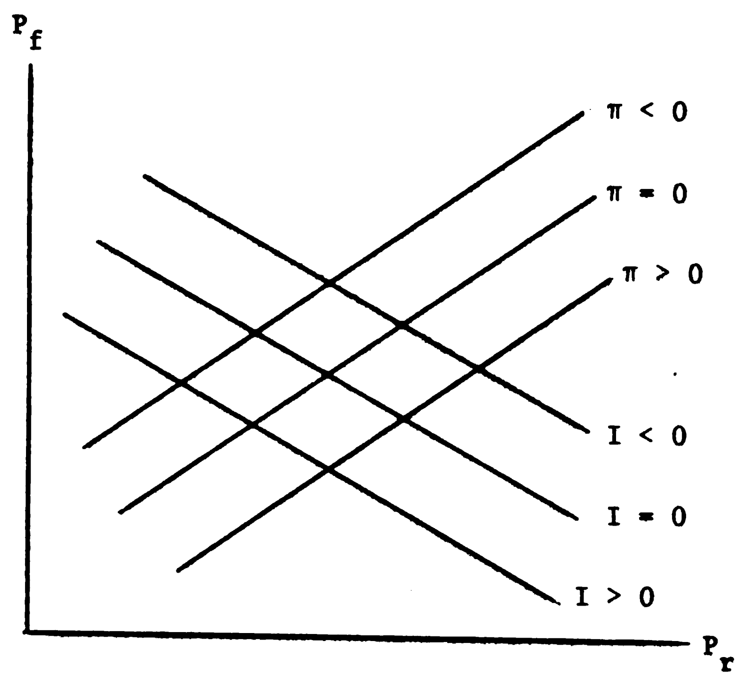


Fig. 2-19 Farm-retail price combinations, imports-exports, and government costs

Geographic Price Relationships

The discussion thus far has emphasized the incentive and disincentive effects of government price policies. Production promotion programs, to be effective, must be supported with sufficiently remunerative producer prices. Frequently, prices paid to farmers under government programs are fixed with the aim of giving producers a "reasonable return" while enabling the marketing organization to earn surpluses to support other government investments and services. Moreover, these prices are usually adjusted only gradually over time, and while this approach shields producers from market fluctuations and price uncertainities, they may receive only a share of realized export earnings or import parity prices for the commodities involved. If so, incentives to produce the price-controlled products will be diminished relative to other crops.

The impact of price policies on the relative price structure is complicated if internal transportation costs are considered. The most common policy is to establish uniform buying prices at all points in a country. In contrast, export-parity or import-parity prices will differ by the cost of transporting the crop from a particular production area to the export/ import point. The comparison of established prices to parity prices by region will likely show a pattern of cross-subsidization whereby producers in regions with high transport costs are benefitted at the expense of producers in regions with low transport costs. This cross-subsidization will be intensified if key inputs are also priced uniformly throughout the country.

Thus, price policies may generate cross-subsidization between regions as well as between crops. Sometimes this kind of cross-subsidization is justified as a means of attaining regional equity. This is especially true when least-developed regions also are the most inaccessible, and hence suffer high costs for input and output movements. However, the implicit subsidies/taxes in a given pricing structure is unlikely to be the most appropriate in terms of producer incentives or from the standpoint of balanced regional development. Improvements in transportation and even transportation subsidies may well be superior if stimulation of regional growth is the goal.

Domestic Price Stabilization Programs

There is no doubt that price stabilization is a theoretical and empirical topic of special interest for the developing nations. Traditional export products are subject to wide swings in market prices. Domestically consumed products are also subject to price instability. Food products that fulfill basic needs are many times the most affected.

The problem of price stabilization was first in 1944 analyzed by Waugh from the consumer point of view. Later, in 1961, Oi approached the problem from the producer point of view. In 1969, Massell integrated both sectors in a welfare analysis of price instability.

These initial analyses are the basis for more sophisticated work on this topic. Getting closer to "real world" situations means more complexity. R. E. Just commented:

> "The general question of price stabilization is one of those problems in economics where the complexity of the issue is far beyond the theoretical and technical capabilities we now possess for analyzing it. Consequently, analytical studies of stabilization policy have been reduced to examination of only one or a few important aspects of the problem (at a time) while disregarding others. As a result, much of the theoretical work on price stabilization has been overlooked by empiricists and those involved directly in the policy-making process."

Generalized Assumptions

Through time, the literature on price stabilization has been elaborated under a fairly homogenous set of assumptions. The first assumption is partial equilibrium. A second common assumption is the existence of a self-liquidating buffer stock to achieve price stability. Third, ignoring the administrative and storage costs of operating a buffer stock has also been typical. Finally, the concepts of consumers' and producers' surpluses are used as a measure of welfare to assess the effects of stabilization.

The procedure here is to find out first what the welfare effects from commodity price variations are, how it affects both consumers and producers, and under what circumstances stabilization policies may be advantageous.

In 1944, F. Waugh demonstrated that with a downward sloping demand curve, assuming consumers to be price takers and starting from a given price, consumers gain more from a price reduction than they lose from an equal amount of price increase for a given commodity. On this basis he argued that consumers gain from price fluctuations caused from random supply shifts and, hence, they would lose from price stabilization.

Assume a cardinal measure of utility and two prices, P_1 and P_2, each with 50% probability of appearing as an equilibrium price after a random shift of the market supply curve.

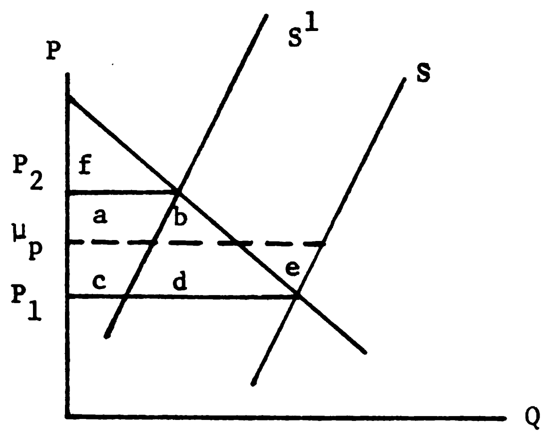


Figure 2-20
Effects of Price Variation On Consumers

Based on Figure 2-20, if P_1 occurs then consumers' surplus (CS) is equal to the area f + a + b + c + d; if P_2 appears CS is equal to the area f only.

Expected consumers' surplus is:

$$E(CS) = f + 1/2\ (a + b + c + d)$$

As an alternative consumers are given a single price μ_p with certainty where 1 μ_p is the mean of the two prices, or:

$$\mu_p = 1/2\ (P_1 + P_2)$$

Then the expected consumers surplus is:

$$E^*(CS) = f + a + b$$

Thus, compared to the prestabilization regime, consumers lose (c+d) if P_1 occurs without the stabilization scheme and gain (a+b) if P_2 occurs. Since E(CS) > E*(CS), stabilization creates a net loss (c+d > a+b) in terms of consumers' surplus.

Walter Oi (1966) made an equivalent argument for producers. He showed that producers facing an upward sloping supply curve and perfect competition gain from price fluctuations arising from random shifts in demand and, hence, would lose from price stabilization.

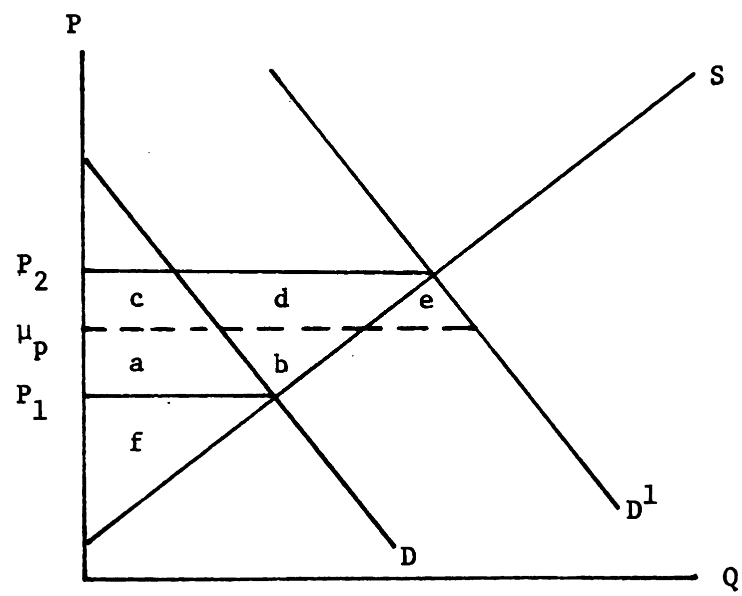


Figure 2-21: Effects of Price Variations on Producers

Assume that producers are faced with either of two prices, P_1 or P_2, with 50% chance of occurrences for each of them. So producers' surplus (PS) is equal to the area f if P_1 occurs and f + a + b + c + d if P_2 occurs (Figure 2-21). The expected value of producers' surplus is given by

$$E(PS) = f + 1/2\ (a + b + c + d)$$

As an alternative, producers are given a single price, μ_p, with certainty.

Where

$$\mu_p = 1/2\ (p_1 + p_2)$$

Then expected producers' surplus is:

$$E^*(\mu_p) = a + b + f$$

and since $E(PS) - E^*(PS) > 0$ stabilization will hurt producers.

B. Massell (1969) tried to reconcile the results presented by Waugh and Oi by using the expected value of the net changes in producers' and consumers' surpluses as a measure of gain. His main conclusion was that a stabilized price brought about by a buffer stock operation provided a net gain to producers and consumers taken together.

Massell utilized linear market demand and supply functions with additive stochastic disturbances. Market price fluctuations arise from shifts in either supply or demand or both.

Referring to Figure 2-20, if μ_p can be achieved by a costless storage activity through a buffer stock operation that buys and sells at price μ_p, raising the price from P_1 to μ_p will result in a gain to producers of c + d

+ e and a loss to consumers of c + d. So there is a net gain equal to the area e[Δ(PS) - Δ(CS) = e]. Reducing the price from P_2 to μ_p will result in gain to consumers equal to the area a + b and a loss to producers of a, so there is a net gain of b. Therefore where price fluctuation arise from random shifts in supply, stabilizing prices at μ_p involves: first, a net gain to producers (c + d + e - a > 0), second, a net loss to consumers (a + b - c - d > 0); and, finally, a net gain of b + e to consumers and producers jointly.

Similarly, looking at Figure 2-21, if price is raised from P_1 to μ_p producers' surplus increase by an amount equal to the area a + b and consumers' surplus falls by a, so the net gain is b. And reducing price from P_2 to μ_p involves a gain to consumers of c + d + e and a loss to producers of c + d, so the net gain is equal to the area e. Therefore, when price fluctuation comes from demand, stabilizing prices at μ_p produces: first, a net gain to consumers (c + d + e - a > 0); second, a net loss to producers (a + b - c - c < 0); and finally a joint net gain equal to the area b + e.

Massell's model can be stated mathematically. For a competitive market, assume the supply and demand curves each have a shift factor that is a continuously distributed random variable:

(1) $S = aP + \alpha$ $(a \geq 0)$

(2) $D = -bP + \beta$ $(b \geq 0)$

where S is the quantity supplied, D is the quantity demanded, P is the price a and b are constants, and α and β are jointly distributed random variables with means μ_α and μ_β variances $\sigma_{\alpha\alpha}$ and $\sigma_{\beta\beta}$, and covariance $\sigma_{\alpha\beta} = 0$, which means that shifts in demand and supply function are influenced by different forces. That is, we assume that:

$$(3) \quad S = S(P, r, \Theta)$$

$$(4) \quad D = D(P, P_J, I, \Theta)$$

Equation (3) states that the quantity supplied is a function of the commodity price (P), the input factor price (r), and the technology embodied in the production process (Θ). Equation (4) states that the quantity demanded is a function of the commodity price (P), price of another commodities P_J, income (I), and the tastes and preference of individuals (Φ). In the case of agricultural commodities, shifts in supply are typically due to weather conditions which are unrelated to the factors influencing demand.

The equilibrium price is given by:

$$(5) \quad P^* = \frac{\beta - \alpha}{a + b} \qquad \text{where } a + b > 0 \text{ and } P^* \geq 0$$

Assume the mean price μ_p is known and that price fluctuation are to be eliminated by establishing a costless buffer stock operation, such that the authority stands ready to buy or sell at price μ_p. In any one year producers gain c + d + e (Figure 2-20) or a + b (Figure 2-21) whenever $\mu_p > P$. Algebraically the gain in producer surplus may be expressed as:

$$\Delta(PS) = G_p = (\mu_p - P)\ [S(P)] + 1/2(\mu_p - P)\ [S(\mu_p) - S(P)]$$

so

$$(6) \quad G_p = 1/2(\mu_p - P)\ [S(P) + S(\mu_p)]$$

Also, since

$$E(P) = \frac{1}{a+b} \cdot E(\beta - \alpha)$$

and

$$(7) \quad \mu_p = \frac{\mu_\beta - \mu_\alpha}{a + b}$$

Substituting (1), (5) and (7) into (6), and simplifying gives:

$$(8) \quad G_p = 1/2\left[\frac{\mu_\beta - \mu_\alpha - (\beta - \alpha)}{a + b}\right]\left[2\alpha + a\frac{(\mu_\beta - \mu_\alpha + \beta - \alpha)}{a + b}\right]$$

Applying the expectation operator to (8) gives:

$$(9) \quad E(G_p) = \frac{(a + 2b)\, \sigma_{\alpha\alpha} - a\sigma_{\beta\beta}}{2(a + b)^2}$$

Analogously, for consumers:

$$(10) \quad E(G_c) = \frac{(2a + b)\, \sigma_{\beta\beta} - b\sigma_{\alpha\alpha}}{2(a - b)^2}$$

Therefore, the total expected gain from stabilization is given by:

$$(11) \quad E(G) = \frac{\sigma_{\alpha\alpha} + \sigma_{\beta\beta}}{2(a + b)}$$

and since $\sigma_{pp} = \text{VAR}\,\frac{(\beta - \alpha)}{a + b} = \frac{\sigma_{\beta\beta} + \sigma_{\alpha\alpha}}{(a + b)^2}$

then

$$(12) \quad E(G) = \frac{(a + b)}{2} \quad \sigma_{pp}$$

The expected gain from price stabilization is larger as price variability increases and as the slope of the demand and supply curves increase. Producers and consumers are better off with price stability than with price variability since those gaining from stabilization can compensate those losing, leaving everyone better off.

S. Turnovsky (1978) worked with a non-linear model and with stochastic disturbances that enter multiplicatively. This led him to some modifications of Massell's results about welfare distrbution. He found out that in such circumstances the desirability of stabilization is independent of the origin of the stochastic disturbance in the price of the agricultural commodity and depends only on the deterministic components of the demand and supply curves.

In more detail, Turnovsky's results showed the following:

a) producers will gain from having either demand and/or supply disturbances stabilized if demand is elastic and supply inelastic; otherwise they lose;

b) consumers gain if demand is inelastic and supply is elastic; otherwise they lose;

c) stabilization leads to an overall welfare gain unless either demand and supply are perfectly elastic. (The assumption of multiplicative disturbance is quite restrictive. These conclusions don't hold when the demand and supply functions are log-linear.)

David Bigman and Sholomo Reutlinger (1978) relaxed some of the assumptions and restrictions of the Waugh-Oi-Massell analysis. First, they argued that certain results arising from linear demand and supply functions do not generalize to the nonlinear case. Second, they felt that a "complete" price stabilization achieved by means of a sufficiently large buffer stock is impracticable and unrealistic since the cost of stock sufficiently large for complete stabilization would invariably exceed the gains, and in practice governments are more likely to engage in only partial stabilization and storage capacity is constrained. Therefore, they focused on gains and costs from partial stabilization and on the extent of stabilization achievable by employing a given size of stock. Third, they noted that the desirability of price stabilization on the basis of welfare gains alone is a weak concept since economic efficiency is only one among several objectives of stabilization policy. They wrote: "In most countries the primary objective of buffer stocks and other stabilization policies is to ensure a regular flow of supplies to consumers and to meet the needs of vulnerable sections of the population." Their main argument is that avoidance of protectionist trade policies can be a more powerful instrument for stabilizing domestic agricultural prices and ensuring the continuity of supplies than any reasonably sized buffer stock.

They presented a method to analyze: a) the extent to which annual instability in a country's food grain production and the world market price of food grains translate into instability in the country's food grain consumption and price, under alternative trade policies and market structures, and b) the extent to which a buffer stock of varying sizes contributes to stabilization and at what social and financial cost or gains to producers, consumers, and the government. For this purpose they developed a stochastic simulation model which assumed that supply decisions of agricultural commodities are made before the actual price is known. That is, they are made on the basis of the past year's price, which is the expected price.

Before examining this complex model in detail, it is useful to look at the stabilizing effects of trade on the domestic market and welfare gain or losses from price stabilization with and without trade by reference to a simple linear two-country model.

Let the markets in two countries be represented by the following supply and demand functions:

$$S_i = a_i + b_i\overline{P}_i + U_i$$

$$D_i = c_i - d_iP_i$$

$$\forall(i = 1,2)$$

where

P_i: actual market price

$\overline{P}_i$: expected price

U_i: random disturbances, which are assumed to homoscedastic and independent across the two countries and time, with:

$$E(U_i) = 0 \text{ and } E(U_i^2) = \sigma i^2$$

Stochastic changes in demand are disregarded. In the absence of trade, prices are determined independently in the two countries:

$$P_i = \overline{P}_i - \frac{U_i}{d_i}$$

When free trade is permitted and abstracting from transportation cost, the price in both countries will be the same:

$$P* = P_1 = P_2$$

so

$$P^* = \overline{P}^* - \frac{U_1 + U_2}{d_1 + d_2}$$

The variance of price and consumption in country 1 <u>without</u> and <u>with</u> trade with country 2 will be as follows:

	Closed Economy	Free trade
Variance of price	$V(P_1) = \frac{\sigma_1^2}{d_1^2}$	$V(P^*) = \frac{\sigma_1^2 + \sigma_2^2}{(d_1 + d_2)^2}$
Variance of consumption	$V(D_1) = \sigma_1^2$	$V(D_1^*) = \left(\frac{d_1}{d_1 + d_2}\right)^2 (\sigma_1^2 + \sigma_2^2)$

Comparing the international price with trade and the domestic price without trade gives:

$$V(P^*) = \frac{d_1^2}{(d_1 + d_2)^2} \cdot V(P_1) + \frac{d_2^2}{(d_1 + d_2)^2} \; V(P_2)$$

Thus, $V(P^*)$ can be smaller than both $V(P_1)$ and $V(P_2)$. Both countries may gain from trade by having a more stable price (a risk pooling arrangement). For the n - country case,

$$V(P^*) = \sum_{i=1}^{n} d_i \; V(P_i)/(\sum_{i=1}^{n} d_i)^2$$

Therefore, the larger is the number of countries engaged in free trade, the more likely it is for all countries to have more stable prices. The same holds for the variance in consumption levels.

The expected gains from price stabilization to consumers, producers, and to the economy as a whole in country 1 with and without trade are given below:

	Closed Economy	Free Trade
Consumers expected gains $E(G_c^1)$	$-1/2\left(\sigma_1^2/d_1\right)$	$-1/2\,\dfrac{d_1}{(d_1+d_2)^2}\left(\sigma_1^2+\sigma_2^2\right)$
Producers expected gains $E(G_p)$	σ_1^2/d_1	$\sigma_1^2/\left(d_1+d_2\right)$
Total expected gains $E(G_T^1)$	$1/2\left(\sigma_1^2/d_1\right)$	$\dfrac{d_1(\sigma_1^2-\sigma_2^2)+2d_2\sigma_1^2}{2(d_1+d_2)^2}$

Therefore for both a closed economy and free trade, producers will always gain and consumers will always lose from price stabilization under the assumptions of linear demand functions and stochastic disturbances in supply. However the net gains for the economy as a whole will always be positive in the closed economy; whereas with trade, the country may gain or lose from price stabilization.

A country will have larger welfare gains the more stable is the supply in the other country but the less stable is its own supply. Furthermore, a country is more likely to gain from price stabilization if its share in the world market is small compared with the other country. Thus, an assessment of stabilization policies that focuses on a closed economy and ignores the effects of trade may overstate the welfare gains.

Now we are in a position to present Bigman-Reutlinger's stochastic simulation model. This approach does not yield readily definable generalizations since the outcomes depend on the specific parameters applied in the analysis. The following is reproduced from Bigman and Reutlinger (pp. 10-29).

"The model is an open economy model, principally concerned with examining stabilization policies for food grains. It examines explicitly random fluctuations in a country's production and in the international price of grain. The country is assumed to be "self-sufficient" in the sense that in a "normal" year, when both the country's production and the world price are at their mean level, there would be no differential between the price in the world and in the country to provide an incentive for trade. Yet random fluctuations in the supply of either the country or the world may create at times price differentials to an extent that despite transportation costs and tariffs, imports or exports could occur. Thus, "self-sufficiency" as such is not assumed to preclude trade. As we shall see below, even countries which embark on the objective of self-sufficiency in food supply could realize substantial gains from trade as a consequence of less than perfectly correlated random fluctuations between food grain production in the country and the rest of the world.

For any given level of grain production in the world and in the country, the model estimates: (a) world price, (b) price and quantity of grain consumed, stored and traded by the country, and (c) gains and losses to consumers, producers, government, and society. Below, the structure of the model is briefly described.

a. World price

Examination of the effect of trade policies on the stability of a country's grain market requires an estimate of the distribution of the world price. Since there is little direct historical evidence for estimating future variability of the world price, a simple (much too simple a model for other purposes) world price model is postulated which transforms any production level into a world price on the basis of a pre-specified world demand function. World production is assumed to be a random variable with a specified probability distribution.

b. Country's production

Production of grain in the country is a random variable with a specified probability distribution. In our stationary model, planned production remains constant. Allowances are made for the possibility of year-to-year serial correlation in production and for correlation between the country's production and world production (and therefore the world trade).

c. Country's demand

The country's demand for grain is assumed to consist of the combined demand of two consumer groups defined by their income level; a low income group and all other consumers. In the version of the model presented here, the government is assumed to have an explicit food policy by which the low income group's consumption is assured not to fall below a desired level. The total demand function consists of two linear segments with a "kink" at the mean, reflecting the inelastic demand, induced by the government's intervention on behalf of the low income group, when supplies are scarce.

d. International trade

Trade activities between the country and the world are carried out by the free market within limits of a specific trade policy implemented by the government. Thus, grain is imported when the domestic price exceeds the import price, and grain is exported when the export price exceeds the domestic price. The import and export prices are determined by the world price, transportation costs and tariffs. The instruments for enforcing government goals with respect to trade are tariffs and quantity constraints. Those goals need not be restricted to the balance of payments and we have also considered policies whereby exports are not permitted when the quantity available for domestic consumption is below a prespecified lower level and import is restricted never to let the domestic price fall below a specified lower limit.

e. Storage policies

Storage policies consist of (a) rules which determine the form of storage activities, and (b) a storage capacity constraining the actual level of storage activity. In the present paper, storage rules are defined by a quantity band. Within the boundaries of the band supply is allowed to fluctuate freely, with no storage activity. When domestic production (Q) exceeds the upper limit of the bank (Q_H) the "desired" amount of grain to be stored is the excess of production above Q_H. Similarly, when production is less than the lower limit of the bank (Q_L) the "desired" amount of grain to be taken out of storage is the amount by which production falls short of Q_L. The actual amount of grain put into storage cannot, of course, exceed available storage capacity and the amount of grain released from storage cannot exceed the amount available in storage, at that year.

Note that trade and storage activities could be substituted for each other on occasion to achieve stabilization objectives. When production is short, the world price is low and stored up grain is unavailable, grain could be either imported or withdrawn from storage. Likewise, when production is plentiful, export prices are high and there is vacant storage capacity, grain could be either exported or stored. We have assumed that the authorities emphasize the food security aspect of the storage operations and thus grain is imported via the free market. On the other hand, in times of good domestic harvest, excess supply is first put into storage and the remaining quantity is released for exports, provided the world price is attractive enough.

One point is worth emphasizing with respect to these storage rules: the domestic price in any given year depends on the quantity produced domestically, the world price and on the quantity of grain in storage or the vacant storage capacity at that year. The latter, in turn, depend on the quantities of grain produced domestically and on the world prices in previous years and on the initial stock and storage capacity. Consequently, some degree of serial correlation is introduced into the time series of domestic prices due to storage operations, even when there is no such correlation in production.

f. Gains and losses from stock operation

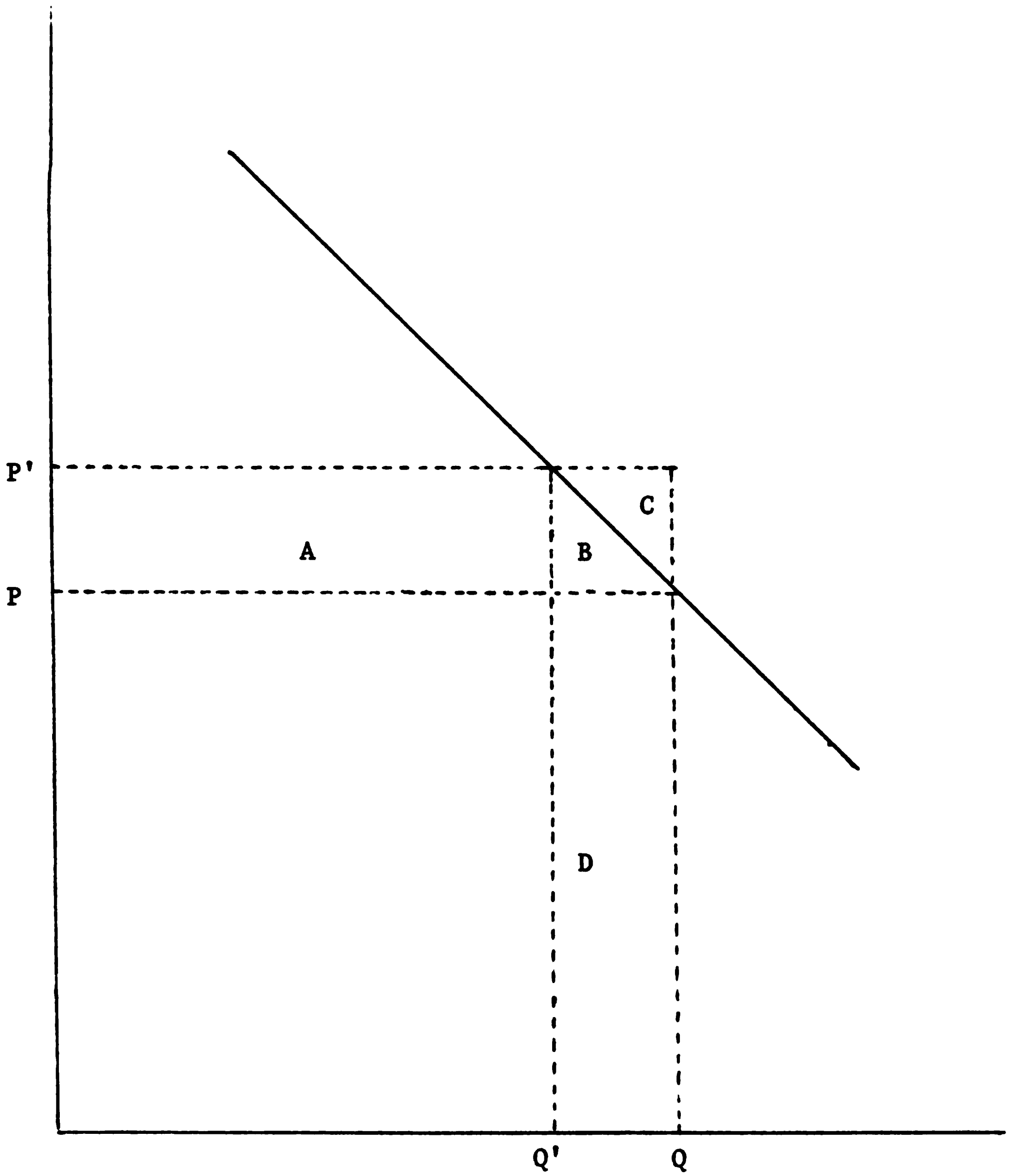
The gains and losses from a stock to society as a whole and the gains or losses to consumers, producers and the government separately depend largely on the difference between the price of grain with and without stock operations. When grain is withdrawn from the market into storage the price is raised; consumers lose and producers gain. Vice versa, when grain is withdrawn from storage to augment current supply the price is reduced; consumers gain and produers lose.

These gains and losses as well as the costs and revenues to the government when grain is put into or withdrawn from storage are illustrated in Figures 2.22(a) and 2.22(b) and are summarized in Table 2-1 in terms of the designated areas on the graph. The government is expected to make its storage and trade policies known. Hence, grain is purchased by the government for storage and by exporters and by consumers at the equilibrium price. In Figures 1(a) and 1(b), the quantity supplied for current consumption without storage is Q and with storage Q'. P and P' are the respective corresponding prices.

Data and Parameters

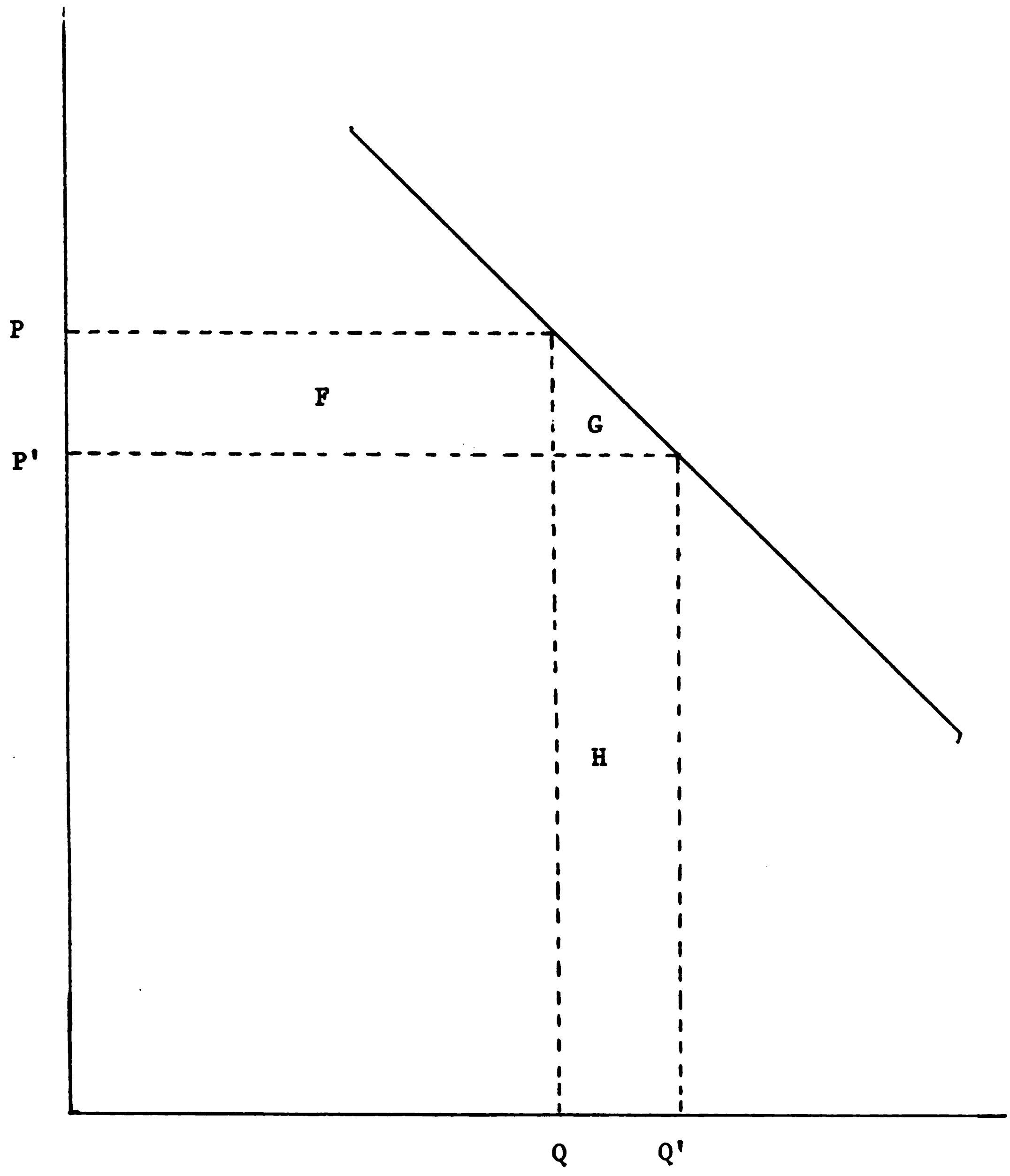
Simulations were conducted with the postulated model in order to investigate orders of magnitude of the likely effects of alternative policies and the sensitivity of such outcomes to parameters and data. Although the data are not representative of any

GAINS AND LOSSES FROM STORAGE OPERATION
Figure 2.22(a): Grain into Storage



SOURCE: D. Bigman and S. Reutlinger (1978)

GAINS AND LOSSES FROM STORAGE OPERATION
Figure 2.22(b): Grain out of Storage



SOURCE: D. Bigman and S. Reutlinger (1978)

Table 2-1: Types of Gains and Losses When Grain is Stored and When Grain is Withdrawn from Storage by Reference to Areas Shown in Figures 2.22(a) - 2.22(b)

Types of Gains and Losses	Designated Area of Gain or Loss
<u>Grain into storage</u> [Fig. 1(a)]	
Consumers	- A - B
Producers	A + B + C
Government (financial)	- B - C - D
Overall (economic)	- B - D
<u>Grain withdrawn from storage</u> [Figure 1(b)]	
Consumers	F + G
Producers	- F
Government (financial)	H
Overall (economic)	G + H

SOURCE: D. Bigman and S. Reutlinger (1978)

particular country, they are deliberately chosen to approximate orders of magnitude to a country like India. In this section we describe the kind of simulations and the data and parameters underlying illustrative runs of the model.

a. Simulation experiments

The results reported in this paper were obtained by simulating 300 runs of 30-year sequences of production "events". The total sample size consists therefore of 9,000 observations drawn at random from the specified probability distribution.

b. Country's production

The country is assumed to produce an average of 110 million tons of foodgrains. Specifically, production is assumed to be distributed normally with a mean of 110 million tons and a standard deviation of 7 million tons.

c. Country's demand

Total market demand is assumed to be the sum of the separate demand of "low" and "high" income consumers. Consumption by the "low" income population is maintained through government intervention at a minimum level, assumed to correspond with their consumption at the median price of $125 per ton. The consumption maintenance policy is implemented through a price subsidy scheme for the low income population. The specific parameters of the demand schedules adopted for the numerical analysis are listed in Table 2-2. Equal foodgrain consumption by the low and the high income group at the median price of $125 subsumes that the low income group consists of more than half of the total population and per capita consumption is less in the low income group.

Table 2-2: Country Demand Parameters

	"Low" Income Population	"High" Income Population	Total Population
<u>Quantity consumed</u>			
at P = $124 (million tons)	55	55	110
<u>Price elasticity of demand</u>			
for P < $125	0.4	0.2	0.3
for P > $125	0.0	0.2	0.1

SOURCE: D. Bigman and S. Reutlinger (1978)

d. World price

World price production (Q) is assumed to be normally distributed with a mean of 350 million tons and a standard deviation of 14 million tons. This distribution is transformed to a distribution of the world price on the basis of a "kinked" demand function. At the mean level of world production the price is $125 per MT and the price elasticities of the two segments of the demand function at that point are as follows:

η = 0.1 for P > $125

η = 0.3 for P > $125

Notice that while production is assumed to be distributed normally, the transformed distribution of price is skewed with its mean being larger than the median.

e. Trade and trade policies

Shipping costs are assumed to be $25 per ton. Trade policies are implemented by quantity restrictions and by the level of tariff. Imports are not permitted to increase total supply above 112 million tons and thereby to reduce the domestic price below .95 of the median price. Exports are not permitted to reduce the quantity available for domestic consumption through imposition of tariffs below 108 million tons. In addition, three trade policies implemented are examined in the base case:

FREE TRADE: No tax is imposed on exports or imports;

RESTRICTED TRADE: The government imposes a tax of $25 per ton on any imports and exports;

NO TRADE: The government imposes a tax high enough to rule out all trade

f. Storage rules and storage costs

Grain in excess of 112 million tons is put into storage to the extent that there is vacant storage capacity. Grain is taken out of storage when domestic production is less than 108 million tons to the extent of the deficit or to the extent of available stocks in storage, provided the world price is so high as to prevent any imports. A handling charge of $2 per ton is assumed at the time grain is loaded into storage. The rate of interest for grain held in storage is 8 per cent and construction costs are assumed to be $100 per ton of capacity, storage facilities are assumed to be amortized within a period of 30 years.

Simulation Results

Tables 2-3 and 2-4 provide results from simulation experiments regarding the stability of a country's grain consumption and price under the three postulated trade policy scenarios and without and with buffer stocks. Clearly, in the closed economy a buffer stock can have a sizeable stabilizing effect. But what is more noteworthy is the striking stabilizing effect of opening up the country to trade. As the country becomes more open to trade, the additional stabilizing effect of the buffer stock is progressively reduced. Comparing the results show that a moderate degree of correlation does not alter these conclusions significantly.

Figure 2.23 illustrates the extent of supply stabilization attained by the three trade scenarios and increasing sizes of buffer

Table 2-3: Stability of Food Grain Consumption and Price Under Alternative Trade Policies, with and without a Buffer Stock

Storage Capacity (million tons)	No Trade 0	No Trade 6	Restricted Trade 0	Restricted Trade 6	Free Trade 0	Free Trade 6
	Probability (%)					
	(No correlation between country grain production and world wheat production)					
Grain consumption (million tons)						
< 100	7.2	4.2	0.8	0.4	0.3	0.1
100 - 105	16.3	9.9	9.8	5.2	5.9	2.9
105 - 115	52.9	72.0	72.4	83.6	81.1	88.0
115 - 120	16.0	10.2	12.4	8.3	11.0	8.0
> 120	7.6	3.7	4.6	2.5	1.7	1.0
	(Correlation (R^2=0.3) between country grain production and world wheat production)					
Consumption (million tons)						
< 100	7.2	4.2	1.8	1.0	0.7	0.3
100 - 105	16.3	9.9	12.4	7.3	8.5	4.8
105 - 115	52.9	72.0	65.8	78.8	74.2	83.2
115 - 120	16.0	10.2	14.1	9.7	13.5	9.7
> 120	7.6	3.7	5.9	3.2	3.1	1.9

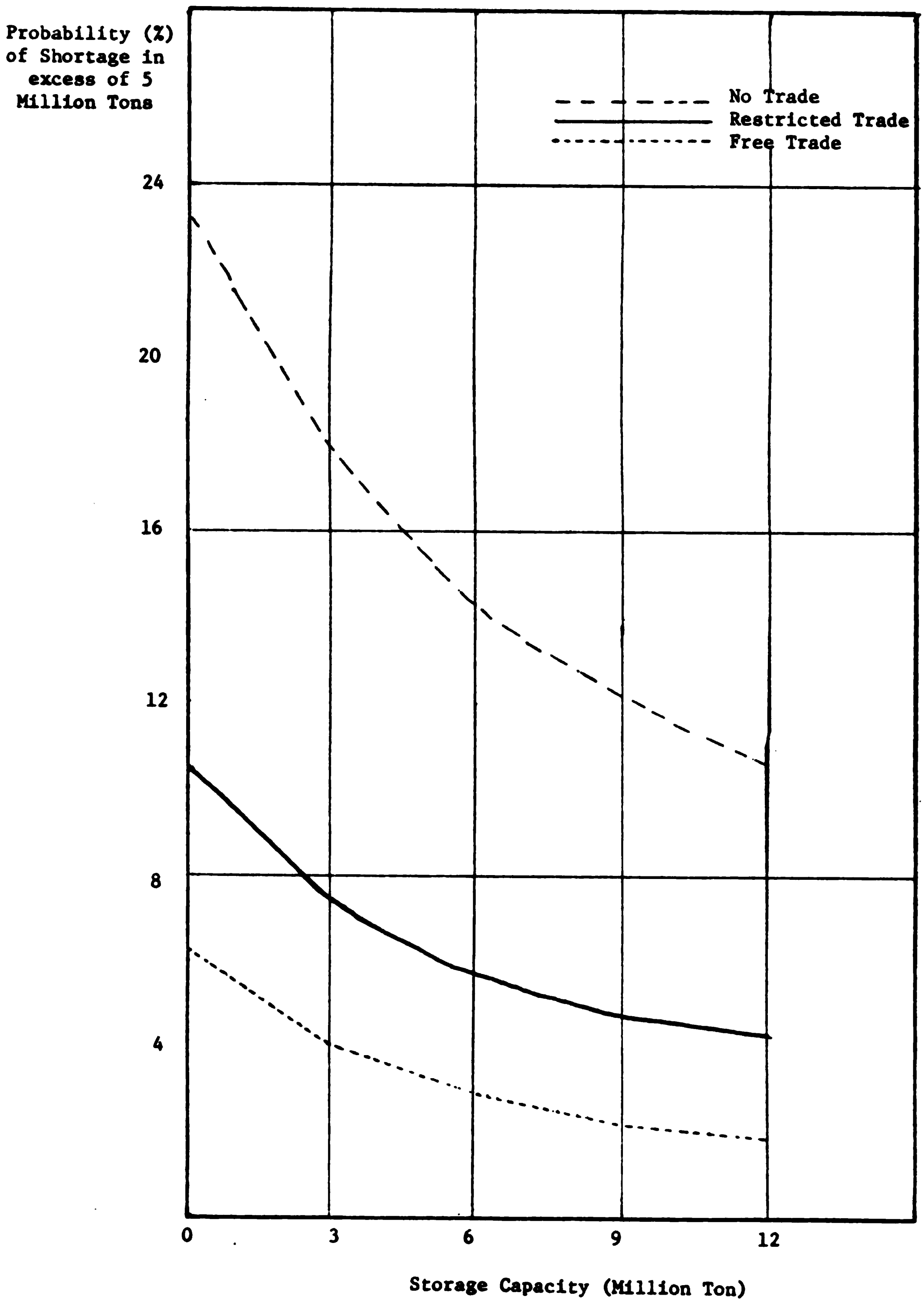
Source: Bigman and Reutlinger.

Table 2-4: Stabilization Effects of Buffer Stock Under Alternative Trade Policies

Storage Capacity (million tons)	No Trade 0	No Trade 6	Restricted Trade 0	Restricted Trade 6	Free Trade 0	Free Trade 6
(No correlation between the country and the world grain production)						
Quantity (million tons): Average (S.D.)	110 (6.9)	110 (5.3)	110 (5.0)	110 (4.0)	110 (3.9)	110 (3.3)
Price ($/ton): Average (S.D.)	145 (54)	140 (43)	139 (35)	136 (28)	136 (27)	134 (22)
Balance of trade ($ millions):						
Average	..	..	3	-2	-4	-16
(S.D.)	..	..	(600)	(515)	(767)	(696)
Subsidy payments ($ millions)						
Average	1,700	1,250	1,175	935	900	750
(S.D.)	(2,500)	(2,050)	(1,465)	(1,185)	(1,150)	(900)
Farmers' revenue ($ millions):						
Average	15,650	15,200	15,070	14,825	14,800	14,635
(S.D.)	(4,750)	(3,600)	(3,000)	(2,300)	(2,435)	(1,940)
(Correlation (R^2 = 0.3) between the country and the world grain production)						
Quantity (million Tons): Average (S.D.)	110 (6.9)	110 (5.3)	110 (5.6)	110 (4.5)	110 (4.6)	110 (3.8)
Price ($/ton): Average (S.D.)	145 (54)	140 (43)	140 (40)	137 (32)	137 (32)	135 (26)
Balance of trade ($ millions):						
Average	..	..	-40	-31	-54	-53
(S.D.)	..	..	(452)	(392)	(626)	(567)
Subsidy payments ($ millions):						
Average	1,700	1,250	1,300	1,000	1,000	850
	(2,500)	(2,050)	(1,700)	(1,400)	(1,350)	(1,100)
Farmers' revenue ($ millions):						
Average	15,650	15,200	15,100	14,850	14,850	14,650
(S.D.)	(4,750)	(3,600)	(3,400)	(2,600)	(2,800)	(2,200)

Source: Bigman and Reutlinger

Figure 2-23: Relative Frequency of Serious Supply Shortfall with Alternative Storage Capacities and Trade Policies



Source: Bigman and Reutlinger

stocks (storage capacities), as measured by the probability of a serious grain consumption shortfall. The graph illustrates that even as larger a buffer stock as 11 per cent of annual average consumption would not have provided the same degree of protection against extreme shortfalls as could have been obtained by opening up the country to trade. The slope of the curves depicts the marginal contribution to stability of each additional unit of storage capacity. Clearly, the marginal effects are smaller when trade restrictions are relaxed and in all cases decline sharply for increasing levels of storage capacity. For instance, increasing the storage capacity from 6 to 9 million tons will reduce the probability of a serious shortage by some 3 per cent if no trade is permitted and by less than 0.5 per cent under free trade. For an illustration of the decreasing marginal stabilizing effect as storage capacities are increased, note that without trade, increasing the storage capacity from 0 to 6 million tons reduces the probability of a serious shortfall from 24 to 14 per cent but a similar increase from 6 to 12 million tons reduces the probability of a serious shortfall only from 14 to 11 per cent.

As seen so far, the stabilization benefit from a buffer stock can be much higher in a closed economy than in a country which takes advantage of opportunities for trade. This relationship is of course reflected in the net cost of the buffer stock operation. This net cost is reduced as the number of transactions (acquisitions for and sales from storage) and the price differentials at which these transactions take place increases. Table 2-5 gives the gains and losses to

Table 2-5: Annual Economic and Financial Gains (Losses) from a 6 MMT Capacity Storage Operation

	No Trade	Restricted Trade	Free Trade
(No correlation between country and world grain production--$ millions)			
Total economic gains	-12	-59	-73
Consumer gains	-30	-35	-8
Producer gains	-380	-180	-125
Storage operation account 1/	-37	-62	-79
Change in tax revenue 2/	..	-12	-4
Saving on subsidy	435	230	143
Total government account	398	156	60
(Correlation of R^2 = 0.3 between country and world grain production--$ millions)			
Total economic gains	-12	-46	-60
Consumer gains	-30	-65	-33
Producer gains	-380	-183	-131
Storage operation account 1/	-37	-53	-69
Changes in tax revenue 2/	..	-9	-2
Savings in subsidy	435	264	175
Total government account	398	202	104

SOURCE: Bigman and Reutlinger

1/ Including $53 million amortization costs.

2/ "Quantity restrictions" on imports and exports are implemented by an appropriate tariff. Thus, the government will have some tax revenues even in "free trade" policy.

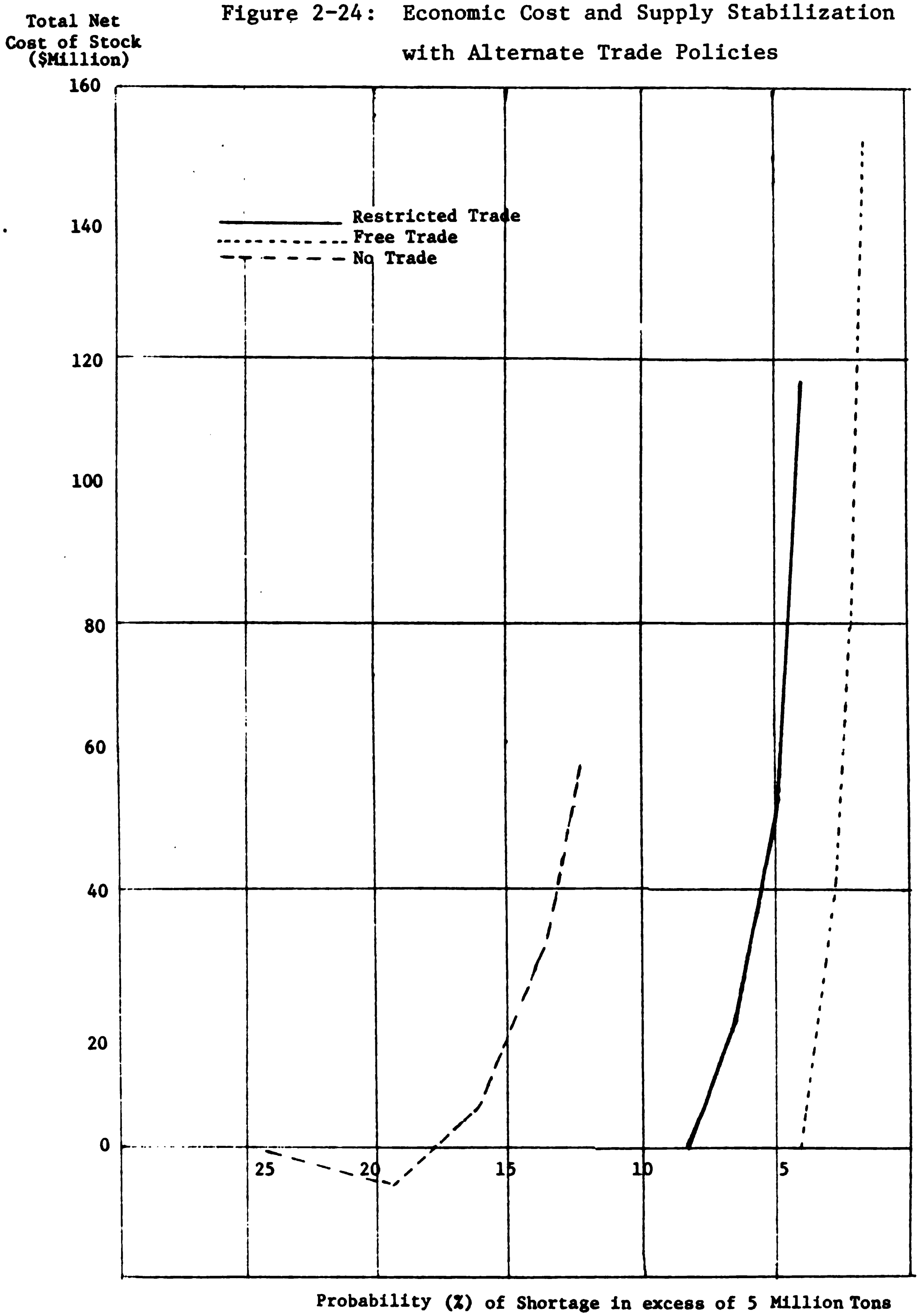
society as a whole and their distribution among consumers, producers and the government from a 6 million ton capacity storage operation.

For the closed economy, net annual economic costs of a 6 million ton buffer stock would be only some $10 million. However, with free trade such a buffer stock would not only contribute much less to stabilization of domestic grain consumption and price, but its net annual cost would be over $70 million.

The distribution of losses and gains is also interesting. With the specified demand function, stabilization is expected to yield a positive consumer surplus and a negative producer surplus. Yet, consumers are seen to suffer losses. The reason is that under the postulated subsidy program, low income consumers do not gain from the reduction in price when grain is removed from storage. They pay the same price regardless of the market price when supplies are scarce. When the subsidy program is practiced, this surplus accrues primarily to the government in the form of savings on subsidy payments. The more closed the economy is to international trade, and the larger is the buffer stock, the larger are these fiscal benefits. This should not be interpreted to mean, however, that governments should favor protectionist policies and large buffer stocks. To the contrary, the "gains" by the government from a stock only partially compensate for the additional fiscal burden the government incurs in the first place, as a consequence of greater instability in grain prices introduced by the trade restrictions.

Figure 2.24 illustrates the rapidly declining cost effectiveness of increasing levels of buffer stock operations under all trade

Figure 2-24: Economic Cost and Supply Stabilization with Alternate Trade Policies



Source: Bigman and Reutlinger

scenarios. While the probability of a severe shortfall in consumption declines with increasing stock levels, this increased protection is bought at rapidly accelerating costs to the economy. Only in the case of a closed economy and only for a very small stock would there be a small gain while the probability of a severe shortfall is reduced. Under the restricted trade scenario, and annual outlay of $45 million for buffer stocks would reduce the probability of a severe shortfall by 5.0 per cent. However, and additional outlay for buffer stocks of the same magnitude would reduce the probability of such a shortfall by only an additional 1.1 per cent.

Conclusions

The single most important conclusion from the theoretical analysis and the simulation experiments with the model presented in this paper is that in most cases, trade and buffer stocks are strong substitutes for stabilizing a country's food grain supply and price. To the extent that trade and buffer stocks are equally effective in achieving a desired level of stability, countries can choose between liberalized trade and buffer stocks. If a high level of stability is desired, the buffer stock option can be very costly. Obviously, the trade option has its costs as well in the form of larger fluctuations in foreign exchange balances. Having recognized, however, the stabilizing effects of international trade, the choice set of various policies aimed at achieving prespecified stabilization goals should include trade policies, and the decision should be made on the basis of cost effectiveness. The option of trade should also suggest different directions in the efforts by the international community to ensure a stable flow of supply to developing countries."

Income Stabilization Schemes

James P. Houck (1973) identified two groups of income stabilization schemes. The first group includes those that operate outside the market to adjust incomes of primary producers without altering the market mechanism, for example, a) progressive income taxes, b) flexibility in debt repayment schedules, and c) flexibility in credit availability for production purposes and family expenses. This type is often carried out by specialized credit agencies, insurance programs against crop yield failures, direct payments to farmers or provision of road and railway facilities. The second group include programs that affect the market mechanism in their attempt to stabilize incomes.

For this second group of income stabilization schemes, Houck established the following specifications. First, assume that the central government decides to stabilize the incomes of primary producers. It decides the device to use, the extent of stability of income to be achieved, and its distribution among participants in the market. Secondly, assume that the aggregate annual or marketing season gross income for the agricultural commodity in question is to be stabilized and that the level at which it is stabilized will be the long-run open market trend value of price multiplied by average annual output. Then, the government will act only if the income flow threatens to exceed or fall short of some acceptable zone, which is itself a function of the resources available to the authority.

In Figure 2.25, the hyperbola UU represent the upper bound of the acceptable zone, such that any pair on this curve yields the maximum acceptable income. Similarly, the hyperbola LL represents the lower bound

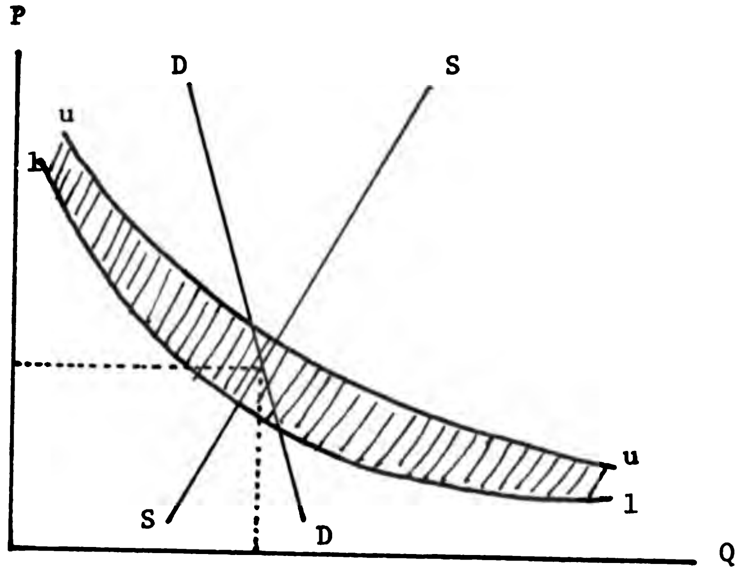


Figure 2-25: Zone of Acceptable Price-Quantity Combinations

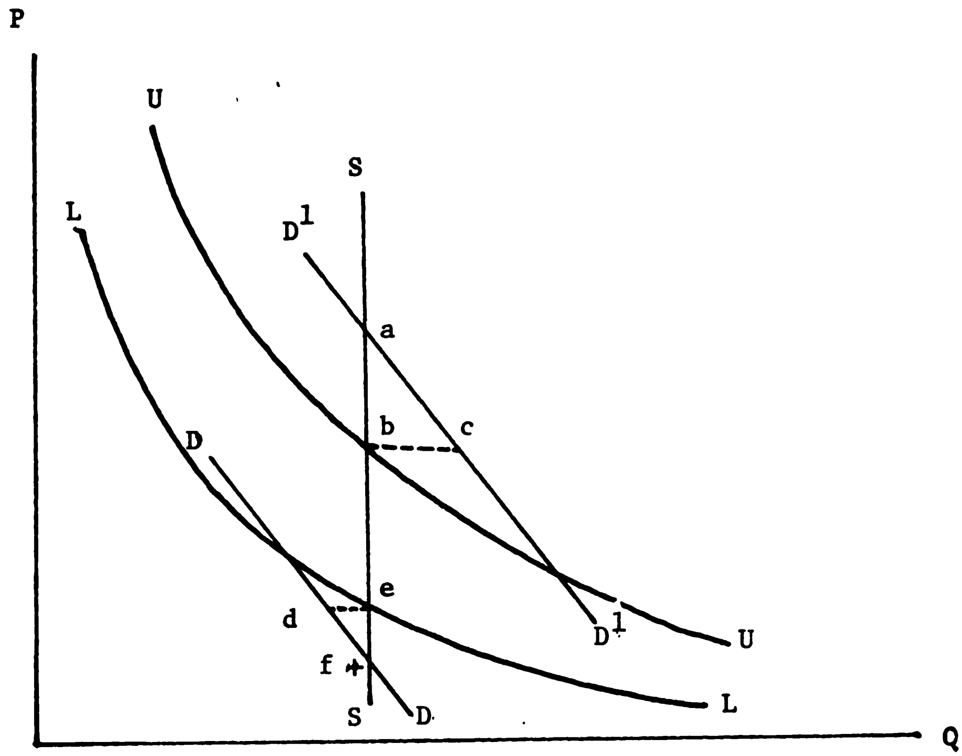


Figure 2-26: Buffer Stock or Buffer Fund Operations With Fluctuating Demand

for a minimum acceptable income. Therefore, the shaded area represents the acceptable zone of combinations of prices and income. If the annual equilibrium in the market for the commodity occurs inside the zone, the government does nothing to alter market operations. Otherwise the authority intervenes in the market.

Houck gave the example of buffer stock or buffer fund programs designed to stabilize aggregate gross income rather than producer prices. Under the assumption of inelastic supply response, income fluctuations caused by fluctuating inelastic demand, such that in periods of low demand (as given by SS) the open market equilibrium will be at point f, which is below the lower permissible income given by the curve LL. Point e could be achieved either through a buffer stock operation, which will require buyers the amount de in the market, or through a buffer fund operation making per unit payments to farmers equal to ef (Figure 2-26). With the former, price for the entire output will rise to the e level. With the latter only the realized price will be adjusted while the market will clear at point f.

The opposite situation will prevail at a high demand level DD'. Either the quantity bc can be sold in the market or a per-unit tax of ab can be applied.

The case for a given demand curve (dd) and fluctuating supply curves (i.e. due to a change in weather conditions, or changes in planned productions) is illustrated in Figure 2-27. Point a reflects an equilibrium for the open market at the low level of supply, which is outside of the permissable zone. A buffer stock operation would require sale of an amount bc, to push the equilibrium market price down to the maximum acceptable. A buffer fund operation could be used by imposing a tax on the producer price in

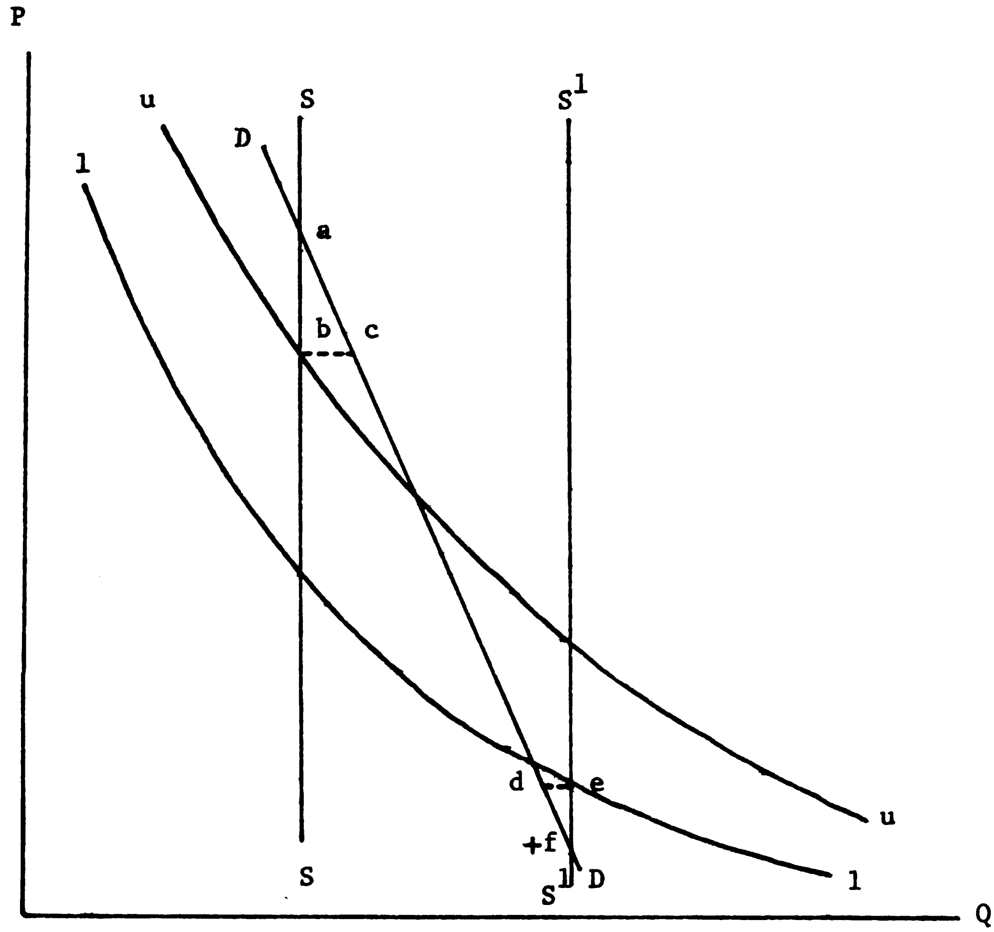


Figure 2-27: Buffer Stock or Buffer Fund Operations with Fluctuating Supply and Inelastic Demand

order to reduce the producers' per-unit return to the permissible level. Similarly, in periods of high supply, a buffer stock operation could acquire an amount de or a buffer fund operation could subsidize producers by ef to move producer income up to the minimum desirable level.

With more elastic demand (in Figure 2-28) in periods of larger supply, the equilibrium on the open market above the maximum acceptable point. In this case opposite operations of buffer funds would be needed to maintain the maximum acceptable P-Q combination given by point e. In periods of low supply, acquisition by the buffer stock agency equal to cb or subsidies by the buffer fund equal to ab would be made if to return to b the minimum acceptable combination. In this case, however, the buffer stock would add instability to the market by acquiring more stocks in periods of low supply or by selling inventories in periods of high supply. As a result producer prices will be unstable and positively correlated with the elasticity of demand. Nonetheless, gross income will be stabilized.

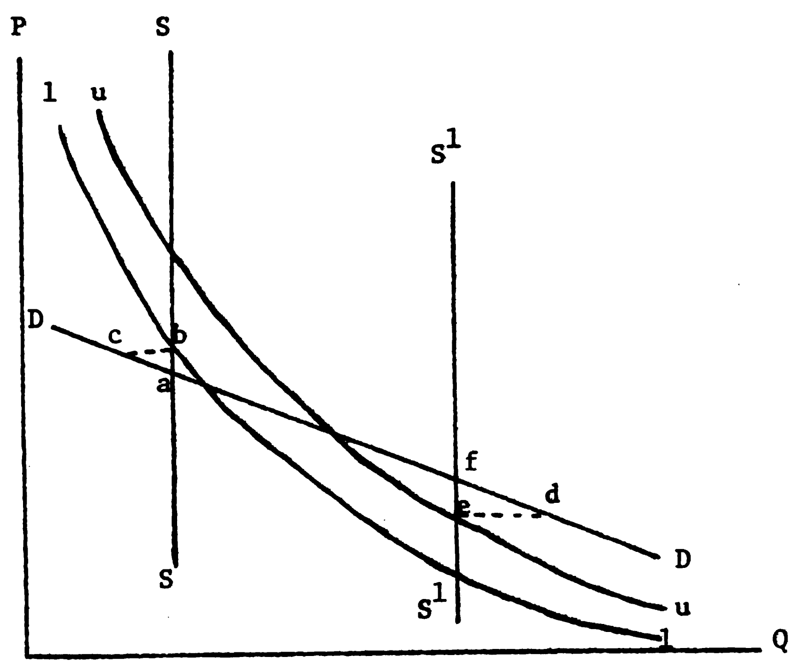


Figure 2-28: Buffer Stock or Buffer Fund Operation With Fluctuating Supply and Elastic Demand

In summary, price stability and income stability can be achieved jointly, depending upon the sequence and correlation of shifts in demand and supply. In Houck's words: "Generally speaking, price stability and income stability are achieved jointly when (1) demand shifts are large relative to supply shifts, and/or (2) demand is relatively inelastic at the producers' level."

Objectives of Price Stabilization Programs

Raj Krishna (1967) pointed out that objectives of agricultural price policies may be quite different in different parts of the world. For example, in Western Europe and USA policies are more concerned with problems created by deceleration of demand and the consequent accumulation of surpluses. In most of the developing countries the problem is a growing gap between demand and supply. Some countries have a diversified pattern of production. In other, one, two or a few crops dominate. In some countries land is still available for settlement and cultivation, but in others there is overpopulation relative to available land. Therefore objectives of price policies may be different in these different situations.

Generally speaking, the objectives of agricultural price policy in Europe and the USA have been price stabilization and income support. A report from OEEC (1961) stated:

> "A reasonable degree of stability of prices and of agricultural markets. . . was historically the first objective of price support policies. . . An important objective of price policy continues to be. . . the avoidance of sharp price fluctuations but its primary feature is to contribute to the long run assurance to producers as regards the support of their income."

Agricultural pricing policies in developing countries have often been used negatively to lower the price of food and other agricultural goods and to increase the relative prices of manufactured goods. Brown (1978) surmised that the reasons LDCs have used price policies based against agriculture include: 1) aggregate agricultural production is not very responsive to price changes, 2) the chief beneficiaries of higher prices would be the larger size farmers who respond by increasing output, 3) that higher prices for food and other agriculturally-related basic goods such as clothing would most adversely affect low-income consumers, 4) manufacturing provides a more rapid means of growth, and 5) achieving a target rate of growth depends on large transfers of income and foreign exchange from agriculture to manufacturing. A negative agricultural price policy (involving both prices and taxation) has been a common feature of policies in the early phases of development in both capitalist and socialist countries, although very dissimilar institutional mechanisms have been used for implementing them (Table 2-6).

Krishna (1967) argued that there is some critical minimum rate of agricultural growth without which a plan would not be able to achieve its general targets over the plan period:

> "If the circumstances of a country permit this critical minimum rate of agricultural growth to be realized while the terms of trade of agriculture are depressed against it in the traditional way, there would be no need for a positive agricultural price policy. But the evidence shows that in many developing countries the minimum rate of agricultural growth consistent with rapid and sustained general growth can be quite high and that a negative price policy cannot be followed without risking failure to achieve the desired growth."

Table 2-6

Country	Nature of Price Policies	Source
United Kingdom	Corn laws in the 19th Century had the aim of lowering the relative price of food and raw materials in relation to the price of manufactures.	Tracy, 1964
Russia	The collectivization of agriculture was theoretically endorsed by Lenin and practically carried out by Stalin explicitly to extract surplus output from the peasantry at a low price.	Georgescu-Roegen 1960 Kahan 1964

Table 2-6 Continued

Country	Nature of Price Policies	Source
Asian Countries	(With the exception of Sri Lanka and Japan), "The interests of agricultural products have been relegated to second place. Such that the agriculture sector provided a large part of the surpluses required for investment in the nonagricultural sectors".	FAO/ECAFE (1958)
China	"As early as 1953 the regime was forced to abandon the market in favor of centrally determined compulsory quotes for major crops....The relative poverty of China made these quotas only a temporary respite of little more than two years in length... By harming individual farmer incentives, they probably hastened the need for measures which would get to the real problem, that of agricultural output... Between 1955 and 1959...the Chinese communists tried first the cooperations, and then the communes."	Perkins 1964
Japan	During the early period of rapid development (1878-1917) the agriculture was taxed heavily to finance industrial growth. The land tax provided about 70% of government revenue during 1878-1907 and 40% during 1908-1917. Rents remained at more than half of the rice yield in the earlier period.	Ohkawa and Rosovsky 1960
Argentina	(Commonly cited as an example of a negative price policy carried to excess). During the period from 1944 to 1955 prices received by farmers were kept low and part of the foreign exchange received for exports was diverted for the benefit of industry by means of multiple exchange rates. At the same time Argentine industrialists were protected by high import duties on competing Products and by a system of import licensing. These had the double effect of lowering agricultural income and raising farmers' cost of production.	Inter-American Committee 1963
Ghana	About 40% of government revenue is derived from the profits of government marketing boards and most of this revenue is used to finance industrial development.	Myint 1964

Krishna further reviewed some reasons why so many developing countries have experienced constraints imposed by the rate of agricultural growth on the general rate of growth:

1) Early decline mortality without matching decline in fertility increases the rate of growth of population. Therefore the demand for food increases to a level which a slow-growing agricultural sector cannot meet.

2) The option of importing cheap grain and raw materials is not available anymore.

3) The peasantry of the 20th century in many developing countries does not seem to help the policy makers by keeping up the rate of agricultural growth at the desired minimum level when the terms of trade are turned against them.

Table 2-7 presents a FAO survey of some less developed countries that have had to turn to a positive price policy because they were unable to realize the minimum required rate of growth of agriculture output without it.

Krishna made some recommendations to be followed when applying price policies:

1) The growth of agricultural output has to be induced primarily through institutional and technological improvements with a great increase in the supply of inputs embodying these improvements.

2) Price variability can retard these changes...therefore a favorable price policy is needed alongside techno-organizational changes.

3) It is desirable to restrict a positive price guarantee program to a few major commodities which are persistently in short supply.

Table 2-7: FAO (1965) Survey Tabulation

Commodity	Countries With Minimum Price Policy		
WHEAT	India	Paraguay	
	Pakistan	Syria	
	Lybia		
RICE	India	Nicaragua	Tanzania
	Pakistan	Peru	
	Guatemala	Senegal	
MAIZE	Guatemala		
	Tanzania		
BARLEY and OLIVE OIL	Libya		

Source: R. Krishna (1967)

4) The minimum guaranteed price should cover the full bulkline cost of improved technology package adoption, including imputed values of family land and labor inputs. Parity prices, in the western sense of moving averages of market prices, or prices derived from general equilibrium models of the agricultural sector will be either inappropriate or unrealistic option for LDCs.

5) A policy using public stock and distribution operations for the benefit of low income consumers is preferable to other types of interventions. But measures taken to protect consumers should not damage producer incentives.

As was well stated by Fletcher (1967), stabilization of prices does not guarantee an optimum price structure for economic development. He defines an efficient price system in terms of the results it should achieve:

> "...An optimum price structure in a growth context would accomplish all of the following: 1) allocate factors to insure the largest output and optimum product mix it produces, 2) insure that the desired goods are produced at optimum levels of cost and efficiency, 3) distribute goods to the "right" consumers at minimum cost and delay, 4) forsee future demand and supply conditions so that required goods and services can be efficiently produced at the appropriate time, 5) facilitate improvements in technology and productive structure in accordance with factor endowments and development. Objectives, and 6) achieve a satisfactory distribution of national income between producers and consumers and between sectors of the economy."

Since there is no price structure that can do all of the above at the same time, what was suggested is that policy makers should evaluate prices on the basis of weights or importance attached to alternative objectives. There is no unique specification of an optimal price structure. It should be recognized, however, that a response to price movements exists in poor economies as well as rich. This price responsiveness is an important factor to consider within the context of price stabilization and support programs.

Food Security

Valdes and Siamwalla (1980) defined food security as the ability of food-deficit countries to meet target levels of consumption on a yearly basis. As a target level they selected the trend level of consumption for the given society. They concentrated on food supply variability due to the impact of fluctuating weather on the size of the harvest. They identified two distinct food supply problems faced by many LDC's. First, a large and growing long-term deficit in domestic supply. Second, and more related to food insecurity problems, the uncertain ability to finance needed imports to meet immediate targets for consumption levels. Also, there are two main causes of food insecurity: 1) shortfalls from domestic production trends, which are usually weather induced; and 2) sudden increases in world prices for food imports and/or decreases in the price of exports used to earn foreign exchange for imports.

These two sources of insecurity lead directly to fluctuations in real income within the country, where the poorer households are the most sensitive to such variabilities. Thus, if the fluctuations in real income can be smoothed, food security could be attained. The authors argue that in order to achieve the aim of food security, the capital market mechanism needs to be operative at all levels for the country as a whole as well as for individual households. The capital market mechanism must involve assets that possess a high degree of liquidity, as their conversion to food must be effected relatively quickly. The type of mechanism proposed is to hold assets in the form of either food stock themselves or in the form of monetary instruments such as foreign exchange reserves to be used to purchase food in the short periods. It has been found that under perfect competition in the world food market, food security can be achieved for some LDC food importers at lower cost through varying the levels of imports while operating a relatively small buffer stock. That is, the problem of which types of assets to hold is amendable to solution using conventional economic criteria. However, regardless of the form in which assets are held, attaining food security is a costly process, the cost essentially being measured by the difference in the rate of return in non-liquid versus liquid assets multiplied by the volume of diversion in investment required.

It may be argued that a country suffering from food security can borrow rather than divert its own resources into liquid assets. However, because this overall ability to borrow is limited in the long term by the wealth of the country the access to a particular line of credit will tend to be at expense of credit for longer-term investments. Again food security can be attained but only at some cost.

The authors suggested that an exact measure of food insecurity would rest on real income fluctuations, but an approximate measure may be obtained by examing deviations from the trend in foreign exchange earnings minus the excess expenditure over this trend in food imports for the current year (defined as "deviations in real export earnings").

Inadequacies of the International Markets for Cereals

Some argue that each country should become self-sufficient in food, and therefore build its own system of national food security. The justification for such policies is that each nation faces highly unreliable international supplies. In much of the discussion, no distinction is made between concessional and commercial food supplies. Valdes and Siamwalla well pointed out that the reliability of their true source differs considerably. The general perception is that concessional supplies are completely unreliable (i.e. reduction in food aid in 1973-74). Furthermore, in individual cases donors have used food aid to obtain political concessions from the recipients. Thus a national food policy that relies on food aid supplies is highly risky. However, they argued that it is quite unjustified to move to complete independence from all forms of food imports without showing that commercial supplies are also unreliable, which they believe cannot be documented.

Barriers to internal trade

In many cases, the state has assumed the functions of the trader in food grains. Many governments have attempted to insure food security by insulating domestic prices from international price. This policy implies that the burden of real income fluctuations caused by price shifts in the world market is borne by the public treasury. These interventions to stabilize prices can indeed insure stability of food consumption in urban areas. That is why there has been an association in the general perception of food security with stability in the price of food. However, if insecurity arises from domestic production fluctuations, such a policy by itself would be insufficient, especially for rural areas.

High transport cost due to geographical isolation of many areas is a form of trade barrier, such that the movement of food grains in and out of these regions is uneconomical. Thus, most isolated areas are self-sufficient, which means that the market for food grains would always clear in response to the local demand-supply situation. Fluctuation of production away from the normal level causes changes in the real income of the community. Therefore because of the high transport cost, local storage of food grains may be preferred to holding other forms of assets or approaches to food security.

Shortcomings in the capital market

The authors suggest introducing credit facilities as a practical way to avoid food insecurity problems. It is argued that in urban areas there is a straight relationship between food security and price stability. This can be achieved when the country adjusts its imports of food or the level of stocks to compensate exactly the aggregate fluctuations in domestic productions. However, a large reduction in agricultural output could result in an unfavorable impact in the industrial sector and hence reduction in employment and income in the urban areas. In this case, price stabilization is no longer a sufficient condition for food security. Furthermore in rural areas where the real income of households are directly affected by fluctuations in farm production, stability of food consumption cannot be achieved by means of price stabilization schemes. Production changes affect both the demand side and supply sides of the market, with no reason to believe that the capital market will act to stabilize the effective demand for food of the household by meeting the shortfall in its income. Any attempt by the government to introduce substitutes for a capital market at this level would be administratively costly. Therefore, in these circumstances income transfer becomes unavoidable at times of shortages. They suggest that crop insurance is one possible means of accomplishing this transfer, although it may be difficult to implement. Public food distribution is another way, but unfortunately there are few of these programs that reach extensively into the rural areas.

Conclusions

These authors suggest the following general points in connection with food security policies:

1) The solution of food insecurity problems must begin at the national level.

2) Such an approach should include large investments in food distribution systems, transport and communications, early warning systems, and a mix of stock and trade policies.

3) Relying only on domestic grain reserves to cover yearly fluctuations may turn out to be an expensive solution, where trade is a real possibility.

4) Three important implications of food security programs are: i) the incentive for private domestic stockholding would be reduced, ii) the foreign trade balance and the government budget would have to absorb the instability; and iii) the loss in purchasing power or real income in the agricultural sector, due to crop failure, would have to be compensated for. Otherwise, stabilizing national food supply *per se* would be insufficient to offset declines in effective demand in the rural areas.

Agricultural Comparative Advantage and Price Uncertainty

Jabara and Thompson (1980) examined analytically as well as empirically the implications of international price uncertainty for agricultural comparative advantage in Senegal assuming risk-adverse policymakers. The analytical part of their work is reviewed here in order to identify the main issues of comparative advantage under international price uncertainty.

For this purpose, imagine a small open economy which has: a) one dominant agricultural export (product X) and one dominant agricultural import (product Y) that can also be produced in the country and b) a welfare function $U(X_c, Y_c)$ which is a function of quantities of both commodities consumed. By comparative advantage is referred that mix of traded product at which this welfare function is maximized.

Certainty Case

The production function for this economy is assumed to be:

$$Y_p = F(X_p), \text{ with } \partial Y_p/\partial X_p < 0 \text{ and } \partial Y^2_p/\partial X^2_p < 0$$

The domestic production of the commodity that is commonly imported (Y) is inversely related to the quantity produced of the commonly exported product (X), and this negative relationship is diminishing. Note $F'(X_p)$ represents the marginal domestic opportunity cost of X production in terms of Y production.

The country can exchange X for Y on the international market at a price ratio $P = P_x/P_y$, which is exogenously given (small country assumption).

Assuming equilibrium in the balance of payments, production and consumption are linked through trade by the following relationships:

$$X_c = X_p - X_e$$

$$Y_c = F(X_p) + P\, X_e$$

where subscript c refers to consumption, p to production and e to net exports (or imports if $X_e < 0$).

The objective of the country is to maximize its real income:

$$\text{Max } U(X_c, Y_c)$$

Rewriting,

$$\text{Max } U[X_c(X_p, X_e), Y_c(X_p, X_e)]$$

The first order conditions for an optimum solution are:

$$\frac{\partial U}{\partial X_p} = \frac{\partial U}{\partial X_c} \frac{\partial X_c}{\partial X_p} + \frac{\partial U}{\partial Y_c} \frac{\partial Y_c}{\partial X_p} = 0$$

$$\frac{\partial U}{\partial X_e} = \frac{\partial U}{\partial X_c} \frac{\partial X_c}{\partial X_e} + \frac{\partial U}{\partial Y_c} \frac{\partial Y_c}{\partial X_e} = 0$$

Rewriting,

$$\frac{\partial U}{\partial X_c} + \frac{\partial U}{\partial Y_c} F'(X_p) = 0$$

and

$$\frac{-\partial U}{\partial X_c} + \frac{\partial U}{\partial Y_c} P = 0$$

Therefore, under perfect certainty the optimum point on production occurs where the terms of trade equal the marginal rate of product transformation $P = -F'(X_p)$, assuming the second order conditions are satisfied. So, no policy intervention which distorts P can improve the society's welfare. This implies that free undistorted international trade is the best policy to follow and the optimum tariff rate for a small country is zero. So in an environment of certainty comparative advantages suggest that welfare is maximized when each country specializes in and exports those goods in which it is a relatively low-cost producer and imports these goods in which other countries are lower-cost producers. The country is said to have a comparative advantage in the good exported and comparative disadvantage in the good imported.

Uncertainty Case

In this case the terms of trade, P, assumed to be a random variable with mean $E(P) = \overline{P}$. The country planners will try to maximize the expected utility:

$$\text{Max } E\,[U(X_c, Y_c)]$$

subject to

$$X_c = X_p - X_e$$

$$Y_c = Y_p + P\,X_e$$

The first order conditions for an interior solution are:

$$\frac{\partial E(U)}{\partial X_p} = E(U_1) + F'E(U_2) = 0$$

$$\frac{\partial E(U)}{\partial X_e} = -E(U_1) + E(U_2\ P) = 0$$

where $U_1 = \frac{\partial U}{\partial X_c}$ and $U_2 = \frac{\partial U}{\partial Y_c}$

Note that $E(U_2\ P) = E(U_2)\ \overline{P} + COV(U_2\ P)$, so rearranging and substituting yields:

$$p + \frac{COV(U_2\ P)}{E(U_2)} = -F'(X_p)$$

where $COV(U_2\ P)/E(U_2)$ is interpreted as a subjective cost associated with uncertainty in international prices.

The sign of the covariance term depends on the loss function or risk associated with uncertainty as well as on the relationship between U_2 and P. If $X_e > 0$ and policymakers are risk-averse, then $COV(U_2\ P) < 0$. If policymakers are risk seekers, then $COV(U_2\ P) = 0$. If they are risk neutral, then $COV(U_2\ P) = 0$. Thus the expected terms of trade can be lower, greater, or equal to the marginal rate of transformation depending on the risk preferences of the decision makers.

For risk-adverse policymakers, $\overline{P} > -F'(X_p)$. The recommended policy to maximize expected utility under uncertainty is not a free trade policy with the international terms of trade reflected in undistorted domestic prices. Rather, the optimum trade policy is for the domestic terms of trade to be set equal to the expected international price ratio plus the subjective risk cost. This implies that some diversification in the production of agricultural commodities in the country can be expected as a result of the uncertainty. That is, small countries in this situation would promote a policy of substitution of domestic production for imported products at the expense of exported products. This is the mix of products that would maximize expected utility. The results of this analysis also suggests that a small country in an environment of uncertainty can increase welfare by distorting domestic prices away from the international terms of trade.

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CHAPTER 2 ANNEX

ANNOTATIONS FOR KEY REFERENCES ON PRICE GUARANTEE AND MARKET STABILIZATION PROGRAMS

Bigman, D. and Shlomo Reutlinger

Food Price and Supply Stabilization: National Buffer Stocks and Trade Policies, World Bank, Washington D.C., May, 1978.

This article is part of a study undertaken by the World Bank on various aspects of food stabilization policies in developing countries. The authors agree that not always will free trade in food commodities provide instability in domestic markets and protectionist policies such as buffer stock schemes will encourage food production and domestic market stability in times of poor domestic harvest and/or high prices for imported grain. Avoidance of protectionist trade policies, therefore, can be a far more powerful instrument for stabilizing domestic grain prices and ensuring the continuity of supplies than any reasonably sized buffer stock. They also argue that the proposition arising from the Waugh-Oi-Massell type analysis is only one among several objectives of stabilization policy. In most countries, rather than being the combined and producer surplus the primary objectives of buffer stocks and other stabilization policies, the primary objective is that to ensure a regular flow of supplies to consumers and to meet the needs of vulnerable sections of the population. Their assertion is based in FAO studies that show that most countries rate this insurance of a continous flow of supply as the main objective of their cereal stock policies. For their work they make use of a stochastic simulation model. This model is an open economy model, mainly concerned with examining stabilization policies for food grains, and it examines explicitly random fluctuations in a country's production and international price of grain. The model was used to evaluate the impact of trade and stock policies on stabilization. Their main conclusion from their analysis was that in most cases, trade and buffer stocks are strong substitutes for stabilizing a country's food grain supply and price and the choice of any type of policy should be made on this basis of cost effectiveness.

Massell, Benton F. (1969)

"Price Stabilization and Welfare," Quarterly Journal of Economics 88, May, pp. 284-98.

This article tried to reconcile the analyses presented by Oi and Waugh concerning the gains to producers and consumers resulting from a stable as compared to fluctuating prices. Using the expected value of the change in producers' and consumers' surpluses as a measure of gain, it was shown that price stabilization, brought about by a buffer stock, provides a net gain to producers and consumers taken together.

Massell, Benton F. (1970)

"Some Welfare Implications of International Price Stabilization", Journal of Political Economy 78, March-April, pp. 404-417.

This paper deals with some welfare implications of price stabilization achieved by international buffer stock. Stabilization is taken to mean not a reduction overtime in price fluctuations, but a reduction in riskiness of this years' income as viewed by the producer of an agricultural commodity at planting time. (Income will depend in yield and price at the time of harvesting, which are stochastic variables.) Massell concludes that although a buffer stock may provide a large increase in welfare (to the producer) than would a forward contract, the former alternative is more expensive than the latter. The extent of a particular crop planted has positive relationship to the expected value of income earned from the sale of the crop and a negative relationship to variance of such income. Massell uses a linear demand-supply model.

Oi, Walter Y. (1961)

"The Desirability of Price Instability Under Perfect Competitions," Econometrica 29, January, pp. 58-64.

This paper analyzes the behavior of a competitive firm faced with an uncertain demand, which takes the form of an instability in the price of the output, such that time price is taken to be a stochastic variable. The analysis reveals the conclusion that instability in prices will always result in greater total returns for the competitive firm under the assumption that firms maximize short run profits during each period of time, and the marginal cost of each firm is upward sloping throughout its relevant range, such that producers could make more profits when the price of the good varies, than when its price is stabilized at the arithmetic mean of variance.

Paish, F. W. and P. T. Bauer. (1952)

"The Reduction of Fluctuations in the Incomes of Primary Producers," Economic Journal, 62(248), December, pp. 750-80.

The authors presented a proposal for reducing the violence and magnitude of temporary fluctuations in the income of primary producers. They examined the supply restriction schemes in the inter-war period and the stabilization schemes of the post-war British Colonial Policy that were used. They tended to maintain or to raise producer incomes. They intended to show their adoptions were used in an incorrect way such that not only prolonged the difficulties the government intended to solve, but have also tended to restrict the supply.

Bauer, P. T., and F. W. Paish (1954)

"The Reduction of Fluctuations in the Incomes of Primary Producers Further Considered," Economic Journal 64, December, pp. 704-29.

The principal purpose of this article is to reply to critics of their 1952 article. Bauer and Paish argue mainly that the inflation problem brought up by Hill and Ady is essentially irrelevant to the problem of reducing fluctuations in producers incomes; and that the attempt to reduce fluctuations in incomes rather than merely in prices, as being suggested as preferable by the two ladies, is that violent accidental fluctuations in output with prices constant may have economic and social effect less frequent than violent fluctuations in prices with output constant, such will reduce instability. Also they think that there is no real problem in preventing year-to-year fluctuations in producers' prices and output such that the effects of inaccurate forecasts of output and price on the operation of their formula as discussed by Hill and Ady is also trivial. With respect to Professor Friedman they feel that the differences were about the functions of government in societies at different stages of development, such that in the case of underdeveloped economies it is not true that free market policies are always better alternatives as suggested by Friedman.

Turnovsky, Stephen J. (1978)

"The Distribution of Welfare Gains from Price Stabilization: A Survey of Some Theoretical Issues," Stabilizing World Commodity Markets, F. G. Adams and S. A. Klein, eds. Lexington: Heath Lexington, pp. 119-48.

The purpose of this paper is to survey some of the most recent developments about this topic which were first stated by Waugh-Oi-Massell. Here is considered the case where demand and supply functions are nonlinear and the stochastic disturbances enter multiplicatively, such that this specification lends to substantial modification of many of Massell's conclusions. (Massell's work deals with linear demand and supply curves and additive disturbances.) It is also considered the welfare effects for both producers and consumers of stabilizing prices in the case where firms make their supply decisions on the basis of expected prices, before they learn the actual market price, and are unable to modify these decisions in the short run.

Briefly considered is how the Waugh-Oi-Massell model can be extended to deal with the worldwide nature of current inflationary conditions. It is also considered an alternative form of government intervention (like government influences on movement of prices by announcing forecasts which in turn influence the behavior of private producers) rather than entering the market directly. Finally a general extension of the basic Waugh-Oi-Massell model is considered through the multimarket situation in a multi-commodity context.

One of the major conclusions is that even though price stabilization always improves aggregate welfare, the distribution of these welfare gains in the society is highly senstitive to the precise specification of the model and the nature of the stochastic disturbances.

Turnovsky, Stephen J. (1976)

"The Distribution of Welfare Gains from Price Stabilization: The Case of Multiplicative Disturbances," International Economic Review, Vol. 17, No. 1, February, 133-148.

Massell, integrating the conclusions of Waugh and Oi and assuming linear demand and supply curves with additive stochastic disturbances, showed: 1) producers lose (gain) from price stabilization if the source of instability is random shifts in demand (supply); 2) consumers lose (gain) from price stabilization if the source of instability is random shifts in supply (demand); 3) where both demand and supply are random, the gains to each group are determined according to the relative size of the variances and to the slopes of demand and supply curves; 4) total gains from stabilization are always positive (gainers compensating losers) if the demand and supply curves are not perfectly elastic; if so, all gains tend to zero. With only minor modifications, the same results hold assuming non-linear functions as long as the stochastic disturbances are still additive. Distribution conclusions have major modification when multiplicative stochastic disturbances are assumed. The author includes in his partial equilibrium framework, assumptions of non-linear functions, a self-liquidating buffer stock and ignore any storage and administrative costs related to operating such stock. An important consideration is that with random disturbances occuring in both sides of the market (supply and demand) the stabilized price will differ from the mean of the fluctuating prices to have a self-liquidating buffer stock.

Assuming multiplicative random disturbances, the desirability of price stabilization does not depend upon the source of the price instability, which is the case when additive disturbances are assumed, but only upon the true shape of the deterministic components of the demand and supply curves. Generally, producers gain and consumers lose from stabilization if demand is elastic and supply inelastic; if demand is inelastic and supply is elastic, consumers tend to gain and producers tend to lose.

An example of log-linearity (constant elasticity functions) with multiplicative disturbances is illustrated. Under this functional specification, producers gain from stabilization only if the elasticity of demand exceeds unity, if not they lose, but consumers always gain from stabilization, irrespective of the underlying elasticities, the allocation of welfare gains in this specific case (of particular interest because it is the exact multiplicative analogue of Massell's linear-additive model) is asymmetric.

Another example is presented through a linear function specification, where producers lose from stabilization if the price elasticity of demand is less than half the price elasticity of supply. In this linear case, consumers lose if the supply curve is relatively inelastic compared to the demand curve. Reversing these elasticity relationships would also reverse the gaining and losing relationships.

The main conclusion the author states in this paper is the importance of the nature of the stochastic disturbances when assessing the distributional effects of stabilization policies: The assumption of multiplicative disturbances can be justified as naturally as additive disturbances, with either assumption price stabilization will lead to a gain in total welfare.

Waugh, Frederick V. (1944)

"Does the Consumer Benefit from Price Instability?" Quarterly Journal of Economics, August 1944, pages 602-614.

Waugh supports the idea that consumers benefit from price instability. Using consumer surplus as an indicator he concluded that consumers will enjoy a greater average consumer's surplus when prices are changing.

The analysis is presented for one commodity case and subsequently is extended to n commodities. The basic results are proven to hold for the n commodities case.

Waugh, Frederick V. (1966)

"Consumer Aspects of Price Instability," Econometrica 34(2), April pp. 504-8.

In this article, Waugh makes use of graphic tools to prove that welfare aspects of price stability depend upon the level at which the price is stabilized and whether one is concerned with welfare of the consumer or of the producer. If prices are stabilized at a very low level the producer is harmed and the consumer benefits, but if the prices are stabilized at a very high level, the opposite will occur.

Waugh, Frederick V. (1945)

"Does the Consumer Benefit from Price Instability? Reply," Quarterly Journal of Economics 57, February, pp. 301-3.

Waugh replied to critics pointing out that he certainly did not intend to conclude that consumers would be harmed by any price stabilization, regardless of level. However, he attempted to show that stabilizing the price of a commodity at a level equal to, or higher than, the arithmetic mean of the unstabilized prices will be harmful to the consumer.

CHAPTER 3

ANALYSIS OF INPUT PRICE POLICIES

Introduction

Farmers in less developed countries (LDCs) have been shown to receive substantially lower ratios of output to input prices--especially fertilizer--than farmers in developed nations. Peterson (1979) concluded that these lower real prices result in a significant reduction of agricultural output and, hence, economic growth in LDCs. He listed several policies which he feels have contributed to this situation: "the imposition of export taxes on farm commodities which have the effect of holding domestic prices below world market levels, the overvaluation of currencies which reduces the export demand for farm products, and the use of state marketing monopolies with power to set farm prices below the levels that would be determined by competitive free markets" (Peterson, p. 12). In addition, certain government trade policies result in artificially high input prices to farmers in LDCs. In other countries, inputs such as fertilizer are subsidized, often to offset low output prices. The motivation behind most of these policies is to increase government revenues and to keep food prices low for the non-farm population. Peterson concluded that there are "social costs"[1] inherent in such policies which bring about price distortions that reduce incentives to agricultural producers. Table 3-1 shows the loss of agricultural output and its accompaning social costs for 27 LDCs in 1969. The total social cost to all 27 countries represents 3.76% of their combined national income. Peterson explains that "at first glance this appears to be a small figure, but it is interesting to note that a nation which is able

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[1]For an explanation of his concept of social costs, see Peterson (1979). Also see chapters 1 and 2 of this manual.

Table 3-1: Loss of Agricultural Output and Social Cost of Price Distortions in 27 LDCs, 1969

	Loss of Output in Wheat Equivalents with a Bench Mark Price of		Social Cost in U.S. Dollars*	
Country	36.89 (1000 MT)	27.04 (1000 MT)	Total ($1000)	Percentage of NI
Mexico	18,258	2,787	8,347	.03
Chile	3,388	663	2,871	.05
Colombia	9,403	1,839	7,963	.12
Morocco	5,001	1,073	4,764	.16
Greece	12,635	4,932	48,727	.58
Tunisia	1,489	588	6,007	.52
Portugal	7,399	3,406	42,728	.74
Kenya	3,820	2,024	31,453	2.45
Ghana	4,752	2,793	43,711	2.53
Panama	1,610	922	16,071	1.89
Jordan	888	516	9,278	1.48
Senegal	3,658	2,233	43,468	5.63
Guatemala	3,042	1,962	42,468	2.94
Iraq	4,952	3,231	71,372	2.73
Cameroon	4,439	3,188	84,578	8.77
Ivory Coast	6,916	5,008	136,194	10.34
Peru	8,581	6,241	170,441	4.74
Uruguay	4,576	3,369	94,601	4.49
Philippines	21,158	15,879	460,412	5.76
Upper Volta	1,646	1,294	40,217	6.63
Argentina	53,206	42,097	1,392,358	6.21
Dahomey	1,713	1,372	46,449	25.24
Burma	23,801	19,531	700,187	38.16
Guyana	1,135	965	38,025	17.77
Khmer Republic	7,395	6,449	263,442	33.60
Paraguay	4,311	3,847	188,733	37.08
Niger	2,284	2,084	100,626	28.92
Total	221,556	140,293	4,095,644	

* Assuming $5.88 per 100 kilograms of wheat equivalent as an equilibrium price. This is comparable to the 27.04 price ratio.

Source: Peterson (1979)

to add 3.76% to its real national income each year, by eliminating social costs or for any other reason, will more than double its output every twenty years" (p. 21).

This chapter of the training manual deals with the welfare effects of input price policies, i.e. government interventions which set input prices either higher or lower than would occur at competitive equilibrium. It endeavors to provide the necessary framework within which analysts can evaluate the costs and benefits of input pricing policies, with special reference to fertilizer. Mudahar (1978) points out that although such policies are widespread, there is little accurate information available on the implications of different types of policies.

This chapter is divided into two sections. In the first, a general theoretical framework for the analysis of input price policies is presented and a specific application of the effects of an input subsidy on input and output markets is considered. The second section examines the special case of fertilizer, using the theoretical model developed in the first section.

Theoretical Framework for Analyzing an Input on Subsidy

In essence, the direct impact of an input subsidy is to change the price of the input and thus its impact can be analyzed in that manner. In order to illustrate the use of a partial equilibrium model to study the impact of a price change on input use and output production, input utilization and pricing in the model of a firm and industry in perfect competition is developed.

Firm Level

Assume that the firm produces an output Q by means of two factors of production X_1 and X_2. Assume further that the firm can produce output Q at constant average cost. Given these circumstances the firm's production function (1) is linearly homogeneous.

$$(1)\quad f(X_1, X_2) = Q$$

Assume given factor prices P_1, P_2 and a given product price P. For a given output costs will be minimized if[2]

$$(2)\quad P \cdot f_1 = P_1$$

$$(3)\quad P \cdot f_2 = P_2$$

where

$$f_1 = \frac{\partial f(X_1, X_2)}{\partial X_1} \qquad \text{(Marginal product of input } X_1\text{)}$$

$$f_2 = \frac{\partial f(X_1, X_2)}{\partial X_2} \qquad \text{(Marginal product of input } X_2\text{)}$$

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[2] Henderson, J. M., Quandt, R. E. (1980).

Hence, cost minimization requires that the value of the marginal product of each input be equated to price of output.

Given (1), (2), and (3), explicit expressions of the demand for factors X_1 and X_2 for a given level of output Q can be derived. They are of the general form:

$$(4) \quad X_1 = X_1(P_1, P_2, Q)$$

$$(5) \quad X_2 = X_2(P_1, P_2, Q)$$

The elasticity of substitution is needed for this purpose. It is defined as the effect of a change in the input price ratio on the least cost input combination needed to produce a given level of output.

At a constant level of output, changes in input use will be given by

$$(6) \quad f_1 dX_1 + f_2 dX_2 = 0$$

where f_1 and f_2 are the marginal products of X_1 and X_2, as specified above. Solving for dX_2/dX_1 gives

$$(7) \quad \frac{dX_2}{dX_1} = \frac{f_1}{f_2}$$

The absolute value of the slope of the isoquant is called the marginal rate of sbustitution. It represents the additional amount of the factor X_2 necessary to maintain output unchanged when a small reduction is made in the use of the factor X_1. The elasticity of substitution (σ) is the ratio of the proportional change in the factor use ratio to the proportional change in the marginal rate of substitution. Expressed in proportional terms, it is independent of units of measurement. Hence:

$$(8) \quad \sigma = \frac{d\ln\left(\frac{X_2}{X_1}\right)}{d\ln\left(\frac{f_1}{f_2}\right)} = \frac{\frac{f_1}{f_2} \quad d\left(\frac{X_2}{X_1}\right)}{\frac{X_2}{X_1} \quad d\left(\frac{f_1}{f_2}\right)}$$

where (9)

$$d\left(\frac{X_2}{X_1}\right) = \frac{X_1 dX_2 - X_2 dX_1}{X_1^2}$$

and

$$(10) \quad d\left(\frac{f_1}{f_2}\right) = \frac{\partial\left(\frac{f_1}{f_2}\right)}{\partial X_1} \cdot dX_1 + \frac{\partial\left(\frac{f_1}{f_2}\right)}{\partial X_2} \cdot dX_2$$

From (7) we know that

$$dX_2 = - \frac{f_1}{f_2} dX_1$$

Substitute in (9) and get

$$(11) \quad d\left(\frac{X_2}{X_1}\right) = - \frac{X_1 f_1 + X_2 f_2}{f_2 X_1{}^2}$$

Substitute in (10) and get

$$(12) \quad \partial\left(\frac{f_1}{f_2}\right) = - \frac{1}{f_2}\left[\frac{f_1 \partial\left(\frac{f_1}{f_2}\right)}{\partial X_1} - \frac{f_2 \partial\left(\frac{f_1}{f_2}\right)}{\partial X_2}\right] dX_1$$

Therefore,

$$(13) \quad \sigma = \frac{\frac{f_1}{f_2}\left[\frac{X_1 f_1 + X_2 f_2}{f_2 X_1{}^2}\right] dX_1}{\frac{X_2}{X_1}\ \frac{1}{f_2}\left[f_1 \ \frac{\partial\left(\frac{f_1}{f_2}\right)}{\partial X_1} - f_2 \ \frac{\partial\left(\frac{f_1}{f_2}\right)}{\partial X_2}\right] dX_1}$$

$$(14)\quad \sigma = \frac{f_1(X_1f_1 + X_2f_2)}{f_2X_1X_2\left[f_1\frac{\partial\left(\frac{f_1}{f_2}\right)}{\partial X_1} - f_2\frac{\partial\left(\frac{f_1}{f_2}\right)}{\partial X_2}\right]}$$

If the production function is homogeneous of degree one, it follows[3]

$$f_{11} = \frac{-X_2}{X_1} f_{21} \quad \text{and} \quad f_{22} = \frac{-X_1}{X_2} f_{12}$$

Substituting in (14) gives

$$(15)\quad \sigma = \frac{f_1f_2\ (X_1f_1 + X_2f_2)}{f_{12}\ (X_1f_1 + X_2f_2)^2} \qquad \text{or} \qquad \sigma = \frac{f_1f_2}{Qf_{12}}$$

Substituting again,

$$(16)\quad \sigma = \frac{f_1f_2}{Q.\frac{-X_2}{X_1} f_{22}}$$

and

$$(17)\quad f_{22.} = -\frac{X_2}{X_1} \cdot \frac{f_1 \cdot f_2}{Q \cdot \sigma}$$

For f_{11} we have

$$(18)\quad \sigma = \frac{f_1f_2}{Q.\frac{-X_1}{X_2} f_{11}}$$

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[3] Totally differentiate $q = X_1f_1 + f_2X_2$. Let $dX_2 = 0$ and divide by dX_1 before solving for f_{11}. See R.G.D. Allen (1968).

and

$$(19)\quad f_{11} = -\frac{X_1}{X_2} \cdot \frac{f_1 f_2}{Q\sigma}$$

Finally, f_{12} is given by

$$(20)\quad f_{12} = \frac{f_1 \cdot f_2}{Q \cdot \sigma}$$

Equations (4) and (5) can be log linearized as follows:

take the total differential of (4) and (5)

$$(4a)\quad dX_1 = \frac{\partial X_1}{\partial P_1} \cdot dP_1 + \frac{\partial X_1}{\partial P_2} \cdot dP_2 + \frac{\partial X_1}{\partial Q} \cdot dQ$$

$$(5a)\quad dX_2 = \frac{\partial X_1}{\partial P_1} \cdot dP_1 + \frac{\partial X_2}{\partial P_2} \cdot dP_2 + \frac{\partial X_2}{\partial Q} \cdot dQ$$

Multiple (4a) by $1/X_1$ and (5a) by $1/X_2$ and rearrange as follows:

$$(4b)\quad \frac{dX_1}{X_1} = \frac{\partial X_1}{\partial P_1} \cdot \frac{1}{X_1}\left(\frac{P_1}{P_1}\right) dP_1 + \frac{\partial X_1}{\partial P_2} \cdot \frac{1}{X_1}\left(\frac{P_2}{P_2}\right) dP_2 + \frac{\partial X_1}{\partial Q} \cdot \frac{1}{X_1}\left(\frac{Q}{Q}\right) dQ$$

$$(4c)\quad \frac{dX_1}{X_1} = \frac{\partial X_1}{\partial X_1} \cdot \frac{P_1}{X_1} \cdot \frac{dP_1}{P_1} + \frac{\partial X_1}{\partial P_2} \cdot \frac{P_2}{X_1} \cdot \frac{dP_2}{P_2} + \frac{\partial X_1}{\partial Q} \cdot \frac{Q}{X_1} \cdot \frac{dQ}{Q}$$

The term $\frac{\partial Xi}{\partial Pi} \cdot \frac{Pi}{Xi}$ is called the input elasticity of demand. It indicates the percentage change in the demand for the ith input as price of the ith input changes. It is represented in general as:

e_{ij} --the percentage change in demand for input i given a 1% increase in the price of input j.

In elasticity terms

$$(21)\quad \frac{dX_1}{X_1} = e_{11}\frac{dP_1}{P_1} + e_{12}\frac{dP_2}{P_2} + e_{1Q}\frac{dQ}{Q}$$

where

e_{1Q} is the percentage change in demand for input 1 given a 1% increase in output.

also

$$(22)\quad \frac{dX_2}{X_2} = e_{21}\,\frac{dP_1}{P_1} + e_{22}\,\frac{dP_2}{P_2} + e_{2Q}\,\frac{dQ}{Q}$$

The purpose of this part is to derive explicit expressions for the e_{ij}. To determine e_{11}, differentiate equations (1), (2) and (3) with respect to P_1, holding P_2 and Q constant. This yields

$$(1a)\quad 0 + f_1\,\frac{dX_1}{dP_1} + f_2\,\frac{dX_2}{dP_1} = 0$$

$$(2a)\quad f_1\,\frac{dP}{dP_1} + P\cdot f_{11}\,\frac{dX_1}{dP_1} + P\cdot f_{12}\,\frac{dX_2}{dP_1} = 1$$

$$(3a)\quad f_2\,\frac{dP}{dP_1} + P\cdot f_{21}\,\frac{dX_1}{dP_1} + P\cdot f_{22}\,\frac{dX_2}{dP_1} = 0$$

Utilizing previous equations gives

$$(23)\quad \begin{pmatrix} 0 & P_1 & P_2 \\ Q\sigma & -\frac{X_2}{X_1}\cdot P_2 & P_2 \\ Q\sigma & P_1 & -\frac{X_1}{X_2}\cdot P_1 \end{pmatrix} \begin{pmatrix} \frac{dP}{dP_1} \\ \frac{dX_1}{dP_1} \\ \frac{dX_2}{dP_1} \end{pmatrix} = \begin{pmatrix} 0 \\ \frac{P\cdot Q\cdot \sigma}{P_1} \\ 0 \end{pmatrix}$$

The determinant (Δ) of the lefthand matrix equals

$$(24)\quad \Delta = \frac{Q\sigma P^2 \cdot Q^2}{X_1 X_2}$$

Use Cramer's rule to find

$$(25)\quad \frac{dX_1}{dP_1} = -\frac{X_1}{P_1} \cdot \frac{X_2 P_2}{PQ} \cdot \sigma$$

and therefore

$$(26)\quad e_{11} = \frac{\partial X_1}{\partial P_1} \cdot \frac{P_1}{X_1} = -\frac{P_2 X_2}{PQ} \cdot \sigma = -k_2 \cdot \sigma$$

where k_1 is the cost share of the second factor of production:

$$(27)\quad k_2 = \frac{P_2 X_2}{PQ}$$

Similarly, obtain

$$(28)\quad \frac{dX_2}{dP_1} = \frac{\sigma X_1 X_2}{PQ}$$

and therefore

$$(29)\quad e_{21} = \frac{dX_2}{dP_1} \cdot \frac{P_1}{X_2} = \frac{P_1 X_1}{PQ}\sigma = k_1\sigma$$

where k_1 is the cost share of the first factor of production:

$$(30)\quad k_1 = \frac{P_1 X_1}{PQ}$$

It also follows, from using Cramer's rule, that

$$(31)\quad \frac{dP}{dp_1} \cdot \frac{P_1}{P} = \frac{P_1X_1}{PQ} = k_1$$

Generalizing the above results

$$(32)\quad e_{12} = \frac{dX_1}{dP_2} \cdot \frac{P_2}{X_1} = k_2\sigma$$

$$(33)\quad e_{22} = \frac{dX_2}{dP_2} \cdot \frac{P_2}{X_2} = -k_1\sigma$$

It will be observed that the factor demand functions are homogeneous of degree zero in the factor prices P_1 and P_2 because for equal percentage variations in P_1 and P_2

$$(34)\quad e_{11} + e_{12} = 0$$

$$(35)\quad e_{21} + e_{22} = 0$$

In order to derive explicit expressions for e_{1Q} and e_{2Q} differentiate equations (1), (2) and (3) totally with respect to Q. This yields the following equations.

$$(36)\quad 0 + f_1 \frac{dX_1}{dQ} + f_2 \frac{dX_2}{dQ} = 1$$

$$(37)\quad f_1 \cdot \frac{1}{P} \cdot \frac{dP}{dQ} + f_{11} \frac{dX_1}{dQ} + f_{12} \frac{dX_2}{dQ} = 0$$

$$(38)\quad f_2 \cdot \frac{1}{P} \cdot \frac{dP}{dQ} + f_{21}\frac{dX_1}{dQ} + f_{22}\frac{dX_2}{dQ} = 0$$

Construct the matric equation

$$(39)\begin{pmatrix} 0 & P_1 & P_2 \\ Q\sigma & -\frac{X_2}{X_1}P_2 & P_2 \\ Q\sigma & P_1 & -\frac{X_1}{X_2}P_1 \end{pmatrix}\begin{pmatrix} \frac{dP}{dQ} \\ \frac{dX_1}{dQ} \\ \frac{dX_2}{dQ} \end{pmatrix} = \begin{pmatrix} P \\ 0 \\ 0 \end{pmatrix}$$

The determinant of the lefthand matrix is the same as in (24).

Using Cramer's rule to find

$$(40)\quad \frac{dP}{dQ} = 0$$

$$(41)\quad e_{1Q} = \frac{dX_1}{dQ} \cdot \frac{Q}{X_1} = 1$$

$$(42)\quad e_{2Q} = \frac{dX_2}{dQ} \cdot \frac{Q}{X_2} = 1$$

Rewriting equations (21) and (22)

$$(43)\quad \frac{dX_1}{X_1} = -\,k_2\sigma\frac{dP_1}{P_1} + k_2\sigma\frac{dP_2}{P_2} + \frac{dQ}{Q}$$

$$(44)\quad \frac{dX_2}{X_2} = k_1\sigma\frac{dP_1}{P_1} - k_1\sigma\frac{dP_2}{P_2} + \frac{dQ}{Q}$$

or

$$\text{(43a)} \quad \ln X_1 = k_2\sigma \ln P_1 + k_2\sigma \ln P_2 + \ln Q$$

$$\text{(44a)} \quad \ln X_2 = k_1\sigma \ln P_1 - k_1\sigma \ln P_2 + \ln Q$$

These equations provide explicit expressions for the demand for factors of production by the firm, under the specified condition.

Industry Level

There are two difficulties when moving from relations that reflect firm behavior to relations that reflect industry behavior, especially when doing farm policy analysis. In the first place a process of aggregation of the production response of different firms is necessary. At the same time, the prices of inputs and outputs are not fixed for the industry as a whole while they are given at the firm level.

Assume that the ith firm operating under perfect competition has the Cobb-Douglas production function:

$$\text{(45)} \quad Q_i = a_i X_{1i}^{b1i} X_{2i}^{b_{2i}} \qquad a_i > 0;\ b_{1i}, b_{2i} > 0$$

where

Q_i: total output for the ith firm

X_{1i}, X_{2i}: inputs 1 and 2 used by firm i

A convenient device, although unrealistic, is to assume that all firms have identical homogeneous production functions, then

$$(46) \quad Q = a X_1^{b_1} X_2^{b_2} \qquad a > 0;\ b_2,\ b_1 > 0; \text{ and } b_2 + b_1 = 1$$

Q: total output of the <u>industry</u>

X_1, X_2: total inputs

The key factor for optimal resource allocation and output determination by an <u>individual firm</u> is that the value of the marginal product of an input equals its price.

Denote marginal products of X_1 and X_2 as:

$$(47) \quad \frac{\partial Qi}{\partial X_{1i}} = \frac{\partial Q}{\partial X_1} = ab_1 X_1^{b_1 - 1} X_2^{b_2}$$

$$(48) \quad \frac{\partial Qi}{\partial X_{wi}} = \frac{\partial Q}{\partial X_2} = a\, b_2 X_1^{b_1} X_2^{b_2 - 1}$$

Equality of the value of marginal product of each input and price is:

$$(49) \quad P_1 = ab_1 X_1^{b_1 - 1} X_2^{b_2} P_Q$$

$$(50) \quad P_2 = a\, b_2 X_1^{b_1} X_2^{b_2 - 1} P_Q$$

For the <u>industry</u> (not firm) more inputs can only be secured at a higher price. Assume the industry supply functions for inputs are given by:

$$(51) \quad X_1 = h_1 P_1^{g_1}$$

$$(52) \quad X_2 = h_2 P_2^{g_2}$$

where

g_1 = supply elasticity of input 1

g_2 = supply elasticity of input 2

The price at which output can be sold by the industry will vary with output. Denote this demand relationship as

(53) $P_Q = cQ^f$

where

f: price flexibility coefficient, or inverse of price elasticity of demand (e_Q)

How will the industry's use of input X_1 vary if the price of X_1 changes? We inquire about the elasticity of demand for the first input when all other inputs are held constant. For this case equations (51) and (52) are dropped from the system because the desired quantity of the first input is assumed to be available at the given price because the quantity of X_2 is assumed to be fixed.

The system becomes

(45) $Q = a\ X_1^{b1}\ X_2^{b2}$

(49) $P_1 = a\ b_1\ X_1^{b1-1}\ X_2^{b2}\ Py$

(50) $P_2 = a\ b_2\ X_1^{b1}\ X_2^{b2-1}\ P_y$

(53) $P_Q = cQ^f$

Solving for X_1 gives

$$(54)\quad X_1 = \frac{1}{ca^f ab_1} \quad P_1^{\;1/b(1+f)-1}\; X_2^{-\frac{b_2(1+f)}{b_1(1+f)-1}}$$

now,

$$\text{denote } \frac{1}{ca^f ab_1} = K_1;\quad \frac{-b_2(1+f)}{b_1(1+f)-1} = K_2 \quad \text{thus}$$

$$(55)\quad X_1 = K_1\, P_1^{\;1/b_1(1+f)-1}\, X_2^{\;K_2}$$

and

$$(56)\quad \ln X_1 = \ln K_1 + \frac{1}{b_1(1+f)-1}\ \ln P_1 + K_2 \ln X_2$$

The elasticity of input demand for X_1 is given by

$$(57)\quad \varepsilon_{11} = \frac{d \ln X_1}{d \ln P_1} = \frac{1}{b_1(1+f)-1}$$

Since $f = 1/e$ then

$$(57a)\quad \varepsilon_{11} = \frac{1}{b_1(1+\frac{1}{e})-1} \qquad\qquad (11)$$

The elasticity of demand for input X_1 when the quantity of the other input is held constant will depend on the elasticity of demand for output (e) as well as the partial elasticity of input X_1 (b_1).

In this case, P_1 and X_2 are the exogenous variables so that we can calculate the elasticity of a change in Q(industry output), P_Q(price of output), or P_2(price of X_2) as a result of changes in P_1 or X_2 (one at a time).

This general model can be modified according to the particular assumptions made. We will look at three variations.

1) Other input prices constant

Assume that inputs are available in any quantities necessary to satisfy demand. The same system as above can be used, however, variables (X, P_Q, X_1, X_2) will be a function of P_1 and P_2 (input prices).

The elasticity of demand for X_1 when the price of the other input is held constant is given by

$$(58) \quad \varepsilon^{1}_{11} = \frac{b_1(1+f)}{f} - 1 = b_1(1+e) - 1$$

Again the demand for the input depends on the elasticity of demand for output. The elasticity of demand for input X_1 is more elastic when the price of other inputs is held constant than when quantities of other inputs are held constant.

The cross-elasticity relating changes in the quantity demanded of input X_2 (the other input) as a result of changes in the price of input X_1 is

$$(59) \quad \varepsilon_{21} = \frac{b_2(1+f)}{f} = b_2(1+e)$$

2) Neither prices nor quantities of other inputs constant

To analyze this case the model is structured as follows:

$$(46) \quad Q = a\, X_1^{b_1}\, X_2^{b_2}$$

$$(49) \quad P_1 = a\, b_1\, X_1^{b_1-1}\, X_2^{b_2}\, P_Q$$

$$(50) \quad P_2 = a\, b_2\, X_1^{b_1}\, X_2^{b_2-1}\, P_Q$$

(52) $X_2 = h_2 P_2^{g2}$

(53) $Q_y = cX^f$

The generalization can be made that the demand for an input is dependent on the elasticity of demand for output, regardless of what happens to prices and quantities of other inputs, so long as the parameters of the system do not change.

3) <u>Output price is changed</u>

The answer to this question can be analyzed using the model dropping equation (53), giving:

(46) $Y = a X_1^{b_1} X_2^{b_2}$

(49) $P_1 = a b_1 X_1^{b_1-1} X_2^{b_2} P_y$

(50) $P_2 = a b_2 X_1^{b_1} X_2^{b_2-1} P_y$

(51) $X_1 = h_1 P_1^{g1}$

(52) $X_2 = h_2 P_2^{g2}$

The elasticity of supply of output is given by:

(60) $$e_Q = \frac{g_1 g_2 + b_1 g_1 + b_2 g_2}{1 + b_1 g_2 + b_2 g_1}$$

If both inputs have the same supply elasticity ($g_1 = g_2 = g$), the supply elasticity of output is also g. If the supplies of inputs are perfectly elastic, so is the supply of output. If the quantities of inputs are fixed, so is the quantity of output.

In conclusion, the long run demand for inputs is often thought to be relatively inelastic, although this concept does not apply over time where farm technology is rapidly changing. Actual short-run demand for an input might be elastic because it might have previously been used below the optimal level. It must be remembered that the Cobb-Douglas production function results in unitary input substitution, hence substitution among inputs might be overstated. In the event of lower substitution the inelasticity of demand for inputs is strengthened.

Graphical Analysis

In this section a graphical representation of the theoretical framework is presented.

Profit maximization indicates that an input will be used up to the point where the value of its marginal product (VMP_i) is equal to its price. That is,

$$(2) \quad P \cdot f_i = P_i$$

where

P is price of output

P_i is price of input i

and f_i is the marginal productivity of input i

In essence, when only one input is variable, its demand curve is equal to the value of its marginal product curve. For illustration, consider the demand for labor when the market wage rate is $O\overline{W}$ (Figure 3-1). Under these circumstances the demand for labor is equal to $O\overline{L}$ units. If only OL_1 units were hired, the VMP will equal L_1C while the cost of employing labor is $O\overline{W}$ ($L_1C>O\overline{W}$). It will pay the entrepreneur to hire more laborers. On the other hand, when OL_2 units of labor are hired the VMP (L_2F) is less than the wage rate ($O\overline{W}$). Here a decline in the employment of laborers is the appropriate step. Based on this analysis, the optimal demand for labor is $O\overline{L}$ when the wage rate is $O\overline{W}$.

This same graph can be used to exhibit the effect of wage rate regulations. Assuming that the equilibrium market wage rate is $O\overline{W}$, the demand for

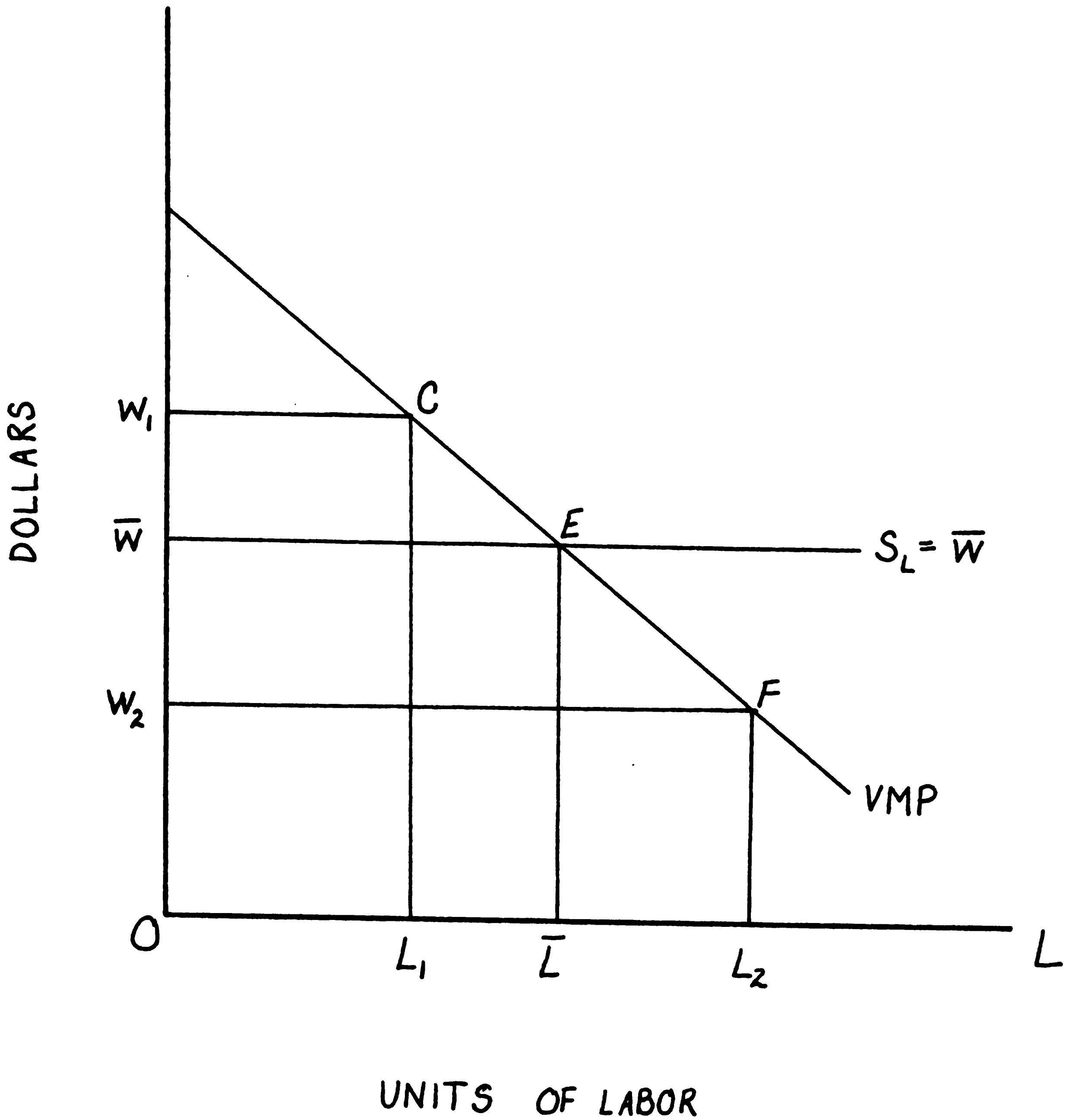

Figure 3-1: Analysis of Input Demand with only one variable input

labor would be $O\bar{L}$. A government decree raising the wage rate to OW_1 will result in less labor being employed (OL_1) as employers adjust to the new wage rate by decreasing the number of their employees so that the marginal productivity of those remaining increases. Implicit in this analysis is the fact that labor is the only variable input used and that the price of the final product is invariant. In the section that follows, the first assumption will be relaxed.

Individual Input Demand Curves When Several Variable Inputs Are Employed

This case is more closely related to the theoretical framework presented earlier.

When the production process involves more than one variable input, the curve representing the value of the marginal product for that input is no larger than its demand curve. To see why this is so, consider Figure 3-2.

A change in the wage rate (denoted by a change in the slope EF to EF') has two effects on the amount of labor utilized--a substitution effect and an output effect. Assume that there are only two variable inputs, capital (K) and labor (L). Q_1 and Q_2 are production isoquants, and the initial input price ratio (when the wage rate is OW_1) is given by the slope of EF. Equilibrium is attained at point A, with inputs of OL_1 units of labor and OK_1 units of capital. Now let the wage rate fall to OW_2, the cost of capital remaining constant. The new input price ratio is represented by the slope of the new isocost curve EF'. Holding total expenditure on inputs constant, equilibrium is attained at point C on the higher isoquant Q_2, with OL_2 units of labor and OK_2 units of capital employed.

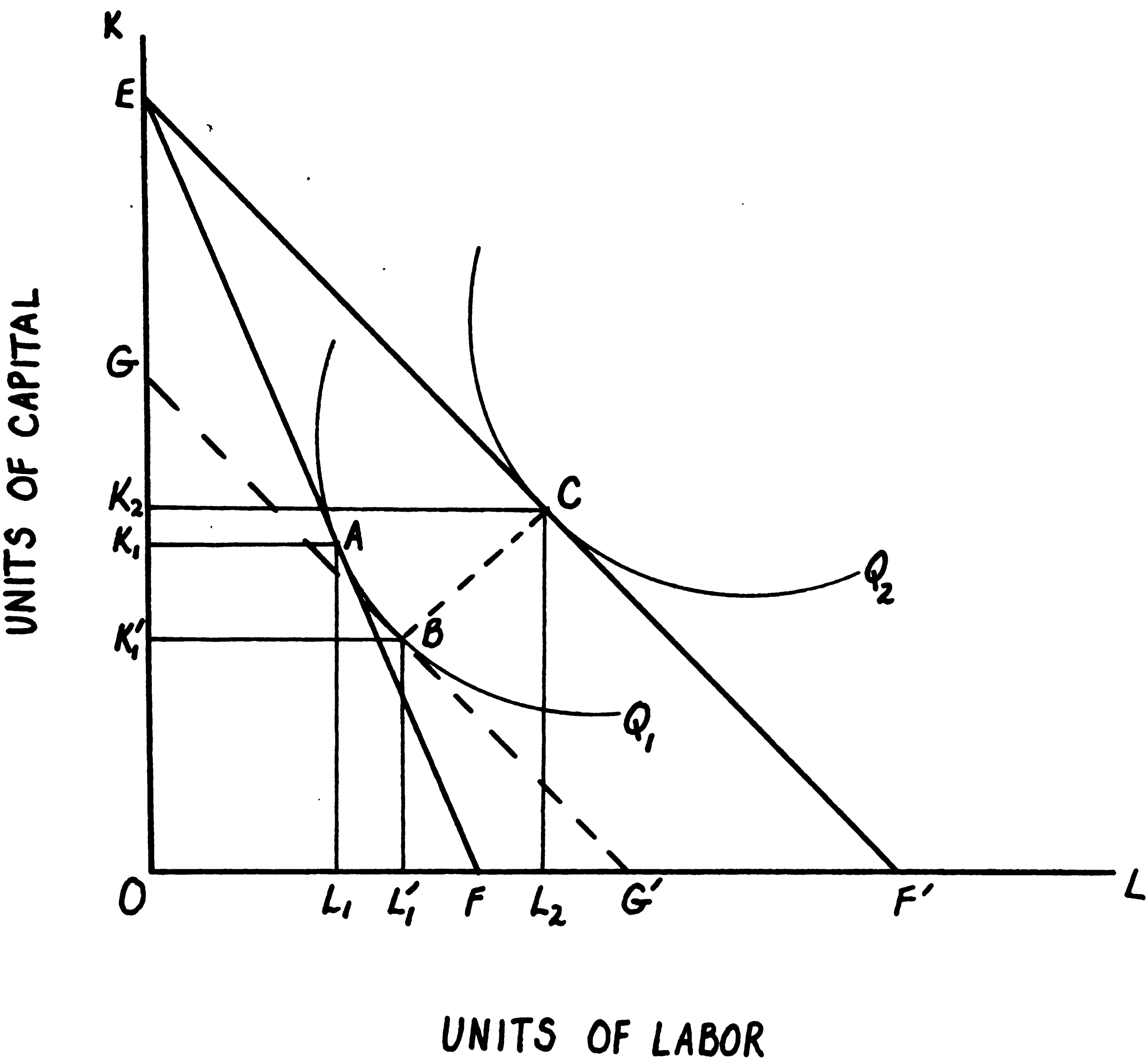

Figure 3-2: Effects of a change in the Wage Rate on Two Variable Inputs

The movement from A to C can be decomposed into two separate "effects." The first is a substitution effect, represented by the movement along the original isoquant from A to B. To understand this movement, construct the fictional isocost curve GG' with the following characteristics: (a) it is parallel to EF', thus representing the new input price ratio, but (b) it is tangent to Q_1, thus restricting output to the initial level. The movement from A to B is a pure substitution of labor for capital. The movement would occur if the entrepreneur were restricted to his original level of output at the new input price ratio.

The movement from B to C represents the output effect. When the price of labor falls, more labor, more capital, or more of both may be bought for the given constant expenditure on imports. The movement from B to C shows this, and position C indicates the ratio in which the inputs will be combined if expenditure on resources remains unchanged.

In summary, the substitution effect resulting from a reduction in the wage rate causes a substitution of labor for capital. This effect alone shifts labor's marginal product curve to the left because there is less of the cooperating factor (capital) with which to work. The output effect generally results in an increased usage of both inputs if both are normal. Thus the output effect alone tends to shift labor's marginal product curve to the right because there is usually more of the cooperating factor with which to work.

Additionally, as the wage rate falls, the marginal cost of production is reduced. In terms of cost curves, the marginal cost curve shifts to the right and the profit maximization level of output for the firm increases. This effect is called the "profit maximizing effect". As output increases,

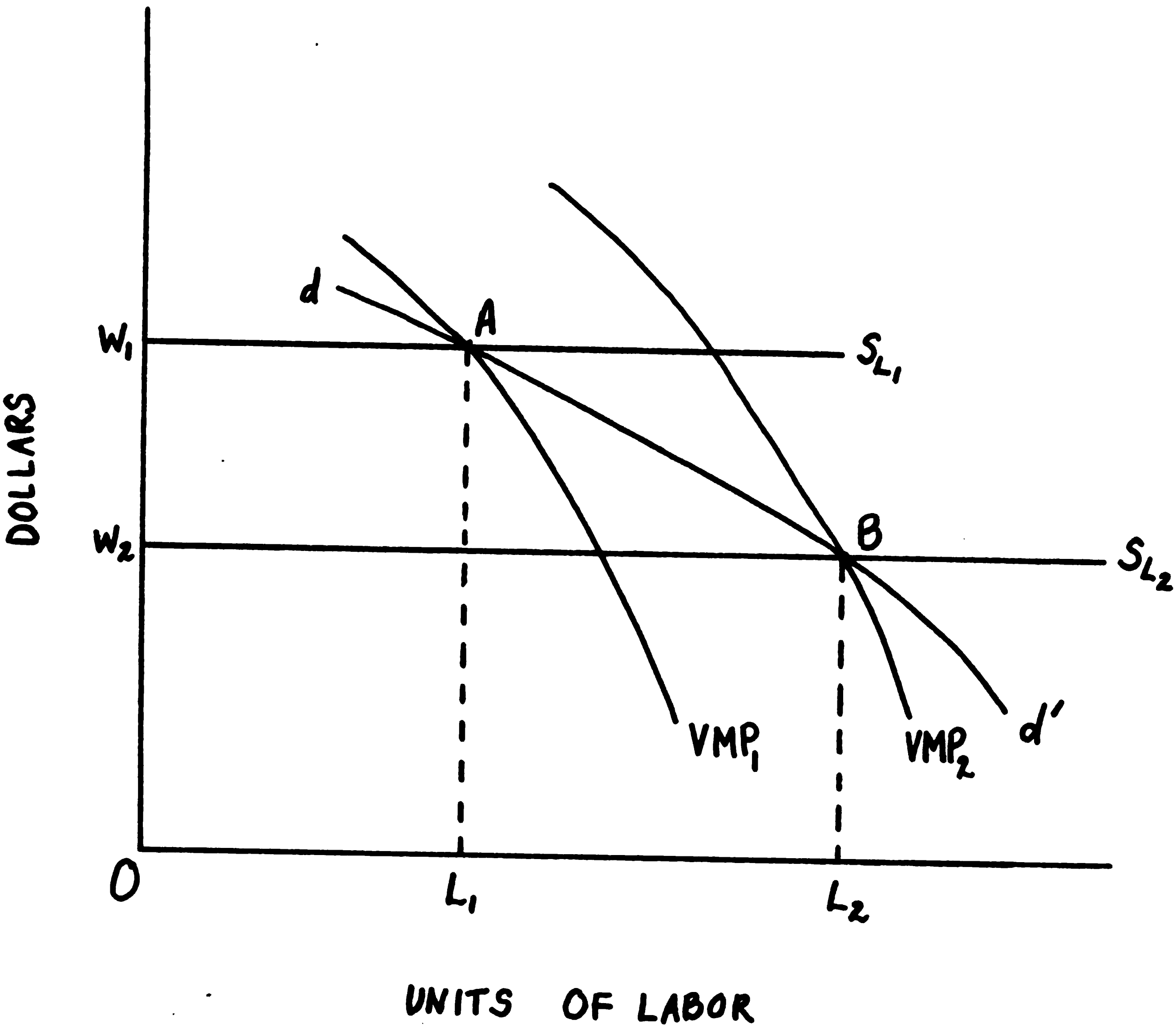

Figure 3-3: Individual Input Demand When Several Variable Inputs Are Used--Outward Shift of VMP

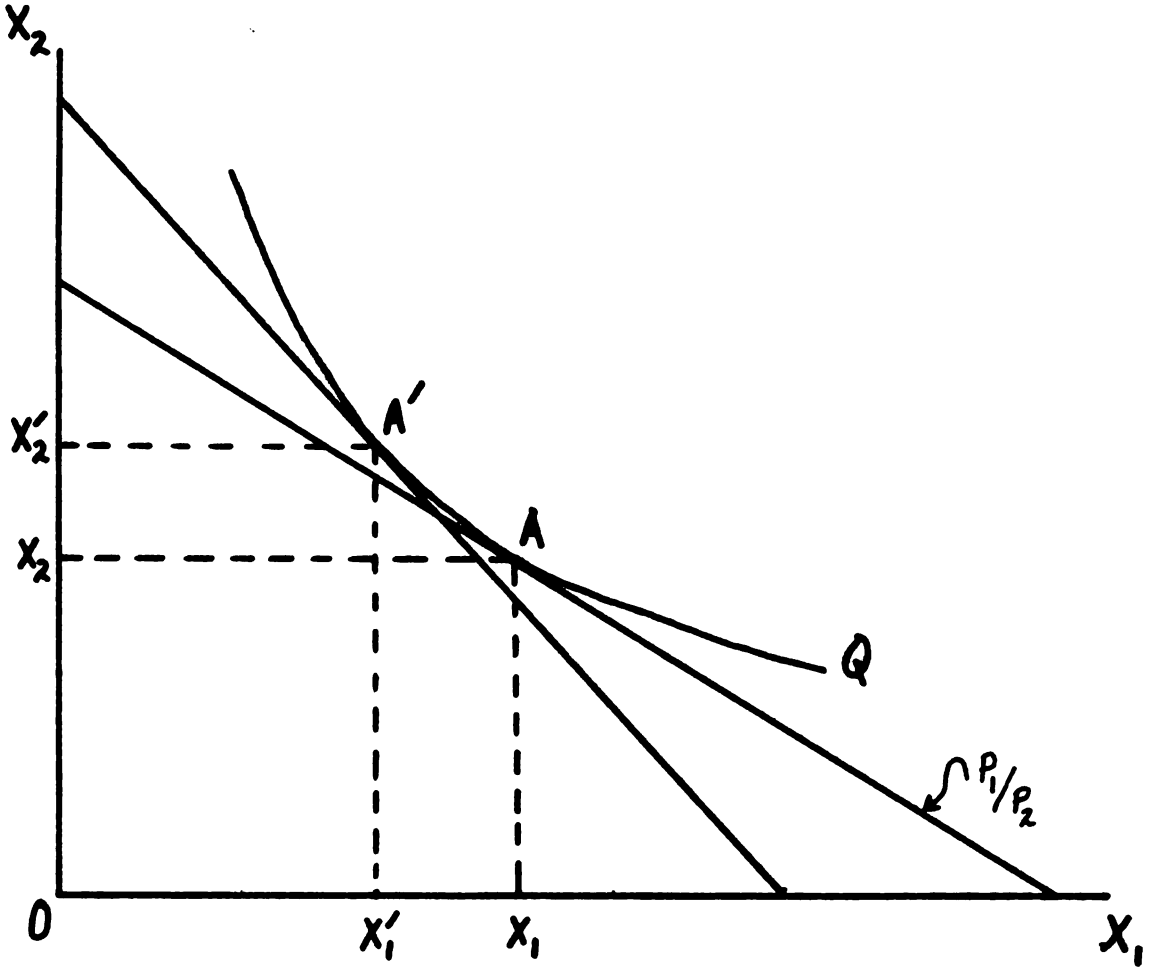

Figure 3-4: Minimum Cost Combinations of Two Inputs

more of both inputs (capital and Labor) is demanded causing the marginal productivity of labor to increase (i.e., the value of the marginal product curve shifts to the right).

Once the effects of a price change are understood, we can restate the change in the demand for labor as the wage rate decreases (Figure 3-3). A fall in the wage rate from OW_1 to OW_2 causes changes in the demand for labor and capital so that the marginal productivity of labor increases (substitution, output, and profit-maximizing effects). This increase in the productivity of labor is reflected in the shift of VMP curve from VMP_1 to VMP_2. The equilibrium usage of labor at B is OL_2 units. Connecting A and B generates the labor demand curve (dd') which is in general <u>not</u> equal to the VMP curve due to changes in the quantitive of other factors.

This model can be used to trace out the impact of an input subsidy on the usage of the subsidized input, the other inputs employed in the production process, and output.

An immediate effect of an input subsidy is to change the price of the input. At lower prices more of this input can be purchased for the same amount of money as was previously spent on it. It is also possible to substitute the subsidized input for the now relatively more expensive inputs. However, the substitution may not be technologically feasible once a certain level of input employment is reached. The ease of substitution among inputs is indicated by the elasticity of substitution parameter. Figure 3-4 shows all the possible combinations of inputs X_1 and X_2 that can produce a given level of output Q (E.g., 10 units). The price line (P_1/P_2) represents the minimum cost of producing 10 units of Q provided that the input prices are P_1 and P_2. An input subsidy on X_2 will lower the price producers have to pay for the input. In terms of our graph the price line rotates. A new minimum cost combination of inputs results, that is, X_1' and X_2' with tangency at A'. Note that use of input X_2 has increased (compared to tangency point A) and use of input X_1 has decreased. The decline in X_1 compensating for the decline in X_2 is measured by the elasticity of substitution.

The welfare effects of an input subsidy can be determined using the Marshallian concept of producer and consumer surplus (see Figure 3-5).

A subsidy on an input will shift SS to the right (S'S') giving the loss in producer's surplus = caAC, loss in consumer's surplus = CAEF, cost of subsidy = caEF and net social loss = aAE.

The supply elasticity (in relation to output price) as well as the output demand (as a function of the price received by producers) will determine the cost, total benefit, and the distribution of benefits of an input subsidy policy.

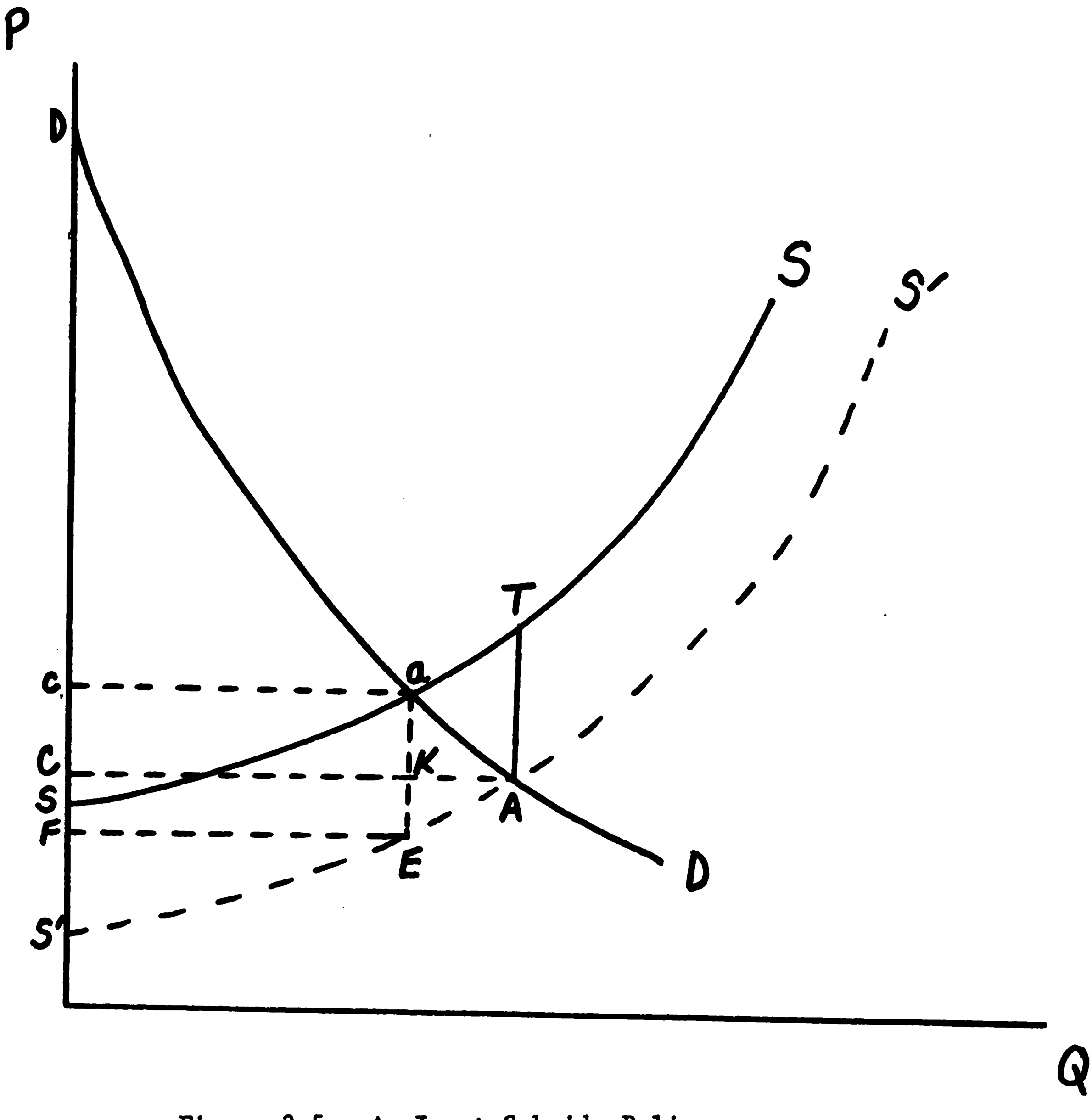

Figure 3-5: An Input Subsidy Policy

DD: demand curve for product using subsidized input

SS: supply curve for product using subsidized input

S'S': supply curve following input subsidy

Determining the Welfare Effects of an Input Subsidy

This analysis of the costs and benefits of input subsidies utilizes the following two relationships:

1. The supply of agricultural output (Q) as a function of input price (P_1).
2. The demand for agricultural output (Q) as a function of its own price (P_Q).

To obtain these relationships, output is made an explicit function of input price, and the resulting system of equations is thus transformed into elasticities. This is shown in matrix form:

$$\begin{bmatrix} 1 & -e & 0 \\ 1 & 0 & -a_1 \\ 0 & 1 & -(1-a_1)/\sigma \end{bmatrix} \begin{bmatrix} dQ/Q \\ dP_Q/P_Q \\ dX_1/X_1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ dP_1/P_1 \end{bmatrix}$$

where

- e: demand elasticity of output as a function of output price
- a_1: elasticity of output as a function of input use
- σ: elasticity of substitution
- Q: initial level of agricultural output
- P_Q: price of agricultural output
- X_1: amount of subsidized input
- P_1: price of subsidized input

The solution of this system will yield the following results: agricultural output elasticity as a function of input prices (E_1) elasticity of the price received by producers as a function of input prices (E_2) and the elasticity of demand for the input as a function of input prices (E_3).

1) Cost of an Input Subsidy to the Government Treasury

Remembering that output has been made an explicit function of the input price, the cost of the subsidy to the government is found by determining the amount of subsidy necessary to attain a given level of output. The cost is then

$$(61)\quad C = dP_1 \cdot (Q + dQ)$$

Note that $(dQ/Q)/(dP_1/P_1) = e_1$

$$\text{or } dQ = e_1(dP_1/P_1)Q$$

so

$$(62)\quad C = dP_1 \cdot Q(1 + e_1 \cdot dP_1/P_1)$$

where

dP_1: amount of the subsidy

dP_1/P_1: subsidy as a percentage of input price

e_1: elasticity of output as a function of input prices

2) Benefits Accruing to Producers from an Input Subsidy

Benefits to producers are equal to:

$$(63)\quad B_p \approxeq [E_1 + E_2 - g_1(1+E_3)]\ P_Q \cdot Q \cdot dP_1/P_1$$

where

$$E_1 = (dQ/dP_1)\cdot(P_1/Q)$$

$$E_2 = (dP_Q/dP_1)\cdot(P_1/P_Q)$$

$$E_3 = (dX_1/dP_1)\cdot(P_1/X_1)$$

and

$$g_1 = \text{supply elasticity of subsidized input}$$

When the demand for agricultural products is perfectly inelastic, the benefits to producers due to an input subsidy becomes

$$(64) \quad B_p = (1-g_1) \cdot P_Q \cdot Q \cdot {dP_1}/{P_1}$$

On the other hand, if the demand for agricultural products is perfectly elastic, the expression becomes

$$(64a) \quad B_p = - g_1 \cdot P_Q \cdot Q \cdot {dP_1}/{P_1}$$

3) Benefits Accruing to Consumers from an Input Subsidy

$$(65) \quad B_c = - Q \cdot dP_1 = 1/2 \; dP_1 \cdot dQ$$

or

$$(66) \quad B_c = -E_2 \; [1 + 1/2 \; E_1 \cdot (dP_1/P_1) \; P_Q \cdot Q \cdot {dP_1}/{P_1}$$

When the demand for agricultural products is perfectly inelastic, the benefits accruing to consumers are greater than zero. These benefits will reduce to zero when the elasticity of demand is perfectly elastic.

4) Total Benefits Resulting from an Input Subsidy

Total benefits from a program of input subsidization are obtained by adding equations (63) and (66).

$$(67)\quad B_p + B_c = [(E_1 - g_1(1+E_3)-1/2 \cdot E_1 \cdot E_2 \cdot {}^{dP}1/P_1]P_Q \cdot Q \cdot {}^{dP}1/P_1$$

Under competitive conditions, output elasticity (g_1) is equal to the ratio of the cost of the subsidized input to total production cost, i.e. $P_1 \cdot X_1/P_Q \cdot Q$.

Nerlove and Wallace[4] evaluate a number of types of government programs in agriculture. Nerlove looked at three alternatives: 1) The government sets a support price above the equilibrium price and purchases and destroys all the excess. 2) A support price above equilibrium price is set. The output is sold in the open market with the government giving a subsidy equivalent to the difference between the market price and the support price. 3) The desired price is achieved by directly restricting output. (Figure 3-6.)

For the analysis Nerlove assumes that SS' represents the marginal social cost of the resources used to produce the commodity and DD' reflects the marginal value of the commodity to the community.

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[4]Taken from Currie, et. al. (1971).

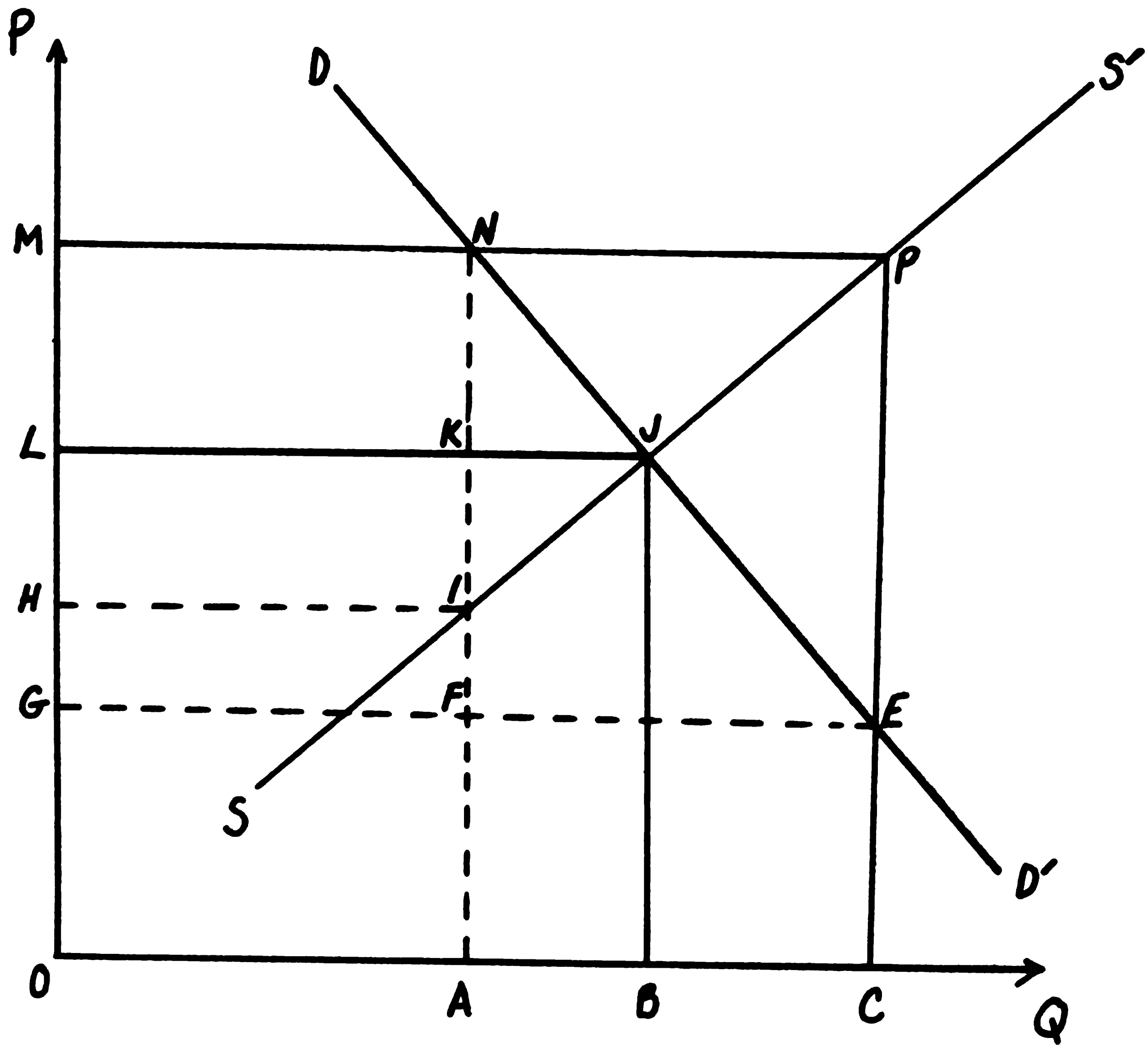

Figure 3-6: Analysis of Three Government Support Programs in Agriculture

When all programs are focused on obtaining price OM, the net losses are given by

Program 1 = ANJPC

Program 2 = JPE

Program 3 = NJI

Nerlove pointed out that program 1 will never involve a lower net social loss than the other two programs. Wallace added that

$$\text{NSL }(3) \gtreqless \text{NSL }(2)$$

as

$$\eta \gtreqless \varepsilon$$

where η is the absolute value of the price elasticity of demand and ε is the absolute value of the price elasticity of supply.

Wallace also analyzes the effects of output restriction through controlling the input of a particular factor of production. (Figure 3-7) The result of the program is to shift the marginal social cost curve from CS to CS' as a result of a less efficient use of other inputs with the limited input. The net social loss is given by the area CAB. Of this loss, ABD is due to output reduction and CAD is due to the inefficient use of the other resources with the limited input. If output were restricted instead, the net social welfare loss would be ADB only. Thus, output restrictions entail a lower net social loss.

The basic formulae for calculating the net social loss in consumption (NSL_c) and the net social loss in production (NSL_p) for an input subsidy policy are given below:

$$(68) \quad NSL_c = \frac{1}{2}\,(Pd - Pw)\,(Qw - Qd)$$

$$(69) \quad NSL_p = \frac{1}{2}\,(P'd - P'w)\,(Q'w - Q'd)$$

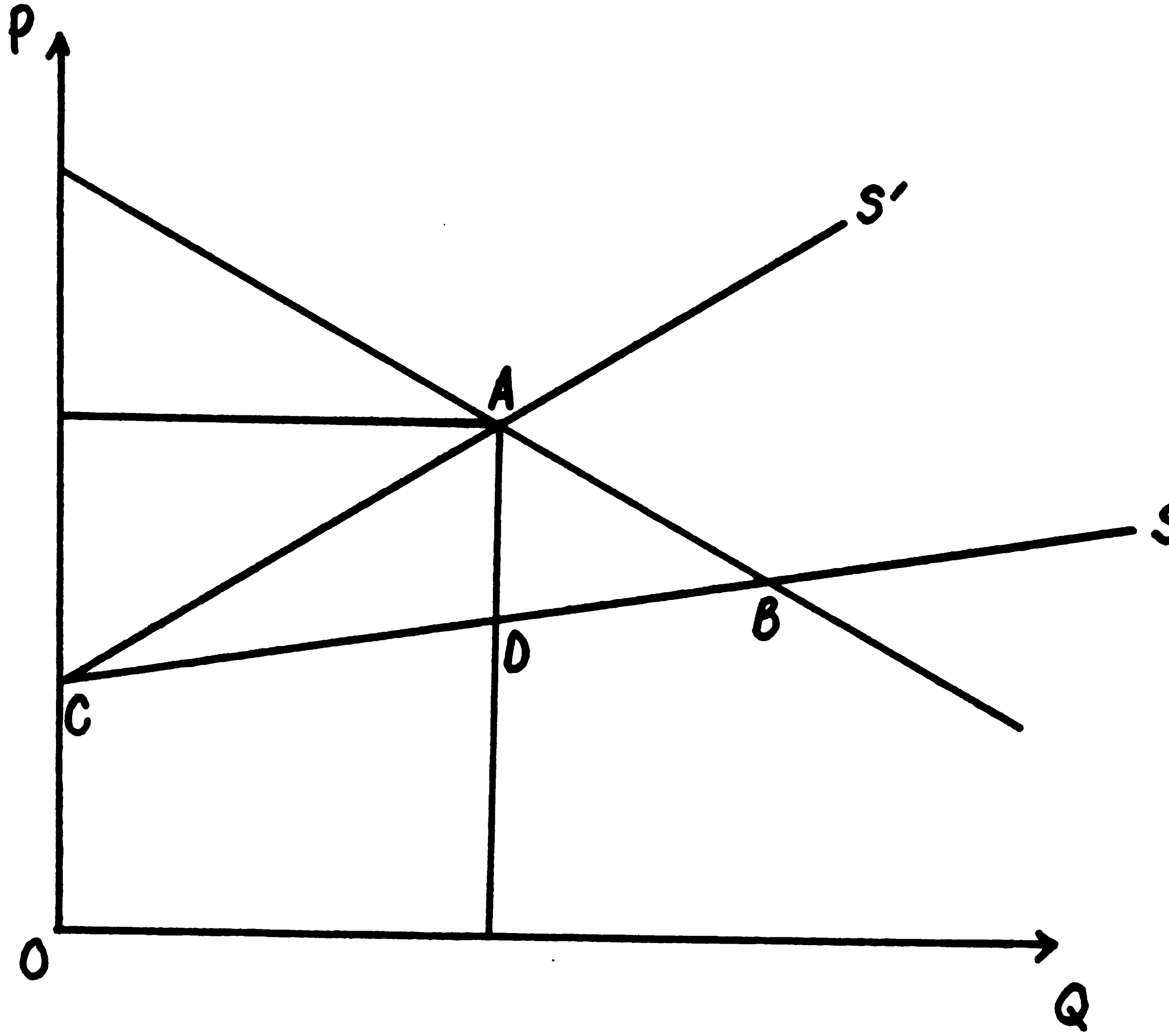

Figure 3-7: Effects of output restriction when use of one input is limited

where

Pw = world price

Pd = domestic retail price

Qd = domestic consumption at domestic prices

Qw = domestic consumption if world price prevailed

P'd = subsidized input price

P'w = world producer price

Q'd = domestic production at subsidized prices

Q'w = domestic production that would be forthcoming at world prices

For the calculation of net social losses in consumption, retail prices are used. Use of wholesale prices instead of producer prices will overestimate the net social losses in production.

In the following example, world retail prices are calculated by applying the existing wholesale/retail margin to the landed prices in Japan for the relevant commodities.

The estimated supply and demand equations to calculate the losses are presented in the tables that follow. To get the net social loss of the 1985/86 level of production in terms of current prices substitute the production goal into the supply equation and get the implicit price that is required to bring forth that level of production.

Description of Variables

Endogenous Variables (units = 1,000 tons)

Y_1 = wheat consumption

Y_2 = wheat production

Y_3 = rice consumption

Y_4 = rice production

Y_5 = soybean consumption

Y_6 = soybean production

Y_7 = food barley consumption

Y_8 = malting barley consumption

Y_9 = barley production

Y_{10} = dairy product consumption

Y_{11} = milk production

Y_{12} = pork consumption

Y_{13} = pork production

Y_{14} = chicken consumption

Y_{15} = broiler production

Y_{16} = beef consumption

Y_{17} = beef production

Exogeneous Variables

X_1 = retail bread price, Tokyo, Yen per kilogram

X_2 = retail rice price, Tokyo, yen per kilogram

X_3 = consumer price index, all Japan, 1970 = 1

X_4 = gross national production (GNP), trillion yen

X_5 = implicit GNP price deflator, 1970 = 1

X_6 = producer wheat price index, 1970/71 = 1,000

X_7 = producer barley price index, 1970/71 = 1,000

X_8 = retail fertilizer price index, 1970/71 = 1

X_9 = producer input price index, 1970/71 = 1

X_{10} = time trend, 1950/51 = 1950, etc.

X_{11} = dummy variable representing unusually low yields not directly attributable to included economic variables, zero when not applicable, one in 1963/64.

X_{12} = dummy variable representing the government program to increase wheat, soybeans, and barley production, zero through 1973/74 and one thereafter.

X_{13} = producer rice price index, 1970/71 = 1,000

X_{14} = producer soybean price index, 1970/71 = 1,000

X_{15} = dummy variable representing unusually low yields not directly attributable to included economic variables, zero when not applicable, one in 1953/54, 1954/55, and 1971/72

X_{16} = retail miso price, Tokyo, yen per kilogram

X_{17} = wholesale barley price index, 1970 = 1,000

X_{18} = wholesale wheat flour price index, 1970 = 1,000

X_{19} = wholesale price index, 1970 = 1

X_{20} = retail beer price index, Tokyo, 1970 = 1,000

X_{21} = wholesale milk price, Tokyo, yen per 200 milliliters

X_{22} = producer milk price index, 1970/71 = 1,000

X_{23} = retail dairy cattle feed price index, 1970/71 = 1,000

X_{24} = retail pork price index, Tokyo, 1970 = 1,000

X_{25} = retail chicken price index, Tokyo, 1970 = 1,000

X_{26} = producer swine price index, 1970/71 = 1,000

X_{27} = producer broiler price index, 1970/71 = 1,000

X_{28} = retail swine feed price index, 1970/71 = 1

X_{29} = retail broiler feed price index, 1970/71 = 1

X_{30} = retail beef price, Tokyo, yen per kilogram

X_{31} = producer beef cattle price index, 1970/71 = 1

Table 3-2: Estimated Demand and Supply Functions

Commodity	Equations	n	R^2	C.V.	d	$\epsilon(P)$	$\epsilon(I)$
Wheat	$Y_1 = 5016.48 - 813.410(X_1/X_2/X_3) + 12.2926(X_4/X_3)$ (18.63) (4.77) (6.32)	15	0.96	2	1.76	−0.16	0.15
	$Y_2 = 79022.4 + 1430.68(X_6/X_7/X_8/X_9)_{t-1}$ (5.23) (5.44)	22	0.91	15	1.39	1.61	
	$- 40.5533\, X_{10} - 660.325\, X_{11} + 622.133\, X_{12}$ (5.34) (4.07) (3.24)						
Rice	$Y_3 = 16563.8 - 1089.70(X_5/X_1/X_3) - 43.0688(X_4/X_3)$ (23.17) (3.86) (7.54)	15	0.89	2	1.83	−0.12	−0.21
	$X_4 = -18.3433 + 18.99(X_{13}/X_{14}/X_8/X_9)_{t-1}$ (4.24) (3.48)	24	0.77	6	1.52	0.16	
	$+ 98.7797\, X_{10} - 2358.07\, X_{18}$ (4.49) (5.05)						
Soybeans	$Y_5 = 537.851 - 60.0182(X_{17}/X_1/X_3) + 1.69923(X_4/X_3)$ (4.63) (1.16) (2.10)	15	0.86	4	1.16	−0.14	0.18
	$Y_6 = 30892.8 + 99.2990(X_{14}/X_{13}/X_8/X_9)_{t-1}$ (6.92) (2.94) $- 15.6541\, X_{10} - 50.8451\, X_{15} + 87.2884\, X_{12}$ (6.95) (2.41) (3.31)	24	0.95	11	1.57	0.46	
Barley	$Y_7 = 1230.45 - 259.416(X_{17}/X_{16}/X_{19})$ (11.87) (2.97)	13	0.95	8	1.82	−0.51	−1.23
	$- 8.45516(X_4/X_3)$ (14.53)						
	$Y_8 = 916\,815 - 0.651812(X_{20}/X_3) + 3.73795(X_4/X_3)$ (3 18) (3.10) (3.33)	11	0.97	5	1.40	−1.28	0.51
	$Y_9 = 223487 + 630.094(X_7/X_6/X_8/X_9)_{t-1}$ (16.69) (2.93)	22	0.98	10	1.43	0.55	
	$- 113.459\, X_{10} - 851.991\, X_{11} + 476.263\, X_{12}$ (16.87) (6.46) (3.08)						
Milk	$Y_{10} = 6847.78 - 168.349(X_{21}/X_3) + 41.9269(X_4/X_3)$ (4.08) (3.03) (15.32)	14	0.98	3	1.18	−1.00	0.55
	$Y_{11} = -83674.9 + 1964.39(X_{22}/X_{23})_t$ (1.80) (3.18)	10	0.96	2	1.67	0.43	
	$- 1403.03(X_{22}/X_{23})_{t-1} + 2038.08(X_{22}/X_{23})_{t-2}$ (2.36) (3.16)						
	$+ 42.0772\, X_{10}$ (1.75)						
Pork	$Y_{12} = 504.819 - 469.074(X_{24}/X_{25}/X_3) + 9.87347(X_4/X_3)$ (4.29) (5.52) (16.86)	14	0.99	5	1.37	−0.76	0.97
	$Y_{13} = -86224.9 - 196.347(X_{26}/X_{27}/X_{28}/X_9)_t$ (5.68) (2.54)	10	0.92	7	1.71	0.14	
	$+ 106.387\,(X_{26}/X_{27}/X_{28}/X_9)_{t-1} + 44.1560\, X_{10}$ (1.38) (5.75)						
Chicken	$Y_{14} = -104.793 - 114.437(X_{25}/X_{24}/X_3)$ (1.06) (2.66)	8	0.99	1	2.75	−0.15	1.33
	$+ 10.1262(X_4/X_3)$ (12.38)						
	$Y_{15} = -165825 + 126.709(X_{27}/X_{26}/X_{29}/X_9)_t$ (7.13) (1.67)	10	0.99	4	1.84	0.12	
	$+ 67.0063(X_{27}/X_{26}/X_{29}/X_9)_{t-1} + 84.3337\, X_{10}$ (0.89) (7.17)						
Beef	$Y_{16} = 286.964 - 140.939\,(X_{30}/X_2/X_3) + 2.82836(X_4/X_3)$ (6.56) (5.97) (11.56)	16	0.96	7	1.40	−0.80	0.66
	$Y_{17} = -28979.0 - 89.9772(X_{31}/X_{22}/X_9)_t$ (2.64) (1.04)	10	0.72	15	1.92	0.66	
	$+ 156.679(Y_{31}/X_{22}/X_9)_{t-2} + 14.7911\, X_{10}$ (0.71) (2 65)						

Source: Bale & Greenshields (1978)

Analyzing the Effects of Output Price Policies on Input Markets

Before specifically discussing fertilizer price policies, the connection between output price policies and input markets will be reviewed. Floyd (1965) considered three types of price-support programs: where output is not controlled, controlled by acreage restrictions, and controlled by restrictions on the quantity of output farmers can market.

In Figure 3-8 $P_0 - Q_0$ represents the equilibrium price and quantity of output. If price is supported at P_1 but there is no restriction on quantity, gross income will rise accordingly. Similarly the demand for all factors will rise. Since land is less elastic in supply than labor, land prices will increase relative to labor prices.

Figure 3-9 shows that under acreage control there is no limit on the amount farmers can produce. Hence they will produce by intensive use of non-land inputs and costs of production will be higher. The supply curve shifts to the left reducing quantity produced and raising price to $P_1 - Q_1$ respectively. If the demand curve for a factor (in this case land) is downward sloping, the value of land in production will rise. The quantity produced and price of labor could decline despite increased demand for non-land inputs.

Under a policy of marketing restrictions (Figure 3-10) output can be reduced by any method farmers choose. Assuming maximization of profits, farmers will produce the given quantity at the lowest price. This can be accomplished by issuing marketing certificates to producers based on their proportional contribution to the total production. The certificates may be tradeable or nontradeable.

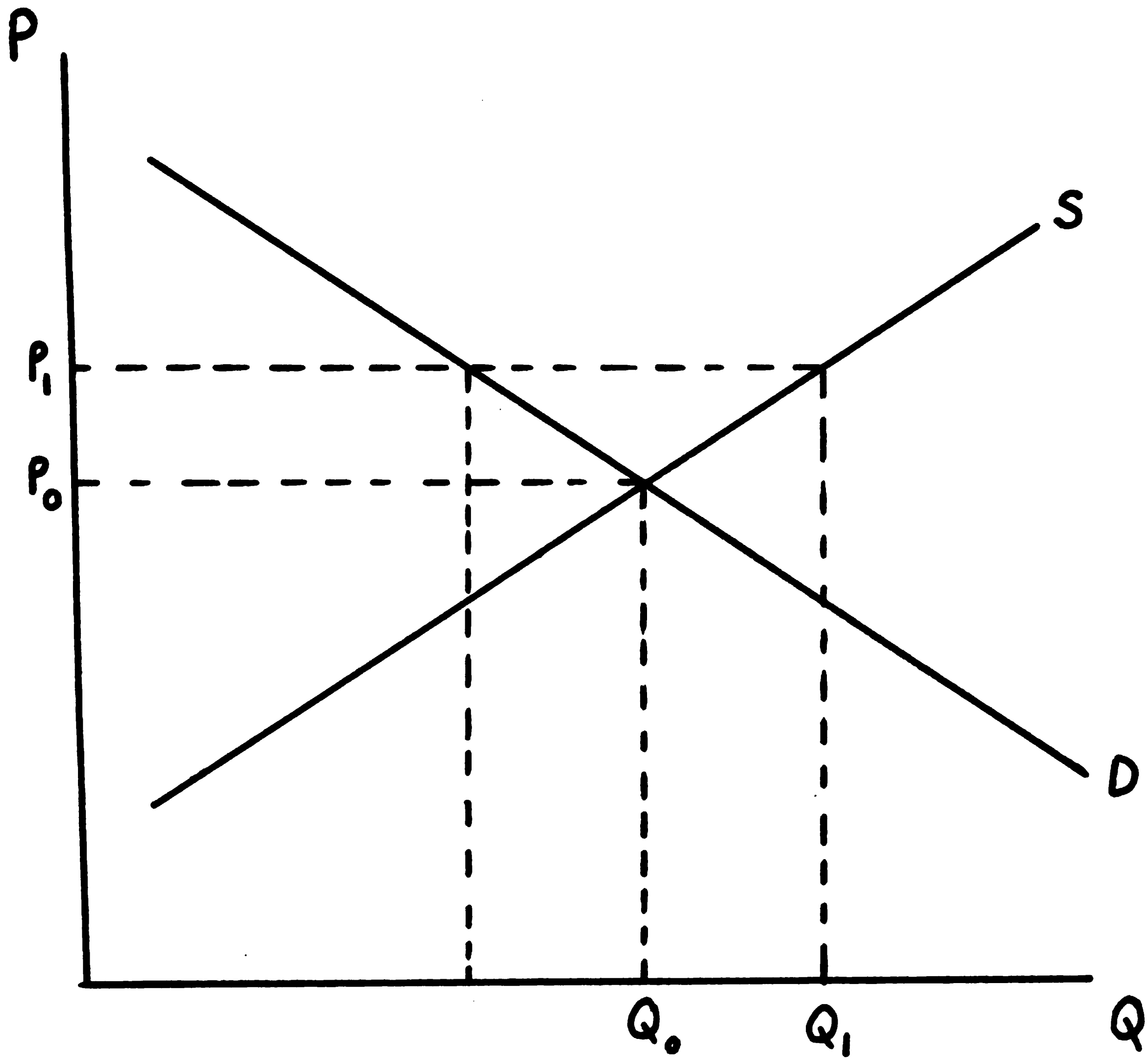

Figure 3-8: A Price Support Program Where Output is not Controlled

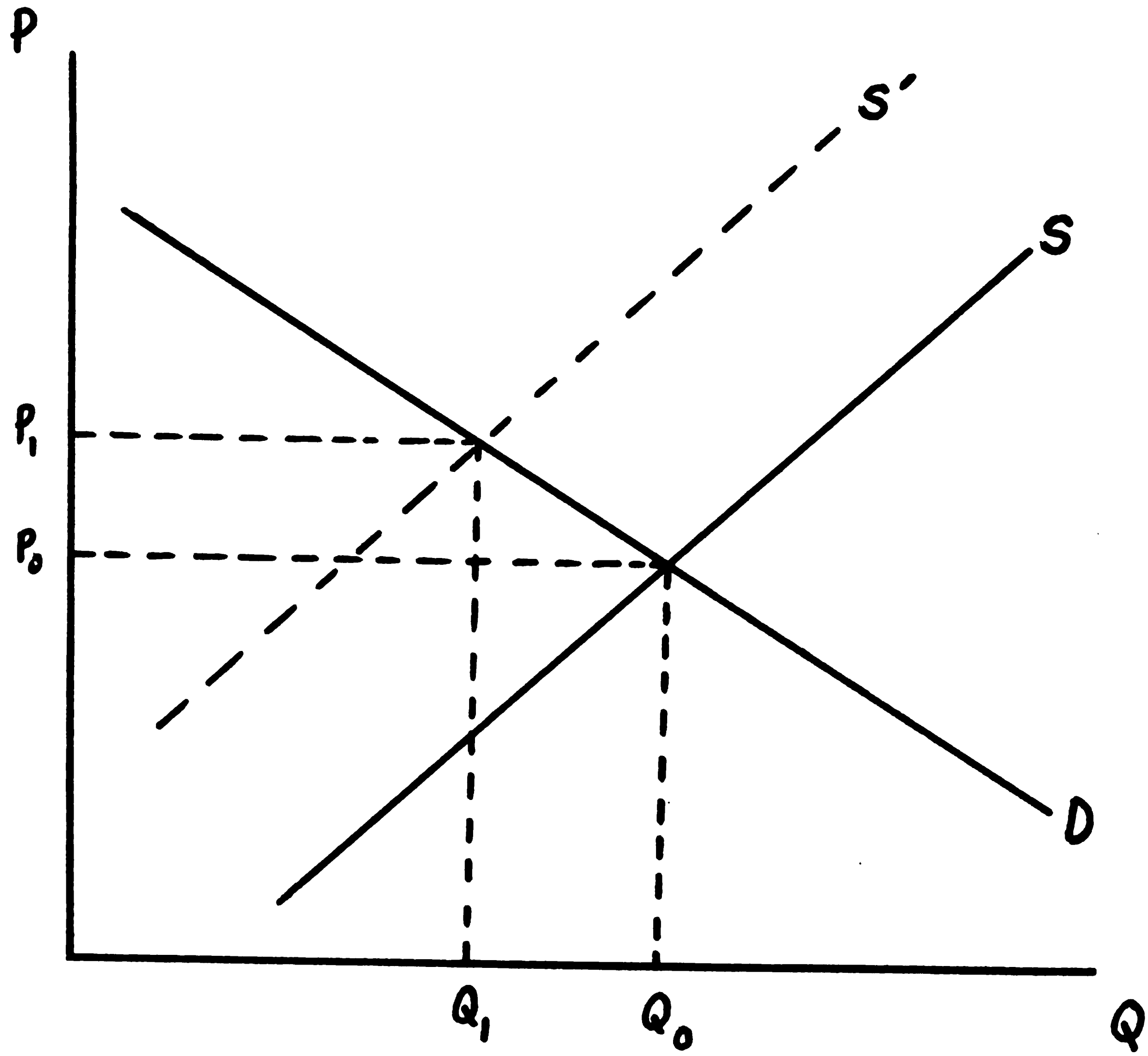

Figure 3-9: A Price Support Program Where Output is Controlled by Acreage Restrictions

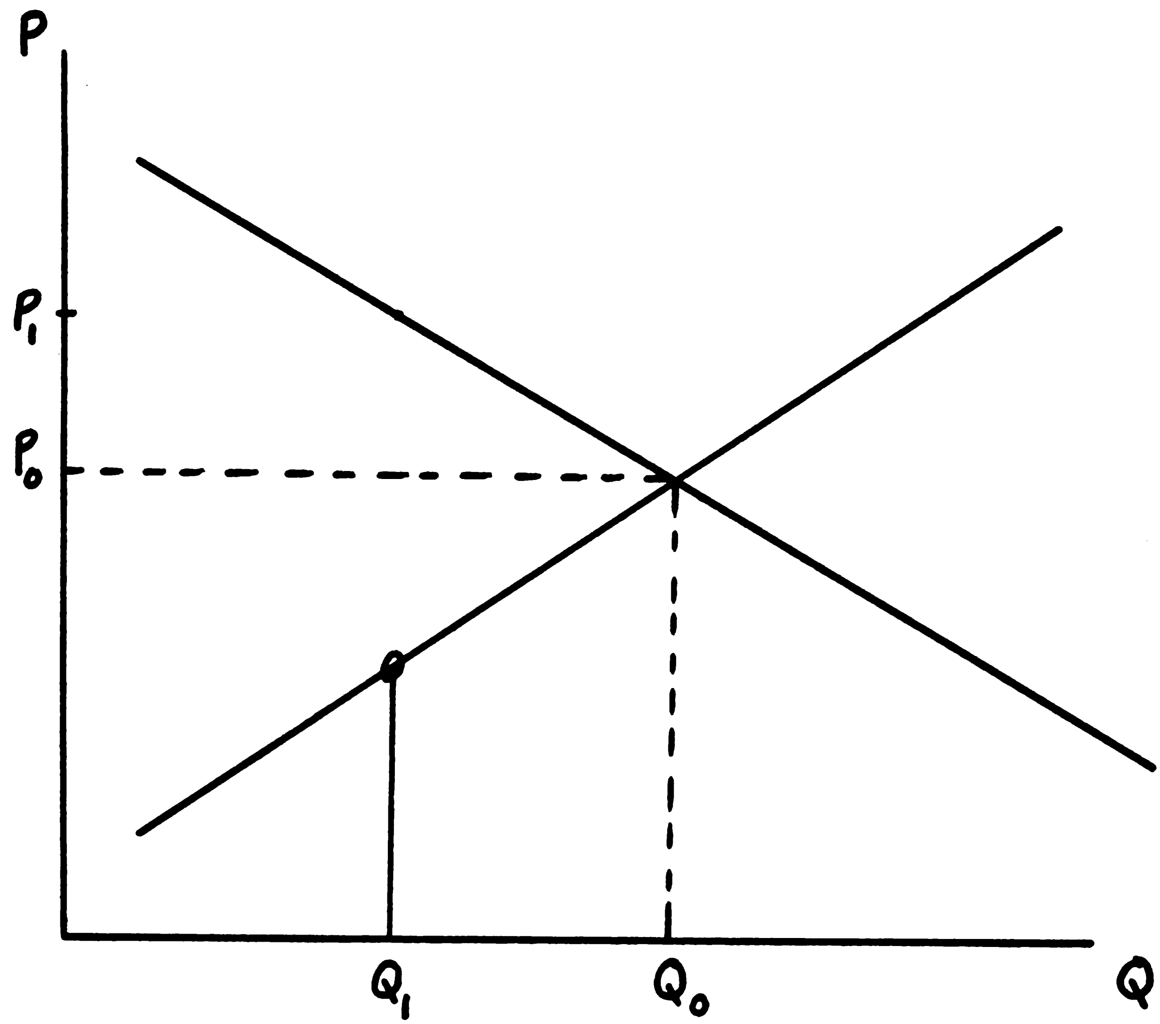

Figure 3-10: A Price Support Program With Restrictions on Marketed Output

In any case the demand for all resources used in agriculture will decline. Those resources characterized by elastic supply will experience the greatest decline in quantity; those with the least elastic supply will exhibit the largest decline in price. Hence returns to land will fall more than farm wage rates.

The arguments presented above can be developed more rigorously using the model of a competitive industry developed earlier in this chapter.

$$(46) \quad Q = a\, X_1^{b_1}\, X_2^{b_2}$$

$$(51) \quad X_1 = h_1\, P_1^{g_1}$$

$$(52) \quad X_2 = h_2\, P_2^{g_2}$$

$$(53) \quad P_Q = c\, Q^f$$

Equation (46) gives the production function where Q is output, X_1 is land and X_2 is labor and capital aggregated. The production function is linear and homogeneous. Aggregation of capital and labor is justified when their supply elasticities are equal and their elasticities of substitution for land are the same.

P_1 and P_2 denote factor prices and P_Q equals price of farm output.

Equations (51) and (52) give the supply relations for factors 1 and 2. G_1 and g_2 (elasticities of factor supply) are assumed constant in the relevant range.

Equation (53) is the demand relation for farm output.

Price Supports With Output Not Controlled

To calculate the impact of this policy, drop equation (53) and consider P_Q as fixed. Solving the system of simultaneous equations we obtain:

$$(70) \quad \pi(\bar{X}_1, P_Q) = \frac{(\sigma + g_2)\, g_1}{\sigma + K_1\, g_2 + K_2\, g_1}$$

$$(71) \quad \pi(\bar{X}_2, P_Q) = \frac{(\sigma + g_1)\, g_2}{\sigma + K_1\, g_2 + K_2\, g_1}$$

where

K_1, K_2 are the relative factor shares

X_1, X_2 are the equilibrium levels of factors 1 and 2 respectively

σ is the elasticity of factor substitution.

These two equations can be identified as the elasticities of the equilibrium quantities of the factors with respect to product prices.

The elasticity of the prices of the factors with respect to product price can be obtained by dividing $\pi(\bar{X}_1, P_Q)$ by g_1 and $\pi(\bar{X}_2, P_Q)$ by g_2, resulting in:

$$(72) \quad \pi(P_{\bar{X}_1}, P_Q) = \frac{(\sigma + g_2)}{\sigma + K_1\, g_2 + K_2\, g_1}$$

$$(73) \quad \pi(P_{\bar{X}_2}, P_Q) = \frac{(\sigma + g_1)}{\sigma + K_1\, g_2 + K_2\, g_1}$$

Price supports will increase the price of factors when:

a) The supply of the factor is not perfectly elastic.

b) The supply elasticity of the other factor is greater than zero;

c) or the elasticity of substitution is greater than zero.

d) The price increase will be larger the smaller its own price elasticity and the greater the supply elasticity of the other factor.

The change in factor price due to a change in product prices will vary directly with its relative share and the elasticity of substitution where its supply elasticity exceeds that of the other factor.

If the supply of the other inputs is perfectly elastic, the elasticity of the price of a factor is equal to the reciprocal of its relative share in total revenue.

The percentage increase in factor prices will equal the percentage increase in product prices where the inputs are perfect substitutes in production, i.e., $\sigma \to \infty$.

Given that elasticity of substitution is positive but not infinite (leaving aside the very short run) and that the supply elasticity of labor is larger than that of land, price supports without output control will raise the price and quantity of both land and labor. Land values will rise more than labor returns and the quantity of labor used would increase more than the quantity of land.

Price Supports and Acreage Controls

A price rise resulting from acreage control can be analyzed by dropping equation (51) and having "X_1" assume the rank of a parameter. The remaining equations are then differentiated with respect to land (X_1).

The elasticities with respect to equilibrium prices where all of the price changes are induced by acreage control are given below.

$$(74) \quad \pi(\overline{X}_2, \overline{P}_Q) = \frac{g_2\ (\sigma + e)}{\sigma + g_2}$$

$$(75) \quad \pi(\overline{P}_{X_1}, \overline{P}_Q) = \frac{g_2 + K_1\ \sigma - K_2\ e}{\sigma + g_2}$$

$$(76) \quad \pi(\overline{P}_{X_2}, \overline{P}_Q) = \frac{\sigma + e}{\sigma + g_2}$$

In general labor (X_2) returns will rise less when acreage is controlled if a) the elasticity of supply of labor is very low, b) the share of land in total revenue is less than the share of the other inputs, c) the elasticity of demand is less than the elasticity of substitution.

Marketing Control Using Production Certificates

When the production certificates are tradeable, the elasticities of quantities and prices of the factors with respect to the price of output will be:

$\pi(P_{\overline{X}_1}, P_Q)$ same as (72)

$\pi(P_{\overline{X}_2}, P_Q)$ same as (73)

$\pi(\overline{X}_1, P_Q)$ same as (70)

$\pi(\overline{X}_2, P_Q)$ same as (71)

and the elasticity of output supply is derived as:

$$(77)\quad \varepsilon = K_1 \cdot \pi(\overline{X}_1, P_Q) + K_2 \cdot \pi(\overline{X}_2, P_Q)$$

Application

Table 3-3 provides the range of values for the parameters needed to carry out these calculations. Where a range is given, there is no consensus of available empirical evidence.

The relative share of income attributable to land is calculated by taking the ratio of 5 percent (the capitalization rate for land rents) of the value of land to gross farm income. The relative share of income attributable to labor and capital would be one minus the land share.

Estimates of the elasticity of demand and the elasticity of substitution are also illustrated in these summaries.

The estimated parameters were used in measuring the impact of a ten percent increase in product prices. The resulting changes are given in Table 3-4.

Table 3-4 indicates several important results if people involved in agriculture are divided into four groups: landowners, tenants and hired workers, owner-operators, and prospective entrants.

Landowners benefit most under these circumstances:

a) price supports combined with non-tradeable production certificates issued to them.

b) price supports with no controls on output.

Landowners will benefit less when:

a) the certificates are tradeable and issued to producers.

b) under acreage control system unless compensatory payments were high.

Table 3-3: Plausible Values of The Parameters

Symbol	Parameter	Value
e.....	Elasticity of product demand	-0.5--0.25
σ.....	Elasticity of substitution	1.5- 0.5
g_2....	Supply elasticity of labor and capital	3.0- 1.0
g_1....	Supply elasticity of land	0
K_1....	Relative share of land	0.2
K_2....	Relative share of labor and capital	0.8

SOURCE: Floyd (1965).

Table 3-4: Extreme Cases of Effects of a 10 Per Cent Government-Induced Rise in Product Prices on Variables Under Study, Given Alternative Assumptions About Output Control

Output Control Accompanying Price Supports	Resulting Change[a]						
	Product Prices (Per Cent)	Output (Per Cent)	Farm Wage Rate[b] (Per Cent)	Quantity of Labor (Per Cent)	Value of Marginal Product of Land[b, c] (Per Cent)	Quantity of Land Used (Per Cent)	Marketing Certificates[d]
No output controls:							
Maximum......	+10.0	+17.0	+8.8*	+13.5**	+31.8**	0	Not applicable
Minimum.......	+10.0	+ 5.7***	+4.5**	+ 8.8*	+14.7*	0	
Acreage controls:							
Maximum......	+10.0	− 5.0**	+5.0*	+ 5.0*	+10.0**	−52.0	Not applicable
Minimum.......	+10.0	− 2.5*	0.0**	0.0**	+ 6.0*	−12.0***	
Marketing controls:							
Maximum......	+10.0	− 5.0	−3.0*	− 6.3**	−14.0** / +62.5*	0	70.2**
Minimum.......	+10.0	− 2.5*	−2.1**	− 3.0*	− 4.9* / +56.2**	0	67.4*

[a] In all cases it is assumed that $K_a = 0.2$, $K_b = 0.8$, and $\beta_a = 0$. Items marked with a single asterisk were calculated on the assumption that $\eta = -0.25$, $\sigma = 1.5$, and $\beta_b = 1.0$. Those marked with a double asterisk were calculated assuming that $\eta = -0.5$, $\sigma = 0.5$, and $\beta_b = 3.0$. In the cases where a triple asterisk appears, it was assumed that $\eta = -0.5$, $\sigma = 0.5$, and $\beta_b = 1.0$. The unmarked estimates were derived on the assumption that $\eta = -0.5$, $\sigma = 1.5$, and $\beta_b = 3.0$.

[b] If it is assumed that the supply of capital is perfectly elastic and the elasticity of substitution is unity, the percentage increases (or decreases) in the marginal returns to land and labor would be in the neighborhood of one-quarter again as large.

[c] The items above the rule show the percentage change in the value of land when the marketing certificates can be traded. Those below the rule show the percentage increase in land values when trading in marketing certificates is prohibited.

[d] The value of the marketing certificates is calculated as a percentage of the initial value of land and equals the percentage rise in land values when trading in certificates is prohibited minus the percentage fall in land values when trading in certificates is allowed.

SOURCE: Floyd (1965).

Tenants and hired workers will benefit the most when:

a) prices are supported and output is not controlled.

b) some gains will also result under an acreage control.

c) marketing certificates are issued to them.

Tenants and hired workers will be worse off under price supports combined with non-tradeable production certificates.

Under price supports with no output control, the owner-operator gains both on his land and labor. With non-tradeable production certificates, he gains on land but loses on labor. Owner-operators will gain more under a program of marketing controls, since the amount of land they own will be large relative to their labor resources.

Prospective farmers would not benefit substantially from any of these programs. With price supports the anticipated future returns are capitalized into the value of land making it more difficult for them to get into the industry. In the case of output controls via production certificates, prospective farmers will certainly be worse off, since the purchase prices of land and the production certificates will include the capitalized gains from the program.

Fertilizer Pricing Policies

With their increases in agricultural production due in substantial part to the increased use of fertilizer, many developing countries have adopted national fertilizer policies to make supplies cheaper and more readily accessible. This section examines fertilizer price policies and subsidies in light of the preceding theoretical analysis of input price policies.

National fertilizer policy can reduce relative fertilizer prices in the short run in one of two ways; either through the use of a fertilizer subsidy or by raising output prices. In the long run, fertilizer prices can be decreased by in-country mixing of fertilizers, expanded domestic production, and more efficient distribution.

Subsidies on fertilizers are sometimes preferred because the benefits farmers derive are in proportion to their use of the input. At the same time, input subsidies may be less costly than product price subsidies and possibly more easily reduced. The establishment of a subsidy, however, does not automatically mean that it will benefit the group for whom it was intended. More will be said about the limitations of fertilizer subsidy programs later.

In general, a fertilizer subsidy may be expected to have the following social effects:

- Strongly positive effects on crop production and consumer surplus,
- Positive effects on exports and producers' income,
- A negative effect on the governmental budget,
- A widening gap in income between farmers using fertilizers and those not using it.

Purpose of Subsidies

There are several reasons given for subsidizing fertilizer in LDCs. The major traditional purpose has been to encourage its use by farmers and thereby expand total agricultural production. Fertilizer prices in LDCs are typically higher than in most developed countries. LDCs must generally depend on imported supplies and therefore pay additional transportation and distribution costs. At the same time, if supplies are domestic, production costs may be higher due to outdated production processes and inefficient management.

Fertilizer subsidies are justified by the claim that they reduce fertilizer price and therefore, cost to the farmer, providing the necessary economic incentive to expand fertilizer use.

In general a subsidy is also justified given that fertilizer prices are high relative to product prices. In the event of a sharp increase in fertilizer prices, a subsidy may help maintain its use, expecially when product prices have not increased accordingly.

Another reason for subsidizing fertilizer rests on the assumption that fertilizer production exhibits economies of scale. A subsidy of fertilizer will help expand the market, and possibly make the establishment of fertilizer manufacturing and distribution facilities economical.

Finally, a subsidy on fertilizers may also be part of a package to increase food production. For example, a program of input subsidies may include not only fertilizer, but other farm chemicals, credit, and seeds as well.

At any rate, in almost all cases of subsidization of fertilizer use, it is implicit that it is a temporary measure and will eventually be withdrawn. Those who benefit from the subsidy, however, normally resist any movement toward withdrawal, so it often remains in effect longer than anticipated. Mudahar (1978) points out that:

> "Since only those farmers who use fertilizer benefit from the subsidy, income disparities may widen through both direct impact on income and also through an indirect impact on increased land values. The use of fertilizer subsidies can also result in an enormous cost to the treasury and hence increased tax burden. Finally, subsidy programmes are difficult to terminate or phase out because of increased expectations by farmers" (p. 55).

Types of Subsidies

Classifying fertilizer subsidies is a more difficult task than it normally appears. In some cases the efforts to equalize prices between regions or for certain types of fertilizers does not involve an actual government subsidy. This is the case where prices are controlled in order to a) equalize prices of imported and domestically manufactured fertilizer, or b) to provide price uniformity in different parts of the country.

In other cases the government levies duties or taxes on imports or production and then returns an approximately equal sum as a fertilizer subsidy. Alternatively, a price ceiling may be placed on domestically-produced fertilizer. Such a price may well be below the price in the world market.

A subsidy on fertilizer may also take the form of a preferential exchange rate, or when the import, production and/or distribution is government controlled, the price charged may be below the actual cost.

The problem of classifying subsidies is compounded by the fact that the subsidy may be applied at many different points: from producer or importer to final user. At the same time the subsidy may apply to only certain crops, types of fertilizers, or certain regions of the country.

In view of all these problems a very aggregated classification is utilized. For presentation purposes subsidies were classified as: direct subsidies and indirect subsidies.

Direct Subsidies. Direct subsidies involve a government payment to some group in the fertilizer production and marketing chain. The major groups are manufacturers, importers, transport firms, distributors (including cooperatives), and farmers. The latter two groups, however, appear to be the most prevalent. This is documented in Table 3-5, which summarizes three different tabulations.

While the data are not complete and not entirely comparable, it would appear that from 1968 to 1974 there was an increase in the number of subsidies applied at the manufacturing and farm levels, while from 1974 to 1975 there was an increase in the number of subsidies applied at the distributor level and a decrease at the farm level.

In certain cases there are restrictions for the application of direct subsidies with regard to the type of farm and/or the type of crop subsidized. That is, they may be limited to small farmers, to producers of specific crops or differential pricing by type of crop.

Indirect Subsidies. Many of the indirect forms of government assistance are much more difficult to classify as subsidies. Many of these were mentioned when discussing the problems associated with classifying subsidies by type.

Table 3-5: Points of Application of Fertilizer Subsidies

Recipient	OECD (1968)*	FAO (1974)*	FAO/FIAC (1975)*
		- number of cases -	
Fertilizer manufacturer	1	6	10
Importers	1	1	4
Internal transporters	3	3	6
Distributors (inc. coops)	3	5	14
Farmers	9	22	7
Unidentified	0	0	11
Total**	17	37**	52**
Number of countries	17	35	43

*The year stated is the year the data were reported; they presumably apply to the previous year or years.

**Payments were sometimes made to more than one of the above recipients.

SOURCES:

OECD. Supply and Demand Prospects for Fertilizers in Developing Countries, OECD, Development Center, Paris, 1968; p. 169.

FAO. "Note on Fertilizer Subsidies," FAO, Rome, January or February 1974, Table 3, Col. 3.

FAO/FIAC. "Possibilities for the Development of Guidelines for the Use of Fertilizer Subsidies in Agricultural Development," FAO/FIAC Working Party on the Economics of Fertilizer Use, Rome, March 17, 1975, Chp. I, p. 3.

A common form of indirect subsidy is the fertilizer transport subsidy which takes the form of a subsidy on costs to remote areas. Credit on concessional terms for fertilizer purchase is also a form of subsidy.

In some countries a double tax writeoff has been allowed to farmers on their fertilizer costs. In the 1950's Brazil used a package involving a favorable exchange rate for fertilizer imports as well as tariff exemptions, state and federal tax exemptions, and highly preferential rail freight rates and port fees.

A less common type of fertilizer subsidy is the set of fertilizer-related services that can be provided by government infrastructure, particularly the extension service.

Limitations of Subsidy Programs

On the management side, administrators of subsidy programs face at least two major problems: reaching the intended recipient and establishing the appropriate subsidy level.

Reaching the Intended Recipient. Since the subsidy can represent a sizeable source of income, many people would like to profit from it. In the process, the benefits to the intended recipient may be substantially reduced. In some cases, although subsidized fertilizer was sold through authorized wholesalers and retailers, it was hoarded to force the price up. As a result, it was sold to farmers at more than double the subsidized price.

An almost unavoidable result of fertilizer subsidization is that some farmers may benefit more than others. In some cases the more economically and politically influential farmers reap the greatest benefits from the subsidies. With this in mind, it has been suggested that the removal of the subsidies should neither dampen fertilizer demand significantly nor cause undue hardship to the poorer farmers.

In most cases subsidized inputs are only a small fraction of the costs of production. Consequently, lower price for those inputs does not imply improved levels of income in the face of downward fluctuations in price. The use of input subsidies does not lend itself to discrimination between products or income groups of users.

A more important problem associated with input subsidization is that they distort both the choice of commodities to produce and the choice of technique of production. As a result of a subsidy, too much of the input may be used or an inefficient cropping pattern may be selected.

A rise in the price of fertilizers is likely to cause the following effects:

- A drop in the use of fertilizers,
- A change in the pattern of utilization,
- The price of food to consumers might rise due to higher input costs and/or lower yields due to less fertilizer used.

Farmers with limited financial resources may be unable to buy as much fertilizer at unsubsidized prices. As a result, fertilizer use in this income group may fall. Change in the pattern of utilization also comes about as crops with highest return absorb almost all fertilizer available.

As mentioned before, an alternative policy to foster fertilizer use is by working on the product price via adjustment in the price support level and/or in official wholesale/retail prices. In general, constraints on fertilizer use range from delivery problems to lack of farmer knowledge about its potential payoff.

Cost of Subsidy Programs

Subsidy programs for fertilizer can be very expensive for the modest agricultural budgets of many LDC's. One of the earlier programs, in Chile, was discontinued several times due to lack of funds. In Uruguay, from 1961 to 1966, the annual cost of a relatively modest subsidization program was $2.53 million and the government "from time to time" had difficulty in meeting payments. The cost of subsidies in countries with more extensive subsidy programs is substantial: in South Korea the fertilizer subsidy cost $8.84 million in 1968 and $17 million in 1969; the expected cost of the fertilizer subsidy program in Afghanistan in 1975 is $15.1 million, while in Bangladesh the proposed subsidy in the Five Year Plan totals $50 million.

Curiously, there does not seem to be a great deal of evidence available to demonstrate the effectiveness of these vast expenditures in stimulating fertilizer use. This absence has been noted in at least several nations--Brazil, Jamaica, Kenya, and Tunisia. This is not to say that subsidies have been ineffective, only that remarkably little evidence seems to be available considering the substantial funds which have been involved.

Mudahar (1978) compared the expenditure on fertilizer subsidies with that on agricultural research and concluded that:

> "The expenditure on fertilizer subsidies far exceeds the expenditure on agricultural research even though the investment in agricultural research generates a stream of economic returns for an indefinite period as compared to investment in the form of fertilizer subsidies" (p. 55).

Table 3-6 shows his findings for a few selected countries.

Estimating Fertilizer Demand

Griliches (1959) developed a model for estimating regional demand functions for fertilizer. A summary of other fertilizer demand studies is shown in Table 3-7. Baker and Hayami (1976) analyzed fertilizer subsidies for two crops as a means of attaining the goal of food self-sufficiency. This article is reviewed more in the next section.

The Griliches model assumed that the desired or long-run level of fertilizer use is a function, linear in the logarithms, of the "real" price of fertilizer. Real price is taken to mean the price paid per plant nutrient unit divided by an index of prices received for all farm crops. Adjustment in the use of fertilizer is incorporated by adding the lagged fertilizer use to the demand function.

The model can be summarized as follows:

$$(78) \quad \log Y_t^* = a_0 + a_1 \log X_t + U_t$$

where Y^* is the "desired" or "equilibrium" level of use of fertilizer; X is the real price of fertilizer.

The adjustment equation is denoted by:

$$(79) \quad \log Y_t - \log Y_{t-1} = b(\log Y_t^* - \log Y_{t-1})$$

where Y_t is actual level of use of fertilizer; b is the "adjustment coefficient."

$$(80) \quad b \log Y_t^* = \log Y_t + (b - 1) \log Y_{t-1}$$

Table 3-6: Fertilizer Subsidy, Agricultural Research Expenditure in Selected Countries (1969-1975)

Country	Subsidy expenditure (million $)	Agricultural research expenditure (million $)	Subsidy as per cent of agricultural research expenditure (per cent)
Afghanistan	15·10	0·63	2,397
Bangladesh	14·63	1·40	1,045
Indonesia	71·90	3·42	2,102
Iran	36·08	16·66	217
South Korea	27·26	2·44	1,117
Pakistan	20·97	1·26	1,664
Philippines	36·77	7·96	462
Sri Lanka	5·25	2·44	215

SOURCE: Mudahar (1978).

Table 3-7: Summary of Fertilizer Demand Studies in Developing Countries

Country	Fertilizer	Time period	Elasticity of demand		Adjust-ment co-efficient	Source
			Short-run	Long-run		
Brazil[a]	NPK	1949-71	—1·12[b]	—	—	Larson and Cibautos (20)
Brazil	NPK	1949-71	—0·33[c]	—1·94	0·17	
India[a]	N	1953/54-67/68	—0·31[d]	—0·34	0·92	Rao (31)
India	N	1953/54-67/68	—0·53[c]	—6·63	0.08	
India[a]	N	1958/59-63/64	—1·20[d]	—2.50	0·50	Parikh (27)
Japan[a]	NPK	1883/1937	—	—0·74[b]	—	Hayami (14)
Korea[a]	NPK	1960-72	—0·17	—0·88	0·20	Sung, Dahl and Shim (38)
Korea[a]	NPK	1971	—0·70[b]	—	—	Shim, Dahl and Sung (36)
Pakistan	N	1959/60-72/73	—0·52[b]	—	—	Salam (34)
Philippines[a]	N	1958-72	—0·59[b]	—	—	Rodrigues (32)
Taiwan[a]	N	1950-66	—0·55[c]	—	—	Hsu (17)
Taiwan	N	1950-66	—2·03[b]	—2·99	0·68	
Thailand	NPK	1954-72	—0·29[c]	—	—	Puapanichya (30)
Thailand	NPK	1954-72	—0·27[c]	—0·37	0·72	
U.S.A.	NPK	1911-56	—0·53	—2·99	0·23	Griliches (13)

[a]Adapted from Timmer (39).

[b]Denotes significance at 0.9 or higher.

[c]Denotes significance between 0.8 and 0.9.

[d]Denotes significance between 0.7 and 0.8.

SOURCE: Mudahar (1978), p. 53.

Multiply (71) by b and substitute for b log Y_t^*

$$(81) \quad \log Y_t + (b - 1) \log Y_{t-1} = b\, a_0 + b\, a_1 \log X_t + b\, U_t$$

$$(82) \quad \log Y_t = b\, a_0 + b\, a_1 \log X_t + (1 - b) \log Y_{t-1} + b\, U_t$$

This equation is then estimated by the method of least squares.

The Variables: Definitions and Sources. The fertilizer variable is measured in terms of plant nutrients. Individual nutrients are weighted by their relative prices before aggregating. The weights were derived from a regression of average 1955 U.S. prices of different mixed fertilizers on their respective percentage contents of the three nutrients. Regional differences were taken into account by dividing the plant nutrient tonnage by a regional index of cropland used for crops.

$$(83) \quad Y_{it} = \frac{1.62\, N_t + .93\, P_t + .45\, K_t}{A_{it}}$$

where (1.62) (.93) (.45) are the weights derived by the previously mentioned regression approach for Nitrogen (N), Phosphoric Acid (P) and Potash (K) respectively.

Regional prices paid by farmers for a plant nutrient was calculated by dividing regional estimates of farmer's expenditures on fertilizer and by the price-weighted regional aggregate of plant nutrients described above.

Regional indexes of prices received by farmers for crops was calculated by dividing the indexes of regional total values of crops by regional farm output index for crops.

The Results and Their Limitations. The regional regressions are presented in Table 3-8. The regression coefficients (a) were computed using the regional estimate of the "real" price received by farmers as the independent variable; the (b) coefficients were computed using the US series on real prices received by farmers.

This very simple model of demand depending on real price received and on adjustment process explains a very high fraction of the variation in annual use of fertilizer.

The estimates of the adjustment coefficients (b, a_1) are less satisfactory. The estimation technique used is likely to result in an upward bias in the estimated coefficient of the lagged dependent variable and hence in a downward bias in the estimated adjustment coefficient. The bias results from leaving out some other variables that affect fertilizer use. These variables will introduce serial correlation in the residual term and intercorrelation between the residual term and the lagged dependent variable. As a result, the estimated coefficient of Y_{t-1} is biased.

The introduction of a lagged dependent variable (Y_{t-1}) into the regression is a useful device to take serial correlation into account. Nevertheless all serial correlation cannot be attributed to the adjustment mechanism.

The estimates of the long-run elasticity can be obtained by dividing the estimate of the short-run elasticity by the estimated adjustment coefficient.

The adjustment coefficient (b) may be low due to serial correlation in the residuals and also due to errors of measurement in X. These two factors contribute to make Y_{t-1} of much "stronger" explanatory power than X.

Table 3-8: Demand Functions for Fertilizer by Regions and for the U.S., $\log Y_{it} = ba_o + ba_1 \log X_{it} + (1-b) \log Y_{it-1} + bu_t$

Region	Coefficients of $\log X_{it}$	Coefficients of $\log Y_{it-1}$	R^2	b	a_1
New England (a)	−.126	.922	.949	.08	−1.62
	(.100)	(.086)			
(b)	−.128	.901	.951	.10	−1.29
	(.080)	(.085)			
Middle Atlantic (a)	−.216	.908	.982	.09	−2.35
	(.088)	(.049)			
(b)	−.185	.877	.985	.12	−1.50
	(.057)	(.048)			
East North Central (a)	−.434	.878	.985	.12	−3.56
	(.087)	(.038)			
(b)	−.514	.823	.986	.18	−2.90
	(.097)	(.044)			
West North Central (a)	−.600	.859	.989	.14	−4.26
	(.098)	(.033)			
(b)	−.771	.845	.987	.16	−4.97
	(.154)	(.042)			
South Atlantic (a)	−.365	.755	.966	.24	−1.49
	(.074)	(.065)			
(b)	−.370	.744	.971	.26	−1.45
	(.064)	(.059)			
East South Central (a)	−.624	.724	.963	.28	−2.26
	(.126)	(.068)			
(b)	−.647	.729	.961	.27	−2.39
	(.136)	(.069)			
West South Central (a)	−.657	.744	.969	.26	−2.67
	(.131)	(.065)			
(b)	−.780	.771	.970	.23	−3.41
	(.155)	(.060)			
Mountain (a)	−.319	.965	.970	.04	−9.11
	(.173)	(.037)			
(b)	−.450	.860	.972	.14	−3.21
	(.194)	(.063)			
Pacific (a)	−.659	.796	.985	.20	−3.23
	(.137)	(.050)			
(b)	−.408	.841	.979	.16	−2.57
	(.132)	(.067)			
U. S. (log Σ)	−.393	.816	.983	.18	−2.14
	(.075)	(.048)			
U. S.* (Σ log)	−.512	.838	.986	.16	−3.16
	(.105)	(.044)			

Source: Griliches (1959) p. 94

Regional Differences in the Coefficients. Several hypotheses about regional coefficients were tested. The first hypothesis was that the more experienced farmers have had in the use of fertilizer, the faster they adjust to price changes. The spearman rank correlation coefficient between the estimated adjustment coefficients and the 1931-56 geometric average of plant nutrients used per acre of cropland was used to test this hypothesis.

The second hypothesis: the demand for fertilizer is more price elastic, in the long run, in regions with low level of fertilizer use. This hypothesis refers to the fact that effect of additional fertilizer use on crop yields decreases after a ceiling is reached. Hence, regions further away from the ceiling will react more strongly to changes in the price of fertilizer. This test used the spearman rank correlation coefficient between the absolute value of the long run fertilizer price elasticity and the average quantity of plant nutrients used per acre of cropland.

Establishing Subsidy Levels

One of the major management problems of fertilizer subsidy programs is the establishment of the proper subsidy level. If the subsidy is too low, it may not accomplish its intended purpose of encouraging farmers to adopt or maintain fertilizer use. If the subsidy is too high it may lead to wasteful resource allocation. In either case, fertilizer use may be more profitable on some crops than others--and these may not be the ones for which it was intended. Just how the subsidy level is actually established in most LDC's is, at this point, a matter of some mystery. It would appear, however, that in at least some countries there is an effort to strike a balance between official fertilizer and product prices. In some countries a given fertilizer/output price ratio is maintained or at least the subsidy is adjusted to keep it within a certain range. In this case the fertilizer/product price ratio or real fertilizer price is used as a guideline. Both Mudahar (1978) and Peterson (1979) point out, however, that there is significant variation in the price farmers receive for their products and hence, such a ratio does not have country wide validity. Griliches (1959) suggests that disaggregation to the regional level to estimate the elasticity of demand for fertilizer is justified due to the existence of such regional variations. In some cases, as fertilizer prices increase, the subsidy level may be set at a level which would maintain an earlier level of farmer purchasing power.

National fertilizer policies are usually cast in terms of price options or of cost-benefit analysis of alternative price levels.

Fertilizer Subsidy for Food Self-Sufficiency

This application illustrates how analysts can evaluate the impact of alternative policies. It is based on Baker and Hayami (1976).

A true self-sufficiency goal can be achieved only if the agricultural production function is shifted via technological improvement (irrigation, research and estension). In the short run, more production can be generated along the same production function by policies such as supporting product prices or subsidizing specific inputs.

If an input, such as fertilizer, is not being used in an optimal quantity a subsidy on this input may result in a net gain to the society. On the other hand, a support of product prices will induce increased use of traditional inputs as well as of modern inputs. The likely result will be more social cost than benefit.

An alternative way of increasing the supply of rice (without resorting to supporting the price at P_s as above) is by shifting the supply curve from SS to S'S'. The relevant parameters for this kind of policy are the production elasticity of fertilizer in the rice sector and the price elasticity of demand for fertilizer used in rice production. The production elasticity of fertilizer will indicate the expected increase in output forthcoming from additional use of fertilizers. The price elasticity, on the other hand, will provide an idea of the additional fertilizer that will be purchased for a given decrease in its price.

Figure 3-12 depicts a model of fertilizer subsidy where two crops are considered. Let's represent the demand curve for fertilizer in the rice sector as D_rD_r and that of the sugar sector as D_sD_s. Total demand for fertilizer will be denoted by DD and domestic supply of fertilizer by SS.

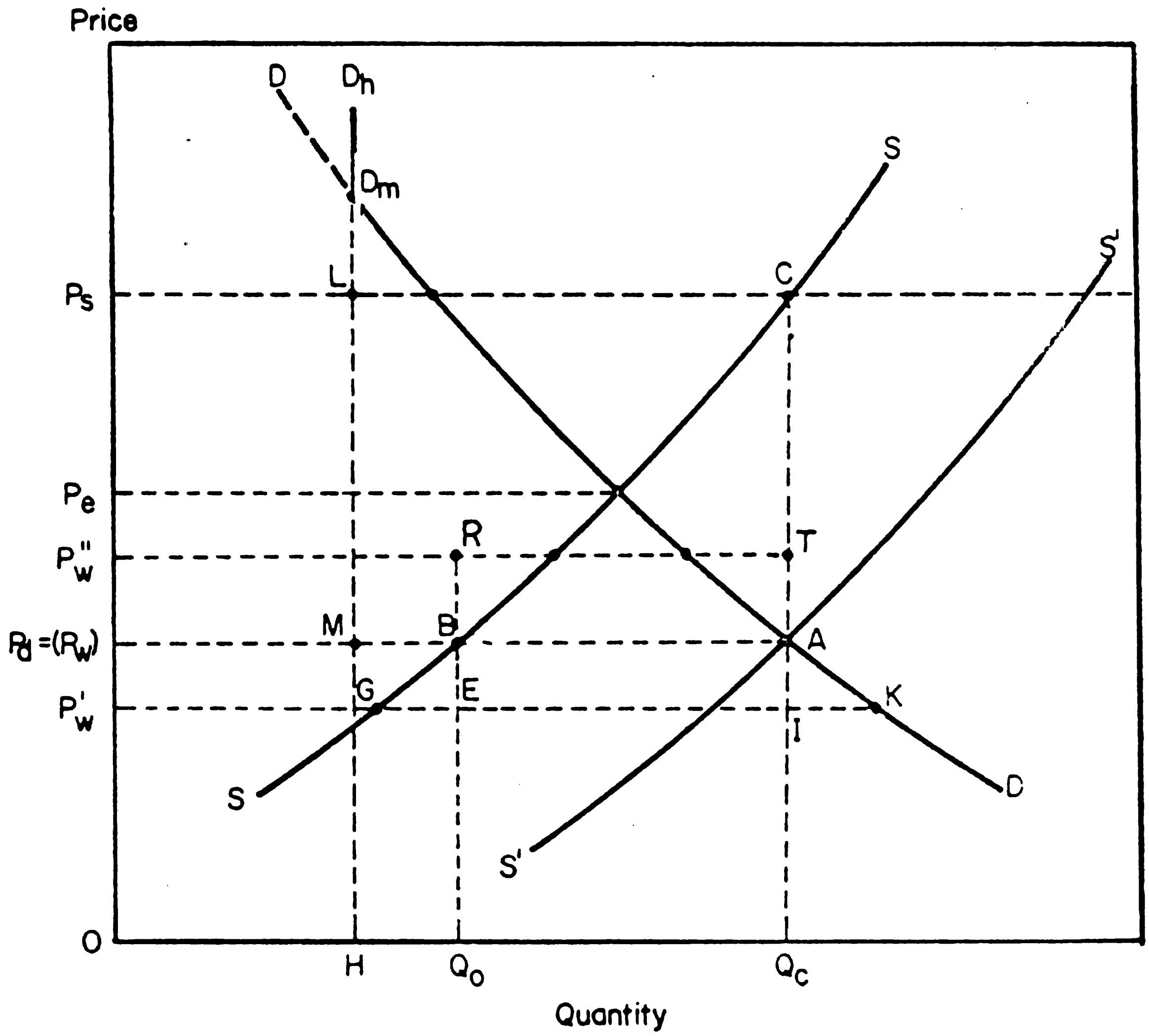

Figure 3-11: A Price Support Policy

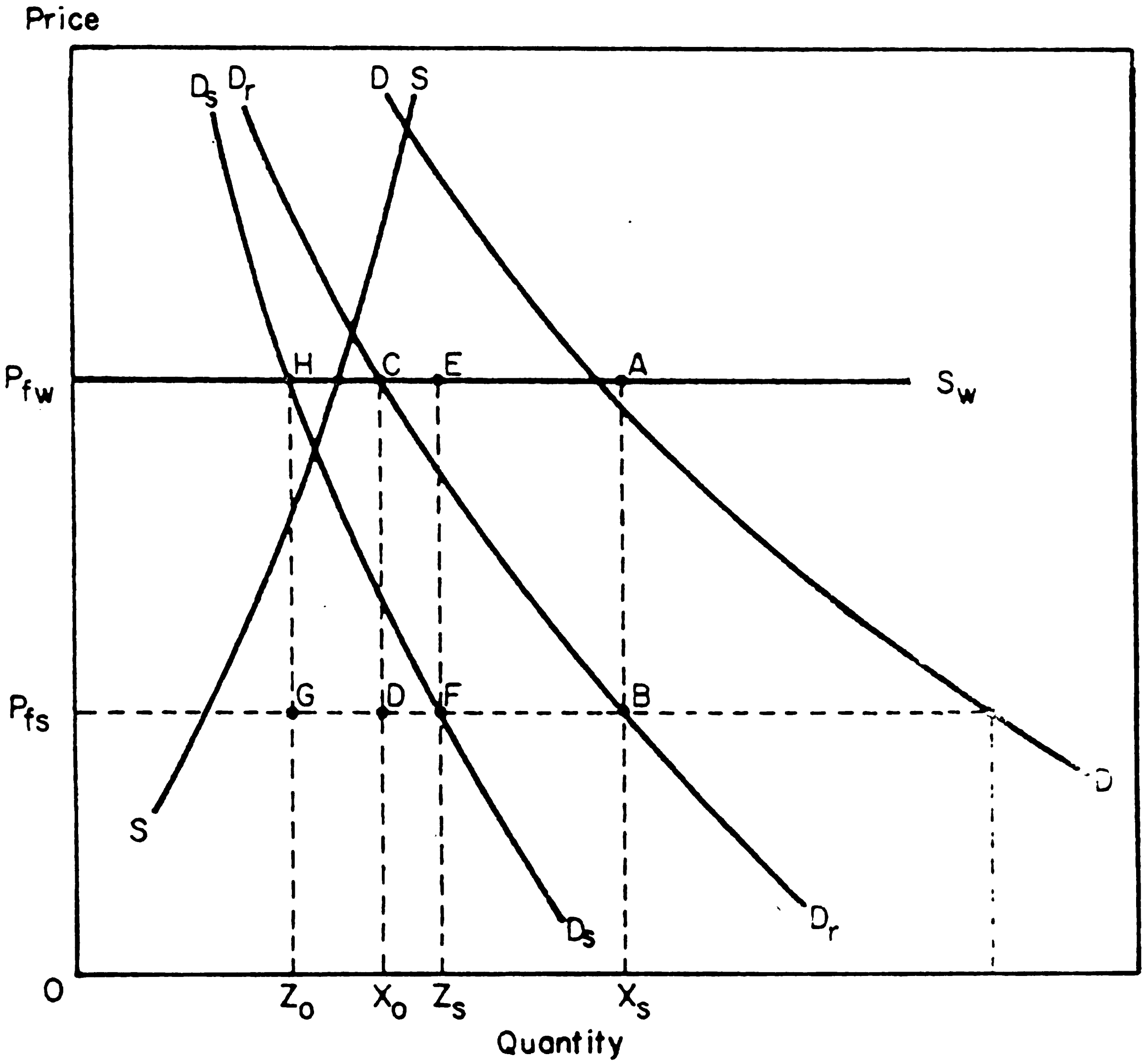

Figure 3-12: A Fertilizer Subsidy Policy (Rice)

The world supply curve is assumed to be perfectly elastic (S_w) at the world price of fertilizer (P_{fw}).

A subsidy to maintain fertilizer prices for rice at P_{fs} will cost the government and amount equal to the area represented by $ADP_{fs}P_{fw}$.

Rice producers will receive a dual benefit: one from being able to buy fertilizer at a lower cost and another from the increased output they can now produce due to more favorable fertilizer prices. Before the subsidy producers bought quantity X_o, whereas after the subsidy, this same quantity will cost them $CDP_{fs}P_{fw}$ less. Similarly, the additional output produced (Q_oQ_c in Figure 3-11) will bring them ABQ_oQ_c in additional revenues. Net revenue from the increased output will equal $ABQ_oQ_c - BDX_oX_s$ in Figures 3-11 and 3-12 respectively.

Net savings in foreign exchange are given by the difference between the expenditures for rice imports, area ABQ_oQ_c in Figure 3-11, minus the foreign exchange requirements for fertilizer import, area ACX_oX_s in Figure 3-12.

A Fertilizer Subsidy for Sugar

In the above analysis two prices of fertilizer existed: a subsidized price for rice producers and another price for sugar growers. In this section the costs and benefits of fertilizer subsidization are estimated when no distinction is made between crops on which fertilizer is used.

In Figure 3-13 DD and SS represent domestic demand and supply schedules for sugar. S'S' represents a shift in the supply schedule due to the subsidy on fertilizer. Let R_w represent the export price of sugar and R'_w the price producers receive after paying an export tax on the product.

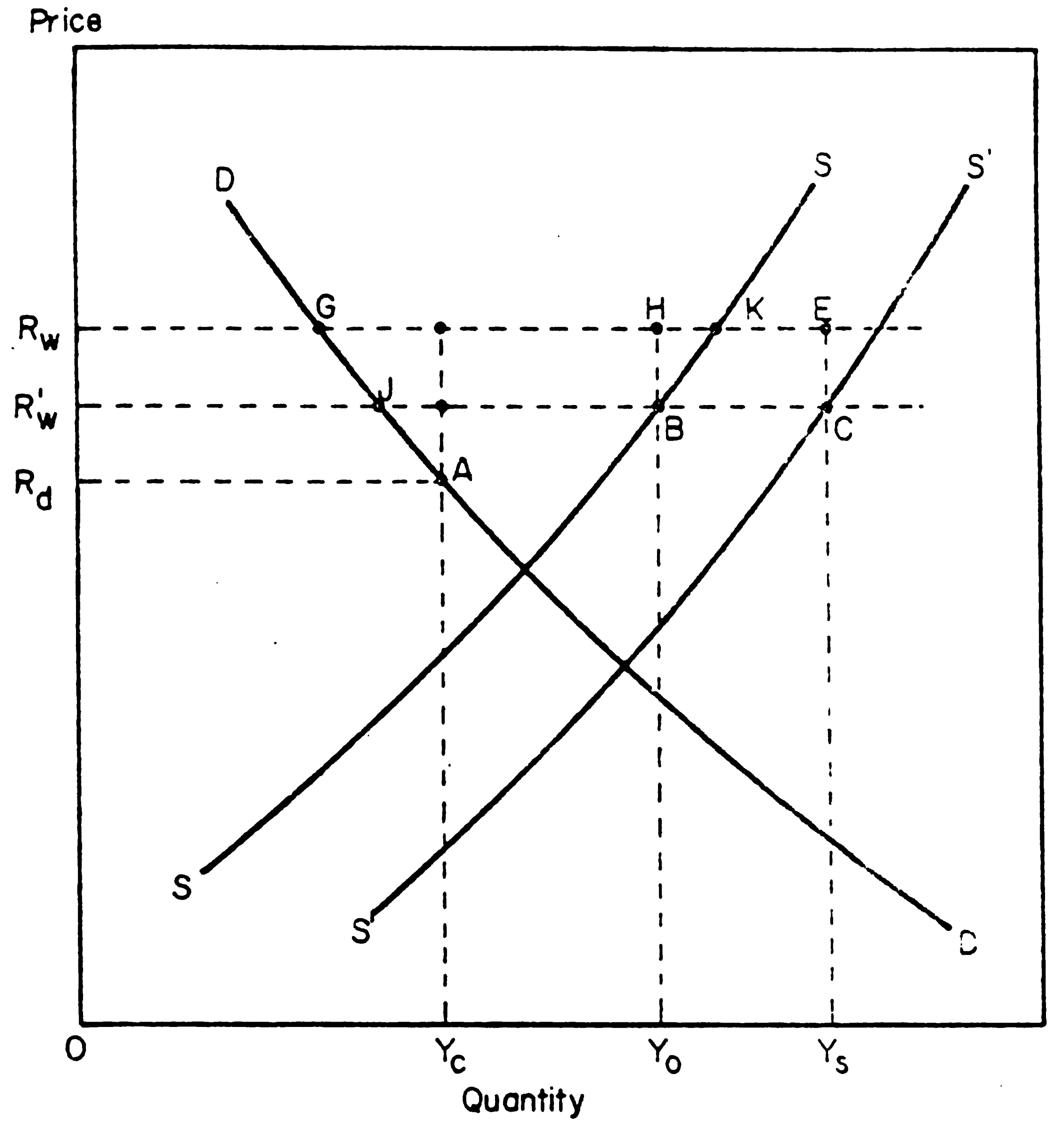

Figure 3-13: A Fertilizer Subsidy for Sugar

In the absence of a fertilizer subsidy, sugar growers would produce the output given by OY_o which implies domestic sugar consumption of R'_wJ and exports of JB. If the government sets a price of R_d at which producers must sell to domestic consumers and such price and quantity parameters are fixed, then consumers' welfare does not change when a subsidy for fertilizer is put into effect.

A subsidy on fertilizer used in sugar production will cost the government an amount equivalent to area $EFP_{fs}P_{fw}$ in Figure 3-12. Assuming that all additional production can be sold in the international market, exports will increase from Y_cY_o to Y_cY_s (Figure 3-13) resulting in an increase of government revenues (from export taxes) equivalent to the area BCEH. Sugar producers obtain dual benefit. In the first place they realize a cost saving by purchasing fertilizer at a lower cost (in relation to the pre-subsidy price it amounts to the area $HGP_{fs}P_{fw}$ in Figure 3-12). In the second place they realize additional revenues from the sale of the increased output (area BCY_sY_o in Figure 3-13). To obtain the gain in net revenues subtract the cost of the additional fertilizer purchased by sugar producers due to the more favorable price (area FGZ_oZ_s in Figure 3-12).

The foreign exchange situation changes as follows. Additional foreign exchange is generated from the sale of the increased output of sugar (area HEY_sY_o in Figure 3-13). On the other hand, foreign exchange is used up in securing the needed fertilizer and is represented by the area HEZ_sZ_o in Figure 3-12.

<u>Formulae to Estimate Benefits and Costs Associated with Alternative Policies</u>

Denote:

β: price elasticity of rice supply

α: production elasticity of fertilizer with respect to rice

δ: production elasticity of fertilizer with respect to sugar

$-\gamma$: price elasticity of fertilizer demand with respect to rice

$-\varepsilon$: price elasticity of fertilizer demand with respect to sugar

1) Fertilizer Subsidy for Rice

Let X_s be the amount of fertilizer that must be used in order to achieve a given level of rice output (Q_c). X_s can be estimated using this relationship:

$$(84) \quad X_s = X_o(Q_c/Q_o)^{1/\alpha} - X_o\left(\frac{1 + (Q_c - Q_o)}{Q_o}\right)^{1/\gamma\alpha}$$

Let P_{fs} be the subsidized price of fertilizer that will induce farmers to apply more of it so as to reach X_s. Also let P_{fo} represent the unsubsidized fertilizer price. The required subsidized price to accomplish the target fertilizer use is given by:

$$(85) \quad P_{fs} = P_{fo}(X_s/X_o)^{-1/\gamma} = P_{fo}\left(\frac{1 + (Q_c - Q_o)}{Q_o}\right)^{-1/\gamma\alpha}$$

The government cost of the subsidy to attain the production goal (Q_c in this case) is equivalent to area $ABP_{fs}P_{fw}$ in Figure 3-12. It can be estimated by:

$$(86) \quad X_s(P_{fo} - P_{fs})$$

The revenue that the government is not receiving by implementing this policy is ABEI. It represents the profits obtained by buying at price P'_w and selling at price P_d. It is given by:

(87) $(P_d - P'_w)\ (OQ_c - OQ_o)$

The benefits accruing to rice producers as a result of the subsidy on fertilizer price is given by:

(88) $(P_{fo} - P_{fs})\ X_o + (1 - M_r)\ (OQ_c - OQ_o)\ P_d - P_{fs}\ (X_s - X_o)$

Net saving of foreign exchange is given by the saving achieved by <u>not</u> importing rice minus the expenditure in importing the needed fertilizer. Net saving of foreign exchange will be given by:

(89) $P_w\ (OQ_c - OQ_o) - P_{fo}\ (1 - M_f)\ (X_s - X_o)$

2) <u>Fertilizer Subsidy for Sugar</u>

The demand for fertilizer input by sugar producers when the price of fertilizer is at the required subsidized level in order to bring about a given rice output is denoted by:

(90) $$Z_s = Z_o\ (P_{fo}/P_{fs})^{\varepsilon} = Z_o \left(\frac{1 + (Q_c - Q_o)}{Q_o}\right)^{\varepsilon/\alpha\gamma}$$

where Z_s is the fertilizer usage at the subsidized price P_{fs} and Z_o is the fertilizer usage at the unsubsidized price P_{fo}.

Output of sugar at the subsidized price of fertilizer is given by:

(91) $$Y_s = Y_o\ (Z_s/Z_o)^{\delta} = Y_o \left(\frac{1 + (Q_c - Q_o)}{Q_o}\right)^{\varepsilon\delta/\alpha\gamma}$$

where Y_s is the sugar output at the subsidized price of fertilizer and Y_o that at the unsubsidized price.

The cost to the government of the fertilizer subsidy for sugar is given by the area $EFP_{fs}P_{fw}$ in Figure 3-13. It can be estimated using the formula:

$$(92) \quad Z_s\ (P_{fo} - P_{fs})$$

The government revenue coming from increased sugar exports (via an export tax) is calculated by:

$$(93) \quad t \cdot r_w\ (Y_x - Y_o)$$

where r_w is the export price of sugar and t is the rate of sugar export tax.

Sugar producer's increased revenue is given by:

$$(94) \quad (P_{fo} - P_{fs})\ Z_o + (1 - t)(1 - M_s)(Y_s - Y_o)\ r_w - P_{fs}\ (Z_s - Z_o)$$

where M_s is the rate of processing and marketing margin for sugar.

Foreign exchange net gain from this policy is given by:

$$(95) \quad r_w\ (Y_s - Y_o) - (1 - M_f)(Z_s - Z_o)\ P_{fo}$$

where M_f is the marketing margin for fertilizer.

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One of the main factors to be considered in any input policy is the effect that the policy will have on output. It is for this reason that estimating supply functions for the products which use the inputs needs to be emphasized. The following articles on supply functions contain real applications to countries dependent on a few products as a source of foreign exchange.

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CHAPTER 3 ANNEX

ANNOTATIONS FOR KEY REFERENCES ON INPUT SUBSIDIES

Blandford, D. and J. M. Currie. (1975)

"Price Uncertainty--The Case for Government Intervention," Journal of Agricultural Economics 26(1), January, pp. 37-51.

This article presents the relevant features of the behavior of farmers in the face of uncertainty about the price of the agricultural product. The effects of guaranteed producer-price scheme on the welfare of producers, consumers, and taxpayers is examined. The authors conclude that in the face of production lags and price uncertainty, there is likely to be a misallocation of resources within the industry concerned; and in the sense that farmers are predominantly risk adverse, it is doubtful that the resulting industry output would be in any sense "socially optimal". Therefore they suggested that in case of producers' uncertainty, government intervention should be considered, such as guaranteed price policy designed to eliminate these types of problems.

Falcon, Walter P. (1964)

"Farmer Response to Price in a Subsistence Economy: The Case of West Pakistan," Papers & Proceedings--American Economic Association 76, May, pp. 580-91.

The purpose of this paper is to examine the direction and magnitude of farmer responses to price in a low income economy. The discussion here is in the context of West Pakistan. The main conclusions arrived at are that even in a low income region such as West Pakistan, there may be significant acreage responses to changed relative prices. There is a limited price response in the allocation of nonland factors (i.e. yield) because changes in rainfall, irrigation water availability and other geographic factors still are the major determinants of changes in yield.

The author also suggested that it is possible to shift the composition of agricultural output by changing the relative prices within agriculture. If there is a thoroughgoing reform in the services and facilities made available to farmers, there will be response to economic incentives such as higher price policies. It was also observed that uncertainty is a major factor in farm planning and it is likely that price responses would be higher if farmers were assured of guaranteed prices.

Harris, Duane G. (1977)

Inflation-Indexed Price Supports and Land Values," American Journal of Agricultural Economics 59(3), pp. 489-95.

Harris developed a theoretical model of land value determination as a function of cost-indexed support prices. The analysis is within the framework price uncertain world, where policy makers are allowed to control the percentage of nonland operating cost and the percentage of land costs covered by a support price. The support-price mechanism is generalized to accommodate either a target price or loan rate program. Harris concludes that the particular scheme used to implement a general cost-indexed support-price policy is crucial to the resulting impact on future land values. It also will have an impact on the social cost of the farm program for years in which actual commodity price falls below the support price. Implementation of a policy that guaranteed a rate on land greater than the market capitalization rate could have substantial impact on land values before the policy authorities can make the necessary adjustments.

Hushak, Leroy J. (1971)

"A Welfare Analysis of the Corn Diversion Program, 1961 to 1966," American Journal of Agricultural Economics 51(2), May, pp. 173-81.

Welfare effects of the voluntary corn diversion program are analyzed in this paper. Under this program, the government buys or sells enough corn to maintain the price and also make direct payments to producers for taking land out of production. Hushak developed a three sector (corn, other crops, and the rest of the economy) supply-demand model which incorporates substitution in production and consumption between corn and other crops. This analysis is within the voluntary corn diversion program in 1961 to 1966 period. Free market equilibrium is also estimated. The net welfare costs and income transfers are computed from the two equilibrium points. The analysis shows that the net welfare costs are small. The major effect of the program was on the transfer of income from consumers to producers.

Johnson, Paul R. (1965)

"The Social Cost of the Tobacco Program," Journal of Farm Economics, Vol. 47, May, 242-55.

Marshallian devices of consumer and producer surplus was used in this article for the calculation of the social gains and losses from the tobacco program in the U.S.A. and its long run implications within the context of welfare theory. The U.S. has been in a strong monopoly position in world trade. This advantage allowed the U.S. government to affect the traditional welfare losses associated with price support programs in tobacco. The author mainly argues that even though the social cost of the tobacco program has been relatively small, the long run implications are that transferring income to tobacco producers will become more costly in terms of lost producer and consumer surplus. The conclusion arrived at from the Marshallian analysis, however, showed that in the decade of the 50's the social cost of operating the tobacco program was quite small. Thus the transfer of income to tobacco producers was not as costly as it might have been.

Lele, Uma (1976)

"Considerations Related to Optimum Pricing and Marketing Strategies in Rural Development," a paper prepared for presentation at the XVI International Conference of Agricultural Economists, Nairobi, Kenya, July 26-August 4, 1976.

The author advocates the use of price and supply stabilization programs involving the fixation of maximum and minimum prices and buffer stocks. The factors that need to be considered in the fixation of maximum and minimum prices are discussed.

Due to the sensitive political conditions of the urban centers, governments commit themselves to controlling the level of prices and ensuring adequate food supplies to urban centers. This can be accomplished by: a) fixing prices ranging from the farm gate to the consumer; b) using imports to stabilize domestic prices and supplies; c) retail distribution (it has been confined to urban centers).

The effects of urban-oriented pricing and marketing strategies is discussed. According to the author, government intervention has been destabilizing rather than stabilizing.

Finally, another objective of pricing policy followed by government is to assure a minimum return to resource use.

Price stabilization is discussed as well as the considerations that have to be examined. These are: costs of holding buffer stocks vis-a-vis alternative uses of government resources; the effect of price stability on production incentives; and the incidence of taxation and/or subsidy by sectors and classes.

Ryan, M. E. and M. E. Abel. (1972)

"Corn Acreage Response and the Set-Aside Program," Agricultural Economics Research 24(4), October, pp. 102-12.

This paper adapts and modifies a model previously developed for the empirical evaluation of the impact of commodity price support programs on corn acreage. The model is used to analyze the effects of the set-aside program on corn plantings. The main objective of this research has been to develop reliable tools for policy advisers to use for estimating the aggregate acreage consequence of changes in government commodity program provisions. The emphasis of this work has been devoted to empirical measurement and analysis of the effects of policy variables on acreage planted. These policy variables are the support price weighted by planting restrictions, and the payments for diverting land from corn production. The corn acreage planted in the U.S. is expressed as a function of the above mentioned policy variables and the supply determinants and random factors. Through the calculation of these policy variables, the authors finally predicted the rise of corn (in acres) planted for 1972, to refect the set-aside provisions as offered in 1972 corn programs by the U.S. government.

Vogelsang, D. L. and J. O. Dunbar (1963)

"A Method for Analyzing the Effects of Voluntary Land-Retirement Programs," Journal of Farm Economics 45, November, pp. 789-98.

This paper outlines a graphic model which has been used to analyze the effects of voluntary land-retirement programs. Under these programs the government would offer payments to farmers in amounts that at least are equal to the net value product from the crops that otherwise would be grown, such that given a sufficient incentive payment farmers would then retire land from production (in a voluntary way). The objective of these programs is to raise prices of agricultural products so that the farmer's income will increase.

CHAPTER 4

ANALYSIS OF INTERNATIONAL TRADE POLICIES

Introduction

This chapter on the analysis of international trade policies covers three topics: welfare costs of trade policies, effective protection rates, and devaluation. A common framework based on a static partial equilibrium analysis is used to provide a homogeneous discussion of the topics. Where possible, graphs and simple algebraic formulas are the basis of the presentation. For each topic, concepts within the established framework are presented first and then expanded with numerical examples. Empirical studies of trade policies are also reviewed.

The first topic, the welfare cost of trade policies, deals with six specific policies affecting either the price or the quantity of imports or exports. Graphical analysis is used to identify geometric areas that represent social welfare costs, which are then quantified with simple formulas. Empirical studies are discussed for agricultural and industrial products.

The second topic covered, the estimation of effective protection rates, deals with computing the percentage excess of domestic value added, obtainable through the protection of an output and its inputs, over world market prices. Starting with the initial concept of nominal protection rates, complexity is added when non-traded goods and over-valuation of the exchange rate are included in the analysis.

This third topic, the effects of devaluation, deals with the short-run impact of a devaluation on the trade balance (the difference between imports and exports). The well-known Marshall-Lerner condition is discussed and the empirical estimates of the elasticities for Latin America, required for the fulfillment of this condition, are presented. The different approaches to devaluation analysis and recent results of empirical studies on devaluation are also discussed.

The Welfare Costs of Trade Policies

Six trade policies, three affecting imports (tariffs, import subsidies, and import quotas), and three affecting exports (export taxes, subsidies, and quotas), are discussed in this section. Their impact on the economy is measured following the traditional treatment of social welfare costs in economic theory, which implies the use of concepts of consumers' and producers' surpluses. Although the theoretical issue of the economic surplus approach is far from settled, the analysis proceeds within the traditional partial equilibrium framework of welfare costs that measure changes in consumers' and producers' surpluses.

The Partial Equilibrium Framework of Analysis

For each policy a price-quantity graph based on linear demand and supply curves is presented, and five types of effects (production, consumption, trade, revenue or expense, and redistribution) are indicated for each policy. Non-linearity can be introduced in the analysis without changing the qualitative directions of the effects although the absolute magnitudes would change.

The specific assumptions for the static partial equilibrium framework, extending those made by Corden (1971), are:

1) Pure competition, where domestic production has constant returns to scale and is vertically integrated.
2) An importable good is homogeneous and a perfect substitute of it is produced domestically. An exportable good is also homogeneous and is accepted in its respective domestic and international markets.

These changes in price and quantities generate changes in consumers' and producers' surpluses. Consumers' surplus decreases by STMK (from SDK to TDM) while producers' surplus increases by STLJ (from HSJ to HTL). The difference between these changes is partially a revenue to the government (FLMG) plus the residual triangle areas JLF and GMK that do not benefit any participant. The sum of these two areas is known as the deadweight loss, which is an estimate of the welfare loss due to the imposition of the tariff and is measured as the difference between the increase in producers' surplus and the decrease in consumers' surplus plus government revenue. The triangle JLF represents the incremental cost of producing domestically the importable good which falls on consumers. The fifth type of effect, called redistributional by Corden (1971), shows that consumers are paying producers STNJ more for the original quantity OA than before the tariff.

At the end, imposing a tariff implies that consumers subsidize producers and government by paying domestically higher than free-trade prices for an importable good. If a tariff already exists, its removal will benefit consumers who would then pay a lower price and consume more units; all the effects of the imposed tariff would be reversed directionally and there would be an efficiency gain.

2) Subsidy

Figure 4-2 depicts the effects of imposing an import subsidy on an importable good. A subsidy of ST per unit would imply a decrease in the price that consumers would pay from OS to OT. This decrease in price will cause production (curve HH') to fall by AA' (from OA to OA') and consumption (curve DD') to rise by BB' (from OB to OB'). Lower

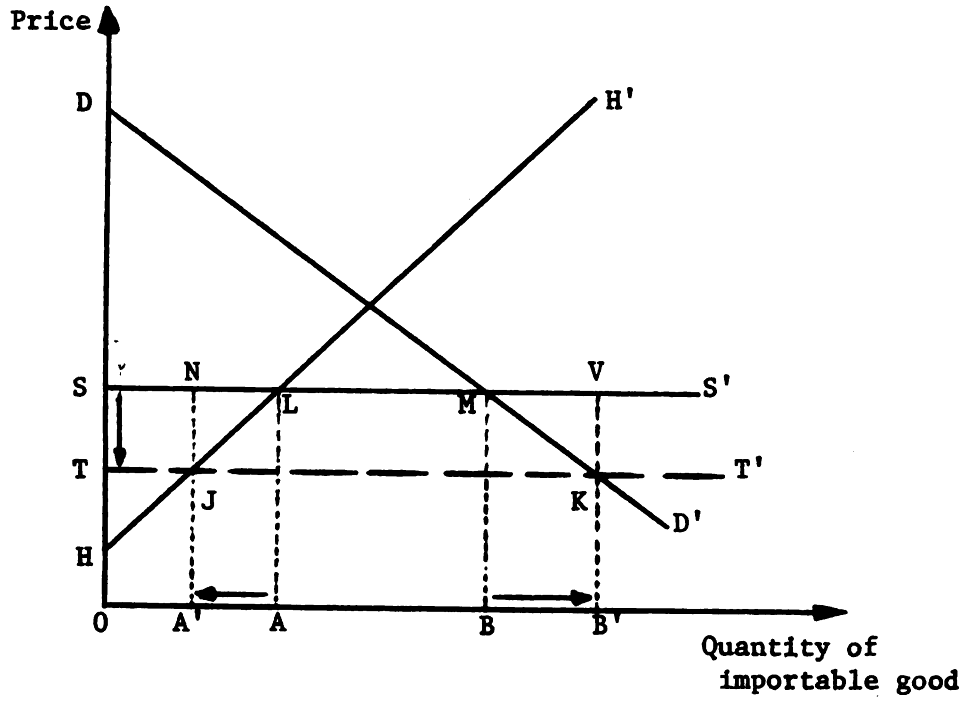

Figure 4-2: Import Subsidy

SS' = foreign supply curve of imports.
HH' = supply curve of domestic production.
DD' = domestic demand curve for importable good.
OS = unit price under free-trade.
OA = production level under free-trade.
OB = consumption level under free-trade.
AB = imports under free-trade.
ALMB = value of imports under free-trade.
ST/OS = import subsidy.
OT = unit price after imposing the subsidy.
OA' = production level after imposing the subsidy.
OB' = consumption level after imposing the subsidy.
A'B' = imports after imposing the subsidy.
A'NVB' = value of imports after imposing the subsidy.
JNVK = subsidy expense for the government.

The government's expense in paying the subsidy is JNVK. In this situation, as was the case for the import subsidy, there is no welfare cost in the sense of a deadweight loss because the changes in the economic surpluses as well as the subsidy are all received by someone. Producers' surplus increases by ETVG (from HEG to HTV) which is obtained from the decrease in consumers' surplus of ETNF (from EDF to TDN) and the subsidy paid by the government. Although only FNVG would had been necessary to obtain the increase in production, JNF plus GVK are extra payments that are made due to the per-unit uniformity of the subsidy, which is ET for each unit exported. Finally, there is a redistributional effect from consumers to producers; after the imposition of the subsidy consumers pay ETNJ more than originally for the same OB' units of the exportable good.

3) Quotas

The effects of export quotas are shown in Figure 4-6. Limiting the quantity of exports to BC = B'A' (from AB, decreasing by AA' plus BB'), producers face a demand curve (QQ') equal to the domestic demand curve (DD') plus the fixed quota (JQ = BC = B'A') for any price below the ED free-trade price. Domestic production falls by AA' (from OA to OA') while consumption increases by BB' (from OB to OB'). Since there is more quantity of the exportable good available for domestic consumption, its price decreases by EP (from OE to OP).

As in the case of import quotas, licenses to export need to be issued, either auctioned by the government or distributed without charge among exporters, creating a value of LFGM. Finally, there is a redistributional effect from producers to consumers of PEJN since producers deliver the

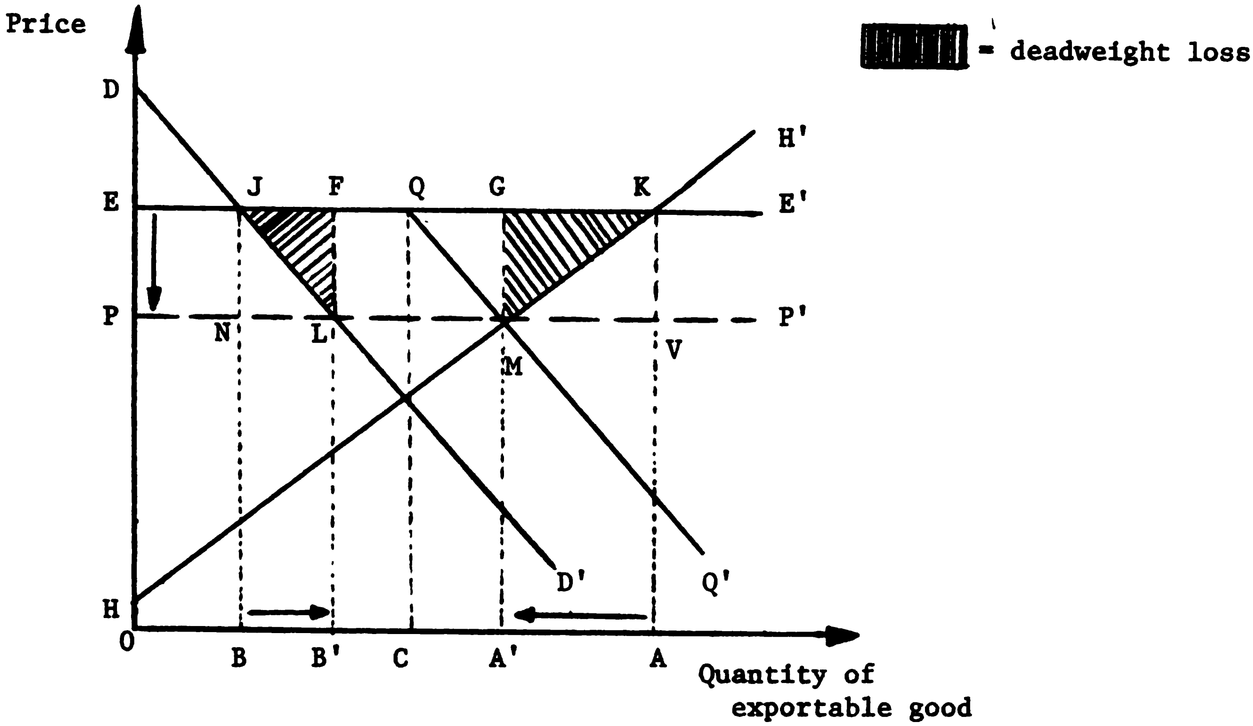

Figure 4-6: Export Quota

EE' = foreign demand curve for exports.
HH' = supply curve of domestic production.
DD' = domestic demand curve for exportable good under free-trade.
QQ' = domestic demand curve for exportable good after imposing the quota.
OE = unit price under free-trade.
OA = production level under free-trade.
OB = consumption level under free-trade.
BA = exports under free-trade.
BJKA = value of exports under free-trade.
BC = B'A' = export quota.
OP = unit price after imposing the quota.
OA' = production level after imposing the quota.
OB' = consumption level after imposing the quota.
B'A' = exports after imposing the quota.
B'FGA' = value of exports after imposing the quota.
LFGM = profits to license holders.
LJF + MGK = deadweight loss.

quantity OB after the quota is imposed at a lower than free trade price (OP).

A deadweight loss represented by triangles LJF and MGK is generated by the export quota because the loss in producers' surplus of PEKM (from HEK to HPM) is not offset by gains to consumers of PEJL (from EDJ to PDL) and by the holders of export licenses of LFGM (= LJQM) which leaves the residual triangles as a net social loss.

Summary of Effects of Trade Policies

The effects can be summarized in a table format. Table 4-1 lists seven types of effects for each trade policy. Changes in domestic prices production, and consumption are measured along given supply-demand relationships. The trade effect refers to the change in the quantity either imported or exported. The government revenue effect refers either to the state's revenue from, or the state's cost for, imposing the policy; in the case of the quantitative policies (quotas) this effect is zero. The redistributional effect is a transfer from consumers to producers, or vice versa, according to the change in domestic price before and after imposing a policy in relation to a given quantity purchased of the importable or exportable good. Finally, deadweight losses exist in the case of price policies and export quotas.

Equivalence of Trade Policies

In Table 1, several policies are seen to have directionally identical effects which leads to the issue of the equivalence of different trade policies. Takacs (1978) examined the equivalence of export quotas, tariffs, and import quotas under different institutional settings.

Table 4-1: Summary of Effects of Trade Policies

	Policy	EFFECTS						
		Domestic Price	Domestic Production	Consumption	Trade	Government	Redistribution	"Deadweight" Loss
IMPORTS	Tariff	↑	↑	↓	↓	revenue	C → P	Yes
	Subsidy	↓	↓	↑	↑	expense	P → C	No
	Quota	↑	↑	↓	↓	0	C → P	Yes
EXPORTS	Tax	↓	↓	↑	↓	revenue	P → C	Yes
	Subsidy	↑	↑	↓	↑	expense	C → P	No
	Quota	↓	↓	↑	↓	0	P → C	Yes

Symbols: ↑ = increase ↓ = decrease C = consumers P = producers

Note: The effects shown are for imposing a trade policy, all of which are directionally reversed and losses are gains when these policies are removed.

In Table 4-2, four institutional settings are compared. First, pure competition in the domestic production, importing and exporting markets is considered. Subsequent cases assume monopoly in one of the individual markets. In the cases of pure competition in all markets and monopoly in the importing market, tariffs and import quotas are equivalent with respect to their effects on domestic prices, import prices, and price discrepancies.

Takacs' own contribution to the equivalence issue was to show that under pure competition in all markets or with monopoly in domestic production, export quotas results in higher import prices than tariffs or import quotas. This indicates that a nation that acts to reduce imports by negotiating export quotas with its trade partners would be better off by utilizing tariffs or import quotas instead.

Other Trade Policies

Although the previous section covered policies both for imports and exports, economic literature has given more emphasis to discussion of trade policies affecting imports. This bias in the case of Latin American countries is illustrated in the work of Prebisch (1959) and the United Nations Economic Commission for Latin America. Prebisch considered industrialization as the way to conquer underdevelopment, and specifically promoted import substitution (IS) as the means to achieve industrialization. In contrast, an export promotion (EP) strategy had been a more recent addition to strategies recommended for developing countries.

The National Bureau of Economic Research (NBER), in a project directed by Bhagwati and Krueger (1973), recently sponsored an ambition study of

Table 4-2: Equivalence Between Tariffs and Import Quotas

Institutional Setting, Monopoly in:	Equivalence With Respect To:		
	Domestic Price	Import Price	Price Discrepancy
None	Yes	Yes	Yes
Domestic Production	No	Yes	No
Importing	Yes	Yes	Yes
Exporting	Yes	No	No

Definitions:

Domestic Price: price of the importable good in the importing nation.

Import Price: price of the importable good paid by the importing nation.

Price-Discrepancy: difference between domestic price and import price.

Source: Takacs (1978).

trade policies. Ten country studies were initially planned, of which nine have been published. The overall conclusions of the NBER project were reported by Bhagwati (1978) which he summarized as having "managed to provide fairly persuasive support to the proponents of the EP strategy."

The NBER project provides ample empirical evidence to support EP. An earlier project of the organization for Economic Co-Operation and Development (OECD) directed by Little, Scitovsky and Scott (1970), corroborates the NBER results in favor of EP policies. Thus, the issue of fostering economic growth and development, identified empirically with industrialization (the creation of value added) by means of the contrasting policies of IS and EP has been, according to these studies, relatively settled in favor of the EP strategy.

The NBER study defined an IS strategy as one where the effect of the foreign trade regime is make the ratio of effective exchange rate of exports respect to the effective exchange rate of imports less than one, as compared to the free-trade situation where this ratio is equal to one. It defines an EP strategy as one where, in contrast with the IS strategy, the rate of effective exchange rates is restored to unity. This IS concept as defined differs from the more conventional definition of IS as an increase in the proportion of an importable good that is supplied by domestic producers.

Based on the individual country studies of the NBER, Bhagwati (1978) presented a taxonomy of trade policies used in attempts to control imports and exports on current account. Quantitative policies affecting imports by means of the allocation of importing licenses were classified in four types: 1) the regulation of imports according to their source, due to aid-typing, bilateral trade agreements, preferential trade agreements (e.g., the

Andean Common Market), or the non-convertibility of currencies; 2) import regulation by commodity composition (itemwise specification) due again to aid-typing as well as to priority decisions (discouraging non-essential imports) and other reasons including the banning of "bad" goods such as heroin and reducing the probability of illegal capital flows, such as occurred in Colombia through the over-invoicing of used machinery; 3) the type and use of the importable good, including capital, intermediate, and consumer goods; and 4) payment conditions due to remittance tying, barter, and foreign credits.

Price and quantitative policies affecting imports were considered jointly in the countries studied in the NBER project. The price policies (predominantly used in Latin America to tax imports) included tariffs, "prior" (advance) deposits, sales taxes on importable goods, multiple exchange rates, and exchange auctions. The objectives of these policies included the use of tariffs to mop up extra profits on the import licenses, to generate fiscal revenues, to protect domestic industries, and to improve the balance of payments deficit.

With respect to trade policies affecting exports, these were found to be much simpler and applied only sporadically as compared to policies affecting imports. Among the quantitative policies affecting exports, the surrender of receipts to the exchange authority was the most common. Only occasionally were exports regulated according to their destination or by their composition. Price policies affecting exports were divided into direct (cash) subsidies and taxes and indirect subsidy and tax schemes. The indirect schemes received more emphasis than the direct ones, mainly subsidizing those who successfully exported by channeling the extra profits created by the policies to them. Rebates, drawbacks, and also marketing and credit advantages were found in the NBER project to be widely used schemes.

Although the list of trade policies used by the countries included in the NBER project was long, the most important are among the six policies analyzed earlier. Import quotas, allocated through fairly complex licensing schemes, is the most widely used quantitative trade policy. The main issue here lies in the distribution of the revenue gain generated by imposing a quota (represented by area FLMG in Figure 4-3). The problem rises as to how to make sure that these gains go to the intended recipients when the quota is applied. Tariffs are the main price policy affecting imports while indirect subsidy schemes are most often used for exports. Indirect subsidies are usually coordinated with import licenses. Export price policies as well as direct taxes and subsidies are used in reduced scale and export quotas were found to be used only occasionally.

Van de Wetering (1980) used a general equilibrium framework for modeling the interaction of commodity and factor markets in order to evaluate the incidence of an export tax in terms of predicted changes in factor employments, factor prices, production, commodity prices, factor incomes, commodity earnings, and tax revenue. A six equation model with a numberical example was presented but no specific empirical application was given. Elasticity values are crucial in this type of model. With minor variations in the equations, a variety of policies could be analyzed and their incidence measured.

The interaction of different trade policies implemented simultaneously in a nation is very complex and also surpasses the analytical capability of a static partial equilibrium framework. No general conclusions can be given, leading instead to the need for specific case studies.

<u>Formulas for Estimation of Welfare Effects</u>

Earlier, the welfare cost of imposing a trade policy was represented by the deadweight loss (when imposing the policy) or gain (when removing the policy). In their present section some simple formulas to calculate the value of such deadweight losses are given for the tariff case. Table 4-3 summarizes the deadweight losses for each of four policies in which they occur, a set loss in either consumers' or producers' surplus that is offset by gain to other participants.

The formulas and terminology presented here were taken from Dardis and Learn (1967). The deadweight area under the domestic supply curve (empirically a function of the price of the importable or exportable good according to the case) is called the production cost while the deadweight area under the compensated demand curve (empirically a function of the respective price of the importable or exportable good and personal income) is called the consumption cost.

The formula to calculate the <u>production cost</u> is:

(1) $PC = 1/2\ t^2\ \eta\ V^s$

where (for the tariff of Figure 4-1):

PC = production cost (JLF)

t = percentage tariff rate ST/OS

η = elasticity of the supply curve (HH') of domestic production

V^s = value of domestic production under the tariff (OTLA')

Table 4-3: Welfare Costs of Trade Policies

	Trade Policy	Deadweight Loss Area	
		Production Cost	Consumption Cost
IMPORTS	Tariff (Figure 1)	JLF	GMK
	Quota (Figure 3)	JLF	GMK
EXPORTS	Tax (Figure 4)	LJF	MGK
	Quota (Figure 6)	LJF	MGK

Source: Figures 4-1, 4-3, 4-4, and 4-6

The formula to calculate the consumption cost is:

$$(2) \quad CC = 1/2\ t^2\ V^d\ (\varepsilon - y\ \frac{V^d}{Y})$$

where (for the tariff of Figure 4-1):

CC = consumption cost (GMK)

V^d = value of consumption under the tariff (OTMB')

ε = elasticity of the domestic demand curve (DD')

y = income elasticity

Y = personal income

Adding PC and CC gives us the welfare cost of imposing the trade policy:

$$(3) \quad WC = PC + CC = 1/2\ t^2\ \eta\ V^s + 1/2\ t^2\ V^d\ (\varepsilon - y\ \frac{V^d}{Y})$$

where (for the tariff of Figure 4-1):

WC = welfare cost (JLF + GMK) = deadweight loss

Empirical Studies

In this final section two specific examples of calculations of the welfare cost of imposing a tariff on agricultural goods in several European countries and the U.S. are reviewed.

Trade policies have also been studied in the context of industrialization and development by OECD and World Bank projects. These empirical studies as well as the most recent one sponsored by the NBER will also be discussed in this section.

1) Tariffs on Agricultural Products

Dardis and Learn (1967) calculated the welfare cost of a tariff equivalent (various trade restrictions are lumped together and expressed in terms of a percentage tariff) imposed on wheat imports of six European countries and the U.S. in 1960. These authors used the respective ordinary uncompensated demand curve for wheat because wheat when used as food is only a small fraction of total expenditures. For this reason the income term of formula (3) is dropped leading to the following formula, used to estimate the welfare cost:

$$(4)\quad WC = 1/2\ t^2\ (\eta\ V^s + \varepsilon\ V^d)$$

To obtain the percentage tariff equivalent (t), the difference between the domestic producers' price (P) and the trade price (T) was taken and then divided by the domestic producers' price. A crucial assumption made by the authors in their calculations is that the elasticities of the demand curve (ε) and supply curve (η) are equal to .5. This assumption simplifies formula (4) even more to:

$$(5)\quad WC - 1/2\ t^2\ (\ .5)(V^s + V^d) = .25\ t^2\ (V^s + V^d)$$

Table 4-4 was constructed based on the results Dardis and Learn published. Domestic production and consumption were valued at export prices. Using the figures of this table and formula (5), the welfare cost in 1960 of the tariff equivalent in Denmark was:

$$WC = (\ .\ 25)\ (\ .22)^2\ (52.5) = \$U.S.\ 600{,}000.$$

Dardis (1967a) also calculated the welfare cost of the tariff system applied to grains (summation of wheat, barley, and oats) in the United Kingdom for 1959-60. The British system of deficiency payments

Table 4-4: Welfare Cost of a Tariff on Wheat, 1960

Country	(1) Producer price P ($US per ton)	(2) Trade price T ($US per ton)	(3) Percentage tariff $t=\left(\frac{P-T}{P}\right)100$ (%)	(4) Value of domestic production and consumption $(V^s + V^d)$ (mill. $US)	(5) Welfare cost (WC**) (mill. $US)
Denmark	72.6	56.9	22	52.5	0.6
France	75.6	64.5	15	1,584.7	9.2
Italy	111.7	63.3	43	1,798.0	80.9
Netherlands	80.3	56.6	30	140.7	3.2
United Kingdom	73.6	61.8	16	216.0	1.4
United States	64.3	62.1	3	3,220.0	0.5
West Germany	99.2	59.1	40	1,112.4	44.5

Sources: Dardis and Learn (1967).

Column (1): a) ECE/FAO, Prices of Agricultural Products, and
b) Fertilizers in Europe 1961/62; UN Geneva (1963)
USDA, Agricultural Prices: 1963 Annual Summary; Government Printing Office, Washington (1964)

Column (2): FAO, Trade Yearbook, 1963; FAO, Rome (1964) (Since some of countries import while others export wheat, according to the case, the respective price was employed).

Column (4): a) FAO, Production Yearbook, 1962; FAO, Rome (1963)
b) FAO, Trade Yearbook, 1963; FAO, Rome (1964)
c) IWC, World Wheat Statistics; IWC, London (1963)
d) CEC, Grain Crops: 1963 ; Her Majesty's Stationary Office, London (1963)
e) USDA, Agricultural Statistics 1963 ; Government Printing Office, Washington (1963)

resulted in equality between the welfare cost and the production cost. Formulas (1) and (3) are equal while formula (2) is equal to zero in this specific case. Several statistical forms of the supply curve of domestic production were estimated by Dardis which resulted in different values of the supply elasticity. Table 4-5 contains part of the data presented by her to estimate the production cost using formula (3). Multiple regression with seven variables explaining grain production was used to estimate the value of the supply curve parameter (η). For example, the production cost calculated with the first linear equation (Q) of Table 4-6 would be:

$$PC = 1/2\ t^2\ \eta\ V^s = 1/2\ (\ .22)^2(\ .27)(252.09) = \text{Br. £}\ 1.63 \text{ million}$$

These two empirical examples illustrate elasticity estimates are crucial in the welfare cost calculations and that the welfare losses are sensitive to the elasticity value.

The inclusion of intermediate goods complicated the analysis which Dardis (1967b) did for the feed and livestock sectors of West Germany. A similar type of situation, where intermediate goods are imported, arises for raw wool in the U.S. Dardis and Dennison (1969) calculated welfare costs under different policy options and concluded that deficiency payments are the most beneficial as compared to direct and compensatory tariffs.

The effects of alternative trade policies adopted by the European Economic Community (EEC) for winter oranges was initially analyzed in terms of spatial equilibrium models and welfare costs by Dean and Collins (1966, 1967). Later, Zusman, Melamed and Katzir (1969) extended and updated the initial work of Dean and Collins. Initially, tariffs were the main trade

Table 4-5: Production Cost of a Tariff on Grains in the United Kingdom, 1959-1960

Equation Form of the Supply Curve	Percentage Tariff t	Value of Domestic Production V^s (mill.£)	Elasticity of Supply η	Production Cost PC (mill.£)
linear (a)	.22	252.09	.27	1.63
log. linear (b)	.22	252.09	.73	4.42
log. linear (c)	.22	252.09	.49	2.96
linear (d)	.25	252.49	.44	3.56
linear (e)	.25	252.49	.75	6.06
predet. η, t (f)	.22	252.49	1.	6.05
predet. η, t (g)	.25	252.49	1.	8.08

Source: Dardis (1967a).

policy applied to winter oranges and the alternatives were reference prices and a countervailing charge mechanism. Both studies arrive at similar results: the price of winter oranges would rise within the EEC block while government and producer gains would surpass losses to consumers, evaluated in terms of economic surpluses.

2) <u>Trade Policies and Industrialization</u>

The World Bank, the OECD, and the NBER have each sponsored large scale projects to analyze trade policies in the context of industrialization and development. The World Bank project directed by Balassa (1971) included country studies for Brazil, Chile, Mexico, West Malaysia, Pakistan, the Philippines and Norway. I.M.D. Little, T. Scitovsky, and M.F.G. Scott (1970) undertook the OECD project which published country studies for Brazil, Mexico, India, Pakistan, the Philippines and Taiwan. The most recent of the three projects, sponsored by the NBER and directed by Bhagwati and Krueger (1973), published individual country studies for Chile, Colombia, Egypt, Ghana, India, Israel, South Korea, the Philippines, and Turkey.

The World Bank study was the most specific of these three projects and dealt mainly with standardized estimates of effective protection rates, which is the subject of the next section. Utilizing implicit tariff estimates, generally the difference between foreign and domestic prices of importables, the IBRD project concluded that the manufacturing sector was highly protected relative to the primary sector in most of the countries studies.

The OECD project was more comprehensive and detailed in its country studies, and emphasized the efficiency losses associated with protection and import substitution policies. The country studies of the NBER project examined export performance in depth, and systematically analyzed changes in the exchange control regime over time and the conditions determing the outcomes of liberalization attempts, and looked more systematically at the dynamic arguments relating to investment, innovation, and savings in relation to the foreign trade regime.

The Estimation of Effective Protection Rates

The concept of effective protection arises when purchased produced inputs are utilized in domestically produced outputs. Such inputs may be subject to taxes, subsidies, or quotas that will affect their prices as well as the value added at different stages of the domestic production process. Differences between domestic and world market prices are due to the protection structure (taxes, subsidies, quotas) in a specific country.

When nominal protection rates are calculated for identified products, they do not consider the effects of tariffs on the cost of inputs. The resource allocation effects of a tariff structure are thus "hidden" when observing only nominal protective rates and, as Corden (1966) states, it is the protective rate for each activity that is most relevant. Balassa (1971a) defined the rate of nominal (output or product) protection as the "percentage excess of the domestic price over the world market price, resulting from the application of protective measures". He further defined the rate of effective (value added) protection as the "percentage excess of domestic value added, obtainable by reason of the imposition of tariffs and other protective measures on the product and its inputs, over foreign or world market prices." Consumer decision will be affected by the nominal rate of protection while producer decisions will be affected by the effective rate of protection. Corden (1966) gave a similar definition for the concept of effective protection as "the percentage increase in value added per unit in an economic activity which is made possible by the tariff structure relative to the situation in the absence of tariffs but with the same exchange rate". The rate of effective protection is a function not only of the tariff on the output produced by the activity but also of the input coefficients and the tariffs on the inputs.

Partial Equilibrium Estimation

Combining the partial equilibrium assumptions made by Balassa (1971b) and Corden (1971) gives:

1) Pure competition and constant returns to scale in production.
2) Physical input-output coefficients same for all firms.
3) The foreign elasticities of demand for all exports and supply of all imports are infinite (small-country assumption).
4) Trade continues after the imposition of taxes, subsidies or quotas so that the internal price is given by world market price plus protection; domestic factor prices do not change.
5) Zero elasticity of substitution between inputs.
6) Transportation costs are nil.

Following Corden (1971), domestic and foreign supply and demand curves for an output and its only input are shown in Figure 4-7. The units are such that one unit of input is required to produce one unit of output, this relation given by the fixed input coefficients. The foreign supply curves are SS' for the output and GG' for the input (infinitely elastic). OS and OG are the free trade c.i.f. import prices of the output and input, respectively. The value added to the input is GS (output = input + value added = OS = OG + GS). The tariff rate ST/OS is the nominal protection rate on the output, which does not account for the tariff GF on its input. The effective protection rate on the output is (FT - GS)/GS, the proportional change of value added domestically (FT - GS or ST - GF) under protection in

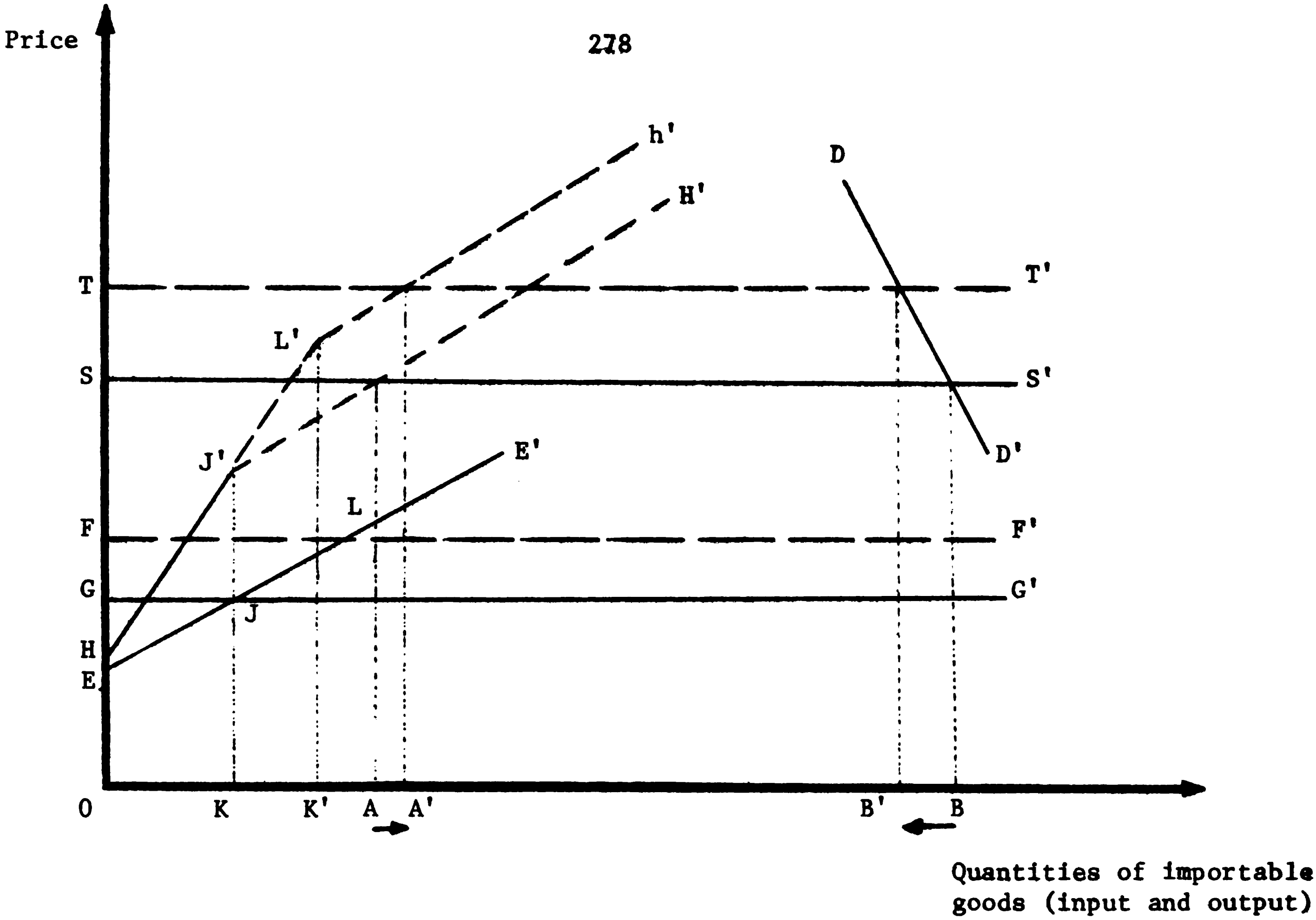

Figure 4-7: Effective Protection of Importable Goods

SS' = Foreign supply for the output.
GG' = foreign supply for the input.
OS = free trade c.i.f. import price of the output.
OG = free trade c.i.f. import price of the input.
GS = free trade value added.
ST/OS = nominal protection rate (tariff) on the output.
GF/OG = nominal protection rate (tariff) on the input.
(FT-GS)/GS = effective protection rate on the output.
DD' = domestic demand for the output.
EE' = domestic supply of the input.
HJ'H' = domestic supply of the output under free trade.
EJG' = total supply of the input under free trade.
OB = domestic consumption of the output under free trade.
OA = domestic production of the output under free trade.
OK = domestic production of the input under free trade.
KA = imports of the input under free trade.
AB = imports of the output under free trade.
HL'h' = domestic supply of the output under protection.
ELF' = total supply of the input under protection.
OB' = domestic consumption of output under protection.
OA' = domestic production of the output under protection.
OK' = domestic production of the input under protection.
K'A' = imports of the input under protection.
A'B' = imports of the output under protection.

relation to value added in the world market (GS) with no protection. Had there been no tariff on the input, the effective protection rate for the product would be (GT - GS)/GS = ST/OS, which is equal to the nominal protection rate.

Incorporating the domestic demand for the output (DD') gives OB as the free trade consumption level and the domestic supply of input (EE') gives OK as the free trade domestic production level. The domestic supply curve of the output (HJ'H') is the result of the vertical addition of the supply curve of the input that producers face (EJG' since after OK of domestic production, the input will be imported along GG') and the supply curve of value added to the input (kinked at J' because the input is imported after that level). Under free trade, OA units of output are produced domestically requiring KA imports of the input and AB imports of the output.

Consider now the situation where tariffs are imposed on both the output and an input. The former (ST) causes a decrease in domestic consumption to OB'. Since a tariff (GF) is also imposed on the input, domestic production of the input increases to OK'. The supply curve of the output shifts (from HJ'H to HL'h') due to the shift of the input supply curve (from EJG' to ELF') as a result of the tariff imposed. The vertical distance between the supply curves HJ'H' and HL'h' at L' is the tariff on the input (GF). The effects of these shifts is to increase the domestic production of output to OA', decrease the level of output imports to OB', and change the imports of the input from KA to K'A'.

The significance of effective protection for the output is that it affects only its level of production and not its consumption nor the consumption of its input. Production of the output depends also on the elasticity of the value-added supply curve (HJ'H' or HL'h'). Finally, under the small-country assumption, the effective protection rate for an output is not influenced by protective measures (tariffs) on inputs to its inputs, i.e., it is necessary to go only one stage upward or downward in the input-output structure.

The relationships between the effective protection rate on an output, its own nominal protection rate, the nominal protection rates on its inputs, and the shares of the inputs in the cost of the output (OG/OS in Figure 4-7) can be expressed and generalized in algebraic form. The following formulas summarizing these relationships were taken from Corden (1966, 1971) and Balassa (1971a):

$$(6) \quad E_{jf} = \frac{V_j - W_j}{W_u} = \frac{T_j - \sum_i F_{ij} T_i}{1 - \sum_i F_{ij}} \qquad i = 1,2,\text{---}n$$

$$(7) \quad E_{jd} = \frac{V_j}{W_j} - 1 = \frac{P_{jd} - \sum_i D_{ij}}{\frac{P_{jd}}{1+T_j} - \sum_i \frac{D_{ij}}{1+T_j}} - 1 \qquad i = 1,2,\text{---}n$$

where

j = output

i = input

W_j = free-trade value added (at world market prices) per unit of j in activity j

V_j = domestic value added (at domestic prices under a protection structure of tariffs, subsidies and taxes) per unit of j

E_{jf} = free-trade effective protection rate for activity j

E_{jd} = domestic effective protection rate for activity j

P_{jd} = domestic nominal price of a unit of j (in domestic currency)

F_{ij} = free-trade share of i in the cost of j (at world market prices)

D_{ij} = domestic share of i in the cost of j (at domestic prices under the existing protection structure)

T_j = nominal protection rate on j

T_i = nominal protection rate on i

The difference between formulas (6) and (7) is that formula (6) uses the free-trade valued share of the input(s) in the cost of the output (F_j) while formula (7) uses the domestically valued share (D_{ij}). Looking at Figure 4-7 again, this means that formula (6) refers to OG/OS and formula (7) refers to OF/OT. This difference is crucial in empirical studies since the physical input-out coefficients available for LDCs are usually those existing under an already implementated protection structure. The two formulas would give the same results only under the strong assumption of constant fixed coefficients for both the free-trade and protection situations. When using formula (1) the free trade price of the output is taken as unity. Formula (2) has the disadvantage that free-trade value-added ($-W_j$) can be negative since it is derived by deflating domestic values (observed directly) of the domestic price of output (P_{jd}) and the domestic value of imports per unit of output (D_{ij}) by the relevant price ratios.

The implications of these two formulas for calculating the effective protection rate (E_j, dropping the subscripts f and d) are:

1) If $T_j = T_i$, then $E_j = T_j = T_i$. When the nominal protection rates of the output and the input are equal there is no divergence between the nominal and the effective protection rate of the output. (If the absolute protection for output and input were equal, the effective protection rate would be zero).

2) If $T_j > T_i$, then $E_j > T_j > T_i$, and if $T_j < T_i$, then $E_j < T_j < T_i$. When the nominal protection rate of the output is greater (less) than the nominal protection rate of the input; the effective protection rate of the output is greater (less) than its own nominal protection rate.

3) If $T_j < (F_{ij} \cdot T_i)$, then $E_j < 0$. If the nominal protection rate of the output is less than (equal to) the free-trade share of the input in the cost of the output multiplied by the nominal protection rate of the input, the effective protection rate of the output will be negative (zero).

4) If $T_j = 0$, then $E_j = -(T_j \cdot \frac{F_{ij}}{1-F_{ij}})$ When the nominal protection rate is zero for the output and positive for the input, the effective protection rate for the output is necessarily negative.

5) If $T_i = 0$, then $E_m = \frac{T_j}{1-F_{ij}}$ This is the formula for the effective protection rate of the output when the input is not nominally protected (zero nominal rate). In this case the output's effective protection rate must be higher than its nominal protection rate because F_{ij} is always less than unity.

A numerical example will illustrate the use of formulas (6) and (7). Empirical studies on protection rates are usually complicated because they are done for many products with many inputs each. Unfortunately most of the published studies give methodology, results, and conclusions but not the data used.

This example involves a metallic shelf that is painted and then assembled manually with screw bolts. The product (metallic shelf) uses 5 items as inputs: sheet metal, paint, screw bolts, electricity, and labor.

Labor is considered the only item of value added by the manufacturer of the shelf. The shelf has a free-trade price (P_{jf}) of $180 per unit.

Table 4-6 contains the basic data used in the calculations. Each item (inputs and value added) is assigned an identification number (i), and the units in which they are measured is also shown. The free-trade effective protection rate for output j (metallic shelf) using formula (1), requires F_{ij} to be calculated multiplying the free-trade physical input-output coefficient (f_{ij}) by the ratio of free-trade (world market) prices of the input (P_{if}) to that of the output (P_{jf}). These were converted to domestic currency (pesos) using an exchange rate of 20 pesos per dollar. The relationship between these variables is as follows:

$$F_{ij} = f_{ij} \cdot \frac{P_{if}}{P_{jf}}$$

In Table 4-6, the physical input-output coefficients f_{ij} are expressed in terms of units of each item per metallic shelf (output unit). Table 4-6 also shows the free-trade prices of inputs, P_{if}, expressed in pesos per input unit. The last column in this table shows the nominal protection rate (T_i for the first three items; the other two are not protected.) These nominal protection rates are the percentage differences between domestic and import prices. This concept of "implicit tariff" takes into account both price and nonprice (quantitative) measures of protection and as such rarely coincides with the percentage nominal tariff. The "implicit tariff" for the shelf is 30% over its free trade price (T_j = .3). The other variables used for calculations with formula (1) are presented in Table 4-7. Substituting the corresponding data from tables in formula (1) gives:

Table 4-6: Data on the Inputs for a Metallic Shelf

i	Item	Units	f_{ij} (Units per shelf)	P_{if} (Pesos)*	T_i (Percentage)
1	sheet metal	square meters	1.5	54	.15
2	paint	liters	.6	36	.35
3	screw bolts	units	10	.18	.10
4	electricity	kilowatts	.25	72	
5	labor	hours	1.6	36	

Source and symbols: See text.

*An exchange rate of 20 pesos per dollar was used to convert these prices which originally were expressed in dollars.

Table 4-7: Calculations for the Effective Protection Rate

i	P_{if}/P_{jf}	$F_{ij} = f_{ij} \times (P_{if}/P_{jf})$	$f_{ij}P_{if}$	$f_{ij}P_{if}(1+T_i)$	$F_{ij} \times T_i$
1	.3	.45	81	93.5	.0675
2	.2	.12	21.6	29.16	.042
3	.001	.01	1.8	1.98	.001
4	.4	.1	18	18	0
5	.2	.32	57.6	57.6	0
Shelf		1.00	180		

Source and symbols: See text.

$$E_{jf} = \frac{T_j - \sum_{i}^{4} F_{ij}T_j}{1 - \sum_{i}^{4} F_{ij}} = \frac{.3 - (.0675 + .042 + .001 + 0}{1 - (.45 + .12 + .01 + .1)} =$$

$$\frac{.3 - .1105}{1 - .68} = \frac{.1895}{.32} = .5922 = 59\%$$

With the information provided in Tables 4-6 and 4-7 it is also possible to estimate E_{jf} by calculating directly the value added at free-trade prices (W_j) and at domestic prices (V_j) by subtracting the corresponding value of the inputs from the relevant price in the following way:

$$W_j = P_{jf} - \sum_{i}^{4} f_{ij}P_{if} = 180 - (81 + 21.6 + 1.8 + 18) = 180 - 122.4 = 57.6$$

$$V_j = P_{jd} - \sum_{i}^{4} f_{ij}P_{if}\ (1 + T_i) = P_{jf}\ (1 + T_j) - \sum_{i}^{4} f_{ij}P_{if}\ (1 + T_i)$$

$$= 180\ (1 + .3) - (93.5 + 29.16 + 1.98 + 18) = 234 - 142.64 = 91.36$$

$$E_{jf} = \frac{V_j - W_j}{W_j} = \frac{91.36 - 57.6}{57.6} = \frac{33.76}{57.6} = .5861 = 59\%$$

Both forms of estimating formula (6) result in an estimate of the effective protection rate of 59%.

In order to apply formula (7) a different set of physical input-output coefficients would be necessary instead of f_{if}. This different set would reflect the distortions of the existing domestic protective structure. These domestic physical input-output coefficients (d_{id}) would be related to D_{ij}, the domestic share of input in the cost of the output, through the ratio of the domestic price of the input (P_{id}) to that of the output (P_{jd}) in the following way:

$$(3)\quad D_{ij} = d_{id} \cdot \frac{P_{id}}{P_{jd}}$$

Once D_{ij} is obtained, substituting the corresponding values in formula (7) is straightforward.

Non-traded Inputs

A protected industry using non-traded inputs will demand more of these inputs than when not protected. Such increased demand may cause an increase in the price of non-traded inputs since they are not subject to international competition as are traded inputs. An increase in the demand for traded inputs will not affect their price due to the assumption of infinite elasticity for their supply curves. In the numerical example, electricity (item 4) is a typical non-traded input where higher requirements of electrical energy by the protected manufacturer of metallic shelves may cause an increase in the price of electricity.

Both Corden (1966), and Balassa (1971b) have proposed methods for handling non-traded inputs. Corden includes the value added in the production of non-traded inputs with the value added in the manufacturing of the output so that the effective protection is calculated with respect to the sum of both. As an alternative, Balassa treats non-traded inputs as traded inputs with zero effective protection, which assumes that all inputs have infinitely elastic supply curves, i.e., that non-traded inputs are supplied at constant costs.

Referring again to the earlier numerical example, the effective protection rate with free-trade input-output coefficients of 59% was obtained with the

Balassa method where traded and non-traded inputs are treated equivalently. The corresponding formula for the Corden method is as follows:

$$(8) \quad E'_{jf} = \frac{V_j - W_j}{W_j + V_i}$$

where

E'_{jf} = effective protection rate for activity j using the Corden method of incorporating non-traded inputs

V_i = domestic value added per unit of non-traded j

This formula requires that the value added of the only non-traded input (electricity), be added to the free-trade value added in the denominator. Assuming \$3.78 pesos as value added in generating electricity the new estimate of the effective protection rate with the Corden method is:

$$E'_{jf} = \frac{V_j - W_j}{W_j + V_i} = \frac{21.36 - 57.6}{57.6 + 3.78} = \frac{33.76}{61.38} = .55 = 55\%$$

Thus, only difference between the methods when using formula (6) is in the denominator where the Corden method requires the addition of the cumulated value added of the non-traded inputs. Since this term is always positive, a positive (negative) effective protection rate will be smaller (larger) when using the Corden method. In other words, as long as there are non-traded inputs in an output, the Balassa method will give higher effective rates of protection than the Corden method.

Net Effective Protection

Under an existing protection structure, balance-of-payments equilibrium is often maintained at a lower exchange rate than would be possible under free trade. When the protection structure is removed a devaluation of the exchange rate is necessary to cover the resulting external deficit. The objective of estimating net effective protection rates is to incorporate the effects of over-valued exchange rates prevailing under protection structures as compared to free-trade rates.

Balassa (1971b) presented two alternative approaches to deal with this adjustment. One approach is to recalculate the effective rate of protection by expressing world market values in domestic currency at the free trade exchange rate. The alternative approach, which was used in country studies by Balassa and Associates, (1971), is to adjust the effective rate calculated at the exchange rate prevailing under a protective structure for the extent of overvaluation under free-trade conditions. The formulas needed in the estimation of the net effective protection are:

$$(9) \quad T_{jn} = \frac{P_{jd}}{P_{jf}} - 1 = (1 + T_j) \frac{R_d}{R_f} - 1$$

$$(10) \quad P_{jd} = P_{jw} \cdot R_d (1 + T_j)$$

$$(11) \quad P_{jf} = P_{jw} \cdot R_f$$

$$(12) \quad \frac{R_f}{R_d} = \frac{\eta_s V_x + \varepsilon_m V_m + U}{\frac{\eta_s V_x}{1 + S} + \frac{\varepsilon_m V_m}{1 + T}}$$

and

$$(13) \quad \eta_s = \frac{\eta_x (\varepsilon_x - 1)}{\eta_x + \varepsilon_x}$$

where

T_{jn} = net nominal protection rate on j

P_{jd} = domestic nominal price of a unit of j under a protective structure

P_{jf} = free-trade nominal price of a unit of j (in domestic currency)

R_d = actual exchange rate under protection

R_f = free-trade exchange rate

η_s = supply elasticity of foreign exchange

η_x = supply elasticity of exports

ϵ_x = demand elasticity for exports

ϵ_m = demand elasticity of import

V_x = actual value (at present exchange rate) of exports

V_m = actual value (at present exchange rate) of imports

S_j = export subsidy on good j

T_j = import tariff on good j

U = unplanned deficit in the balance-of-payments

Formula (9) relates the net nominal protection rate (T_{jn}) to the nominal protection rate (T_j), and the exchange rates that create the need for the adjustment. Formula (12) is the devaluation rate necessary to cover the deficit in the balance-of-payments due to the changes in the value of exports (decreasing, because of lower prices in domestic currency) and imports (increasing, because more units of domestic currency per unit of foreign currency are required) that occur when the protective measures are eliminated. If we assume that the balance-of-payments is initially in equilibrium then U in Formula (12) will be equal to zero. More usually, U will be positive.

Formula (12) shows the sensitivity of the devaluation rate to the values of the various elasticities. The effects of a devaluation depend on the price elasticities of imports and exports of a country since both types of outputs are affected. For this reason export subsidies also need to be included in the formula. Once an estimate of the devaluation rate is calculated using formula (12) net nominal protection rate can be obtained from (9) and used in either formulas (6) or (7) to obtain the net effective protection rate (E_{jn}).

Referring once more to the metallic shelf example, the estimated effective protection rate of 59% can be adjusted for over-valuation. Assume the balance-of-payments of the country where the shelves are manufactured to be initially in equilibrium (U = 0). Also assume that the value of total exports is equal to the value of total imports ($V_x = V_m$).

The following elasticites are assumed: X is 11, ε_m is 3, and ε_x is 2. The exchange rate under the present protection measures is 20 pesos per dollar. To promote exports the government grants an export subsidy (S) averaging 10% while the nominal protection rate (T) averages 30%. Substituting all these numbers in formula (12) results in the following devaluation rate:

$$\frac{R_f}{R_d} = \frac{\eta_s V_x + \varepsilon_m V_m + U}{\frac{\eta_s V_x}{1+S} + \frac{\varepsilon_m V_m}{1+T}} = \frac{.85V_x + 3V_x + 0}{\frac{.85V_x}{1 + .1} + \frac{3V_x}{1+.3}} = \frac{3.85V_x}{\frac{4.41V_x}{1.43}} = \frac{5.51}{4.4} =$$

$$1.2523 = 25\%$$

where

$$V_x = V_m; \; U = 0$$

$$\eta_s = \frac{\eta_x(\varepsilon_x - 1)}{\eta_x + \varepsilon_x} = \frac{11(2-1)}{11+2} = \frac{11}{13} = .85$$

This devaluation rate is now substituted in formula (9) to obtain the net nominal protection rate on the metallic shelf (j) as follows:

$$T_{jn} = (1+T_j)\,\frac{R_d}{R_f} - 1 = (1+.3)\,\frac{1}{1.25} - 1 = (1.3)\;(.8) - 1 =$$

$$1.04 - 1 = .04 = 4\%$$

Knowing the devaluation rate which estimates the extent of over-valuation of the actual exchange rate (25% for our example), we can calculate the net effective protection rate of metallic shelves using the Balassa method (considering non-traded inputs as traded inputs with zero effective protection) with the following formula:

$$(14)\quad E_{jn} = \frac{R_d\;(1 + E_{jf})}{R_f} - 1$$

where

E_{jn} = net effective protection rate for activity j

Substituting in formula (14) the information presented above gives us the following result:

$$E_{jn} = \frac{R_d\;(1 + E_{jf})}{R_f} - 1 = \frac{1}{1.25}\;(1 + .59) - 1 = (.8)\;(1.59) - 1 =$$

$$1.272 - 1 = .272 = 27\%$$

Alternatively, the same result is obtained if the net nominal protection rates (T_{in} and T_{jn}) for each input and for the output calculated using formula (9) are substituted in formula (5) for the nominal protection rates (T_i and T_j). These rates (Table 4-a) can then be substituted in (5):

$$E_{jn} = \frac{T_{jn} - \sum_{i}^{4} F_{ij}\, T_{in}}{1 - \sum_{i}^{4} F_{ij}} = \frac{.04 - (-.036 + .01 - .001 - .02)}{1 - (.45 + .12 + .01 + .1)} =$$

$$\frac{.04 - (-.047)}{1 - .68} = \frac{.087}{.32} = .272 = 27\%$$

Using either formula (10) or re-estimating formula (5) gives the same result of a net effective protection rate of 27%.

To obtain the net effective protection rate using the Corden method, it is necessary to substitute the net effective rates T_{in} and T_{jn} for the effective rates T_i and T_j in formula (8). The net rate according to Corden's method (combining value added in producing inputs with value added in manufacturing the output), is found using the following formula:

$$(15) \quad E'_{jn} = \frac{V_{jn} - W_j}{W_j - V_i}$$

where

E'_{jn} = net effective protection rate for activity j using the Corden method

Table 4-a: Net Effective Protection Rate: Balassa Method

i	T_i	$T_{in} = (1+T_i)\frac{R_d}{R_f} - 1$	F_{ij}	$T_{in} \cdot F_{ij}$ '
1	.15	-.08	.45	-.036
2	.35	+.08	.12	.01
3	.1	-.12	.01	-.001
4	0	-.02	.1	-.02

Source and symbols: See text.

Table 4-b: Net Effective Protection Rate: Corden Method

i	$f_{ij}P_{if}$	$f_{ij}P_{ij}\ (1+T_{in})$
1	81	74.52
2	21.6	23.33
3	1.8	1.58
4	18	14.4
5	57.6	57.6

Source and symbols: See text.

Substituting the data presented in Table 4-b in formula (15) gives:

$$E'_{jn} = \frac{V_{jn}-W_j}{W_j-V_i} = \frac{73.37 - 57.6}{57.6 + 3.68} = \frac{15.77}{61.28} = .257 = 26\%$$

where

$$V_{jn} = P_{jf}(1+T_{jn}) - \sum_{i}^{4} f_{ij} P_{if} (1 + T_{in}) = 180(1 + .04) -$$

$$(74.52 + 23.33 + 1.58 + 14.4) = 187.2 - 113.83 = 73.37$$

Table 4-8 presents all the estimates of protection rates for the metallic shelf estimated by both methods.

Table 4-8: Protection Rates for a Metallic Shelf

Method	Nominal	Net nominal	Effective	Net effective
Balassa	30%	4%	59%	27%
Corden	30%	4%	55%	26%

Source: See text.

The use of effective protection both in its initial form and including complexities such as the treatment of non-traded inputs and the net protection rate which adjusts for over-valuation of the exchange rate prevailing under a protective structure is illustrated in Balassa's (1971a) study. He pointed out three specific applications: first, as an indicator of the effects of protection, which shows relative incentives provided to determined activities ranked according to their effective protection rate; second, to calculate the cost of protection to the national economy of the excess of domestic compared to foreign manufacturing costs, which is shown by the effective protection rate; and third, to evaluate alternative investment projects, which requires the reinterpretation of the effective protection rate in terms of domestic cost of saving or earning foreign exchange.

Empirical Studies

1) Protection in Latin America

An advantage of the Balassa and Associates (1971) study is the comparability of the estimates for the countries included (Tables 4-9 and 4-10). Other studies of the protection structures of Brazil, Chile, Colombia, and Mexico have been done by Bergsman and Malan (1971), Bergsman (1970), Jaenneret (1971), Behrman (1976), Diaz Alejandro (1976), Bueno (1971), and King (1970).

The Bergsman (1970) and King (1970) studies cover industrialization and trade policies in Brazil and Mexico, respectively. More recently Behrman (1976) and Diaz Alejandro (1976) studied the relationship between foreign trade regimes and economic development in Chile and Colombia, respectively. These four studies are quite detailed and they cover several topics beyond the scope of this manual. Empirical estimates of nominal and effective protection rates are found in each one of them, although the calculations are not strictly comparable.

Studies by Bergsman and Malan (1971), Jaenneret (1971), and Bueno (1971) are much more comparable as their numerical results for Brazil, Chile, and Mexico, respectively, as Tables 4-9 and 4-10 demonstrate. It should be remembered that effective protection is a relative concept which means that

Table 4-9: Nominal and Effective Protection Rates for Brazil, Chile, and Mexico (%)

Industry group		Brazil (1966) T	Brazil (1966) E	Chile (1961) T	Chile (1961) E	Mexico (1960) T	Mexico (1960) E
Agriculture, forestry, and fishing	D	63	53	42	49	7	3
	F	50	46	53	58	7	6
Mining and energy	D	27	25	8	-2	4	-5
	F	23	-16	39	72	-1	-13
Primary production, total	D	59	52	28	21	6	1
	F	38	18	47	64	3	-3
Processed food	D	82	87	82	2,884	18	6
	F	71	92	101	255	13	20
Construction materials	D	79	86	66	64	-4	1
	F	67	79	115	154	4	-5
Intermediate products I	D	92	110	53	70	22	37
	F	68	115	60	105	14	25
Intermediate products II	D	a	a	118	159	25	38
	F	121	187	113	195	33	56
Nondurable consumer goods	D	140	173	204	277	25	30
	F	157	218	188	300	33	45
Consumer durables	D	108	151	84	101	49	93
	F	154	218	95	123	50	85
Machinery	D	87	100	92	98	29	38
	F	80	93	86	97	32	38
Transport equipment	D	b	b	b	b	26	37
	F	26	-26	16	-65	26	30
Manufacturing, total	D	96	113	111	182	24	26
	F	86	127	89	158	20	32

Source: Brazil - Bergsman and Malan (1971).
Chile - Jaenneret (1971).
Mexico - Bueno (1971).

Symbols: T = nominal protection rate.
E = effective protection rate.
D = estimates using domestic input-output coefficients.
F = estimates using free-trade input-output coefficients.

Notes: effective rates were estimated with formulas (5) and (6) of this section of the manual.
a, included in the intermediate products I industry group.
b, included in the consumer durables industry group.

Table 4-10: Net Nominal and Effective Protection Rates for Brazil, Chile and Mexico (%)

Industry group		Brazil (1966)		Chile (1961)		Mexico (1960)	
		T_n	E_n	T_n	E_n	T_n	E_n
Agriculture, forestry, and fishing	D	29	21	-15	-11	-2	-6
	F	18	15	-9	-6	-2	-3
Mining and energy	D	0	-1	-36	-42	-5	-13
	F	-3	-34	-17	2	-9	-20
Primary production, total	D	25	20	-24	-28	-3	-7
	F	9	-7	-12	-2	-6	-11
Processed food	D	44	48	8	1,676	8	-3
	F	35	52	20	111	4	10
Construction materials	D	41	47	-1	-2	-12	-7
	F	32	41	28	51	-5	-13
Intermediate products I	D	52	66	-9	1	12	26
	F	33	70	-5	22	5	15
Intermediate products II	D	a	a	30	54	15	27
	F	74	127	27	76	22	43
Nondurable consumer goods	D	89	115	81	124	15	19
	F	103	151	71	138	22	33
Consumer durables	D	64	98	10	30	37	77
	F	100	204	16	33	38	70
Machinery	D	48	58	14	18	18	27
	F	42	52	11	17	21	27
Transport	D	b	b	b	b	16	26
	F	-1	-42	-31	-79	16	19
Manufacturing, total	D	55	68	26	68	14	16
	F	47	79	13	54	10	21

Source: Brazil - Bergsman and Malan (1971).
Chile - Jaenneret (1971).
Mexico - Bueno (1971).

Symbols: T_n = net nominal protection rate.
E_n = net effective protection rate.
D = estimates using domestic input-output coefficients.
F = estimates using free-trade input-output coefficients.

Notes: net nominal and effective rates were estimated using formulas (9) and (12) of this section of the manual.
a, included in the intermediate products I industry group.
b, included in the consumer durables industry group.

some industries are protected relative to others. It is not possible to derive a general pattern of protection across countries from the information presented in Tables 4-9 and 4-10 since each of the three countries differ in their industrial structure. A general observation based on these tables is that the results are similar using either free-trade (F) or domestic (D) input-output coefficients. A major drawback in the estimation of effective rates protection is that the data required does not always exist and even when available it is outdated unless the assumption of a productive structure fixed over time is valid. In her study Jaenneret first described Chile's natural resource endowment, the patterns of growth and structural change in the country, and specifically the import substitution policies applied. The system of protection prevailing until 1955 was described, which included as measures exchange controls, multiple rates of exchange, quotas and import licenses, special regimes, and lobbying. A reform of the foreign trade system was undertaken in 1955 following the advice of a team of foreign experts. This reform was the base of the Chilean protection structure prevailing in 1961, the year for which her calculations were made.

The nominal and effective protection rates calculated by Jaenneret (Tables 4-9 and 4-10) refer to the period July-September 1961 and used the only input-output table available for Chile based on the productive structure of 1962. The first adjustment made on the input-output table data was to deduct indirect taxes net of subsidies from the value of output. In some cases further adjustment was required to account for special regimes. Trade and transportation costs were also deducted. These initial adjustments were performed to obtain the value of output at producer prices (from which value added was obtained and used in the effective protection calculations) from the table that originally estimated output value at user prices.

The estimates of the rates of nominal protections involved 1) classifying 5000 import items in the tariff schedule to conform the SITC categories and group them according to the classification used by the input-output table; 2) determining for each item the tariff equivalent (for the c.i.f. value of each item) of the various protective measures such as specific duties import surcharges, prior deposits, and ad valorem tariffs; 3) giving separate consideration to the so-called special regimes such as GATT agreements and duty-free ports; 4) estimating the implicit tariffs (ratio of import to domestic prices) of previously identified prohibitive tariffs; 5) distinguishing between the nominal protection of the industry and that of its products used as inputs and; 6) averaging (using domestic import weights as well as world trade weights) the nominal protection rate for each SITC category and then for each sector of the input-output table. Once the nominal protection rates were obtained, the calculation of effective protection rates was performed and results reported for 28 industries.

2) Protection in Australia

Using the 1958-1959 input-output table for the Australian economy, Evans (1972) specified a general equilibrium model to analyze the effects of protection. Theoretically, Evans' model is a modified classical (Ricardian) one which was solved using linear programming. Given the level of disaggregation used (more than 30 industry levels), this general equilibrium model leads to significantly different predictions of the resource-pull of the tariff in comparison with a simple partial equilibrium model. Interesting policy implications are also discussed by Evans. The effective protection in Australia was estimated by computing directly unit value added for production from base year capacities under protection and under free-trade situations. Since factor substitutes is not allowed, this model does not have to deal with the problem of input coefficients for measuring effective protection because these coefficients do not change when tariffs are introduced.

The Effects of Devaluation

Devaluation, an increase in the exchange rate (the value of foreign currency in terms of domestic currency) from one par value to another, is the subject of this section. A common policy instrument in LDCs, devaluation is used to ease existing balance-of-payments deficits. The main focus in the discussion is on the effects of a devaluation on prices, exports, imports, and national income. A static partial equilibrium framework is used, which is the oldest of the approaches that have been developed.

Following Corden (1977), the analysis is based on the "small-country-assumption", which means that the terms of trade of a country are not affected by the policies it implements. Cooper (1971b) gave a useful description of the small-country case: a country with balance-of-payment difficulties, a normal importer of capital (fixed in terms of foreign currency, under a foreign assistance program; the country cannot influence the price of its imports, although it is not necessarily a price-taker in the markets for its main exportable goods; the country's government covers any budget deficity by borrowing from the central bank.

Different Approaches to the Analysis of Devaluation

The economic literature on devaluation can be classified into alternative, though not necessarily conflicting, approaches. The elasticity approach has its roots in Robinson's (1937) paper, which uses a partial equilibrium analysis of the separate markets for exports and imports with emphasis on the effects of devaluation on the trade balance but ignoring the role of capital movements on the balance of payments. The absorption approach was first proposed by Alexander (1952), who emphasized the effects on aggregate domestic income and aggregate domestic expenditure. Some attempts have been made to integrate these two approaches, for example, the works of Alexander (1959) and Tsiang (1961). Textbook authors such as Kindleberger (1978) have interpreted this integration by considering that the elasticity approach looks at the price effect of a devaluation while the absorption approach looks at the income effect. The former is a short-run effect and the latter a medium-run effect. The elasticity and absorption approaches have generated relatively simple algebraic formulas to quantify the effect they emphasize. Stern (1973) provides a formula that combines both of these approaches.

In a revised and extended version of his Ph.D. dissertation, Kyle (1976) attempted to integrate fully the elasticity and the absorption approaches to balance-of-payments using an open-economy model. He recognized that his model lacked a sector incorporating international capital movements, which is the third approach to devaluation analysis. The main theorems derived from the monetary approach were shown to be special cases of his model. By including a production and a monetary sector and by defining real variables consistently, Kyle was able to utilize a macroeconomic model to analyze the short-run response of output, employment, and balance of payments to changes in the exchange rate. Given the completeness of the model the effects of a devaluation were quite complex.

The monetary approach, and the problems of balance-of-payments in general, is discussed in two volumes edited by Frenkel and Johnson (1976 and 1978). This approach stresses the importance of the concept of money as a stock and that the balance-of-payments is a monetary phenomenon in an international monetary economy. The different aspects of devaluation have yet to be fully integrated. Each of the three approaches reviewed in this section.

1) Elasticity Approach

This approach focuses on the effects of a change in relative prices on the trade balance of a country. If a trade balance deficit exists, devaluation is meant to increase the value of exports and decrease the value of imports, both expressed in domestic currency. This follows from an increase in the domestic price of tradable goods, since higher prices tend to increase the quantity of exportables and to decrease the quantity of importables. Supply and demand elasticities are crucial in the general algebraic formula that effects an exchange-rate change on the trade balance. The derivation of this formula is somewhat tedious. It starts by differentiating the trade balance identity:

$$TB = V_x - V_m$$

and uses several algebraic manipulations to arrive at the following expression in elasticity form:

$$(16)\quad E_{tb} = \frac{dTB/V_m}{dr/r} = \frac{V_x}{V_m}\,\frac{\varepsilon_x + 1}{\dfrac{\varepsilon_x}{\eta_x} - 1} - \frac{\eta_m + 1}{\dfrac{\eta_m}{\varepsilon_m} - 1}$$

where

E_{tb} = elasticity of TB with respect to r

TB = trade balance (net surplus on current account)

r = exchange rate (price of foreign exchange)

V_x = value of exports before devaluation

V_m = value of imports before devaluation

ε_x = demand elasticity for exports

ε_m = demand elasticity for imports

η_x = supply elasticity for exports

η_m = supply elasticity for imports

This specific form of the elasticity approach was obtained from Kindleberger (1978). Alternative forms are given by Alexander (1959) and Grubel (1977). These three references also contain similar detailed derivations of the elasticities formula.

A special case of the elasticities formula is the famous Marshall-Lerner condition for improvement of the trade balance after a devaluation of the exchange rate takes place. This condition states that the effect of a devaluation on the trade balance will depend on the outcome of the sum of the absolute values of the two demand elasticities (ε_x and ε_m). Assuming that the two supply curves are infinitely elastic ($\eta_x = \eta_m = \infty$) and that initially the trade balance is zero, (the values of exports and imports are equal, $V_x = V_m$); the trade balance will improve by devaluating the exchange rate if the sum is greater than unity. The Marshall-Lerner condition takes the following form:

$$(17)\quad \frac{dTB/V_m}{dr/r} > 0 \quad \text{if} \quad |\varepsilon_x + \varepsilon_m| > 1$$

when

$$\eta_x = \eta_m = \infty \text{ and } V_x = V_m$$

Kindleberger (1978) also discussed the effect of a devaluation on the terms of trade (ratio of export prices to import prices expressed in the same currency) of a country. The following general formula quantifies the elasticity of the terms of trade with respect to the exchange rate:

$$(18)\ E_{tt} = \frac{dP_x/P_x - dP_m/P_m}{dr/r} = \frac{\eta_x\eta_m - \varepsilon_x\varepsilon_m}{(\varepsilon_x - \eta_x)\ (\eta_m - \varepsilon_m)}$$

where

E_{tt} = elasticity of the terms of trade with respect to r

P_x = export prices, P_m = import prices: expressed in the same currency.

A devaluation will improve the terms of trade if $\varepsilon_x\varepsilon_m > \eta_x\eta_m$. It will worsen the terms of trade if $\varepsilon_x\varepsilon_m < \eta_x\eta_m$. It will not affect the terms of trade if $\varepsilon_x\varepsilon_m = \eta_x\eta_m$.

In table 4-11 the effects of a devaluation on the trade balance and the terms of trade are presented for four special cases of formulas (16) and (17) with different values of the elasticities assumed in each case. In the small-country case, the effects of a devaluation in the short run are to improve its trade balance and leave its terms of trade unchanged. Long-run effects can be analyzed only after the inclusion of nontraded goods and monetary considerations, which is beyond the scope of the present manual.

The partial-equilibrium basis for the elasticity approach requires the assumption that incomes and prices of all other goods be considered constant, which is an unrealistic assumption. Johnson (1977) identified

Table 4-11: Effects of a Devaluation

Case	Elasticities	Effects	
		Trade balance	Terms of trade
Inelastic demands	$\varepsilon_m = \varepsilon_x = 0$	worsens	worsens
Small Country	$\eta_m = -\varepsilon_x = \infty$	improves	unchanged
Prices fixed in buyers' currencies	$\varepsilon_m = \varepsilon_x = -\infty$	improves	improves
Price fixed in sellers' currencies	$\eta_x = \eta_m = \infty$	improves if $\lvert\varepsilon_x + \varepsilon_m\rvert > 1$	worsens

Source: Kindleberg (1978) and text.

five specific limitations of the approach. First, cross-effects in demand and supply are assumed to be zero. Second, income is implicitly held constant instead of appearing as an argument in the demand and supply functions. Third, the approach does not provide an analysis of the sources of increased production and the extra labor required to produce it to fulfill the increased demand for domestic production. Fourth, the approach treats the demand for or supply of money as a flow demand or supply, while monetary theory claims that the demand for money is a demand for a stock. And fifth, the possibly crucial role of domestic monetary policy in determining the success of a devaluation is concealed.

It is also useful to stress some theoretical problems that are present when the elasticities required for formulas (16), (17), and (18) are econometrically estimated. A sense of "elasticity pessimism" that existed earlier was due to the need for relatively high elasticity values for the Marshall-Lerner condition to hold and assure the success of a devaluation in improving the trade balance of a country. Orcutt (1950) pointed out several pitfalls in the statistical estimates of price elasticities that were the basis for the "elasticity pessimism" of the 1930's. Such estimates were biased towards zero because 1) there is an identification problem due to the dependence between relative prices and the random deviation in the import-demand function; 2) the sample period used for the estimations reflected adjustment to smaller price changes than that occurring with a devaluation; 3) short-run elasticities (one-year) are lower than long run elasticities; 4) use of aggregated data may give undue weight to goods with relatively low elasticities; and 5) the data may reflect measurement errors for prices, quantities, and other variables.

Time lags in the adjustments of imports and exports following a devaluation is another factor affecting measured elasticities. Junz and Rhomberg (1973) have studied the response of trade flows to exchange rate changes which they decompose over time considering five types of lags: 1) recognition--it takes time for buyers and sellers to become aware of the changed competitive situation; 2) decision--new business connections need to be formed and new orders to be placed; 3) delivery--trade flows and payments respond to price changes only as the goods are delivered; 4) replacement--which takes place after inventories of materials are used or equipment is worn out; and 5) production--to shift from one market to another requires producers to be convinced of adequate profit opportunities in the new market. These authors concluded that the response of trade flows to relative price changes stretches over a period of four to five years. Almost 50 percent of the full effects of a devaluation occur during the first three years, while about 90 percent takes place during the first five years. This was termed the J-curve effect, to reflect the small initial effect of a devaluation that increases rapidly in the medium-run and fades away over time.

2) <u>Absorption Approach</u>

Harberger (1950) developed a revised analysis using a Keynesian model that allowed for variations in output and national income. The idea was that the elasticities results were the initial results of a devaluation, which then led to secondary income effects that could either reinforce or offset the initial ones. The formula suggested to evaluate the final effects of a devaluation on trade balances was:

$$(19) \quad E_{tb} = \frac{h_d \; h_f \; V_X \quad 1 + \varepsilon_x + \varepsilon_m + \eta_d + \eta_f}{h_d \; h_f + \eta_d \; h_f + \eta_f \; h_d}$$

where

h_d = domestic marginal propensity to hoard

h_f = foreign marginal propensity to hoard

η_d = domestic marginal propensity to import

η_f = foreign marginal propensity to import

Thus, the necessary condition for a devaluation to be successful, is that the absolute value of the elasticities of demand for export and imports exceed unity plus the sum of the domestic and foreign marginal propensities to import:

$$(20) \quad |\varepsilon_x + \varepsilon_m| > 1 + \eta_d + \eta_f$$

Johnson (1977) considered this "Keynesian multiplier approach" to be an improvement over the elasticity approach. He identified its limitations to be: 1) cannot be used to analyze devaluation under full employment or inflationary conditions because it assumes mass unemployment and a rigid money wage, 2) it makes the monetary theory mistake of treating a demand for increased money balances as an equilibrium flow demand, and 3) it ignores the importance of the conduct of domestic monetary policy to improve the balance of payments according to whether an increased domestic demand for money is met by international reserve inflow or domestic credit creation. Estimation of the relevant parameters is also more difficult than for the elasticity approach.

Alexander (1952) switched the focus of analysis of a devaluation from the trade balance as a difference between the values of exports and of imports to the trade balance as the difference between aggregate domestic income and aggregate domestic expenditure. His absorption approach is a straightforward application of the standard Keynesian closed economy model to an open economy. The difference between aggregate output and the trade balance (exports minus import) is current aggregate expenditure or absorption; a trade deficit is then an excess of expenditure over output. To restore balance, either expenditure must be decreased (this the only way when the economy is in a situation of full employment of resources) or output must increase (this is possible if a situation of unemployment prevails). The policy prescription under this approach requires that a devaluation be accompanied by deflationary monetary and fiscal policy. Corden (1977) refers to devaluation as a switching device that helps reduce absorption, which is the typical case of LDCs with trade balance deficits.

Johnson (1977) also made some theoretical criticisms of this approach. First, it treated devaluation as a single policy to be implemented on its own. Second, the balance of payment was treated as a repetitive flow equilibrium instead of a shock-adjustment equilibration of actual to desired balances. Third, it does not take into account the monetary policy roles of devaluation under unemployment.

Following the criticism of his absorption approach, Alexander (1959) attempted to combine the elasticity and absorption approaches. He called the elasticities effects, assuming money income constant, the impact effect which then caused changes in money income that also affected the trade balance via secondary "reversal" effects. He defined a reversal factor, R, which represents the effects of a change in income, initiated by the elasticities effect, on the trade balance. Alexander's (1959) synthesis formula, as presented by Kyle (1976) is:

$$(21) \quad E^*_{tb} = \frac{R_d R_f \; E_{tb}}{1 - (R_d - 1)\;(R_f - 1)}$$

where

E^*_{tb} = elasticity of TB with respect to r

R_d = domestic reversal factor

R_f = foreign reversal factor

E_{tb} = see formula (1)

Formula (21) can also be expressed in terms of marginal propensities to hoard and to import, both with respect to money income, as:

$$(22) \quad E^*_{tb} = \frac{E_{tb}}{1 + \frac{m_d}{h_d} + \frac{m_f}{h_f}}$$

3) Monetarist Approach

The elasticities and absorption approaches to devaluation analysis focused on the trade account of the balance-of-payments. In recent years the monetarist school has shifted the emphasis toward the monetary consequences of capital movements. The two collections of papers edited by Frenkel and Johnson (1976, 1978) explain the development of the approach, its propositions, and its applications.

As Grubel (1977) points out, the monetarist challenge to traditional Keynesian approaches has been successful from the point of a higher relative ability to explain real-world phenomena and predict the effects of determined government policies. Neither approach can provide a genuine general equilibrium model nor the empirical values of all the adjustment paramenters, which suggests the need for simplified theoretical models that emphasize different but complementary aspects of reality.

Johnson (1977) provides a clear and nontechnical guide to the monetarist approach by stressing that "a balance-of-payment deficit or surplus is a stock-adjustment disequilibrium phenomenon and not a flow equilibrium phenomenon." Using Walras' Law which states that the excess demand for or a supply of money must be matched by an excess supply or demand somewhere else in the market system, monetarists consider that in an open economy excess demands and supplies can be eliminated by net purchases and sales (exchanges) of goods or bonds for money in the international market. They consider that the process of adjustment toward equilibrium will automatically take place unless deliberately frustrated by policy and that the balance-of-payments policy should aim to speed up this process by reducing or reversing the initial disequilibrium between quantity of money demanded and supplied.

Johnson (1977), writing with reference to 1975, stressed that balance-of-payment deficits and surpluses are "monetary symptoms of monetary disequilibrium that will cure themselves in time without any inherent need for a government balance-of-payments 'policy'". Monetary contraction would be necessary to speed this process. Devaluation (alternatively, import restrictions and export promotion) has the same effect but it is achieved by deflating the real stock of money backed by domestic credit through raising the price level rather than by deflating the nominal stock at money through open market sales.

Empirical Studies

Empirical analysis of the effects of devaluations has received much less attention than theoretical analysis. As Miles (1978) indicated, empirical studies are few in number and limited in scope.

Literature on estimations of price elasticities in international trade abounds. Some studies have also been done with respect to devaluations by LDCs, but this specific question encounters the classic difficulties of data availability. Most of the recent empirical work has been oriented to the monetarist approach, and seems to support its propositions. The latest empirical trend is to look at devaluation effects over time, beyond its initial impact, and to include other policy variables along with the change in the exchange rate to explain the changes in the trade balance and the balance-of-payments.

1) Magnitudes of Price Elasticities

Stern, Francis, and Schumacher (1975) published an annotated bibliography of 130 references on price elasticities of import and export demand functions. Unpublished Ph.D. dissertations and foreign sector equations of different macroeconometric models were not included by the authors but nevertheless their bibliography covered the most important work done between 1960 and 1975. Each bibliographical entry was summarized, its numerical results reproduced, and the equations from which the estimates were obtained were also included. A comparative summary of aggregate elasticity estimates and also by commodity groups for 18 industrialized countries plus a chapter on methodological aspects makes this book a valuable self-contained volume on the topic of price elasticities in international trade.

The standard reference for empirically estimated income and price elasticities for import and export demand is the article by Houthakker and Magee (1969) which contained estimates for 15 industrial countries and 14 non-industrial ones. Their results of the elasticities of export demand functions for six Latin American Countries are reproduced in Table 4-12. Log-linear equations for the import and export demand functions were estimated by ordinary least squares on the basis of 16 annual observations. The export function was of the form:

$$(23) \quad 1_n V_x = \beta_0 + \beta_1 \quad 1_n W + \beta_2 \frac{P_x}{P_x W}$$

where

V_x = value of exports in 1958 dollars

W = index of GNP for 26 importing countries

P_x = export prices in 1958 dollars

$P_x W$ = index of export prices for 26 other exporting countries

β_0 = regression constraint

β_1 = income elasticity for export demand (y_x)

β_1 = price elasticity for export demand (ε_x)

The lack of data and specification problems did not allow them to estimate elasticities of import demand functions. For export demand functions, the income elasticities were noted to be quite low (see Table 4-12) which is presumably explained by the importance of such traditional products as coffee. This would be less true at the present time when the proportion of nontraditional (manufactured goods) exports by Latin American countries

Table 4-12: Income and Price Elasticities (ε_x) of Export Demand, 1951-1966

Country	Constant	Elasticity	
		Income	Price
Argentina	5.39	.87	-.55
Brazil	7.45	.34	-.39
Chile	1.87	.99	-.09
Colombia	5.13	.41	-.18
Peru	-.3	2.01	-.7
Venezuela	-1.23	1.12	.83

Source: Houthakker and Magee (1969).

(specifically Brazil, Argentina, and Mexico) has been rapidly increasing.

Estimates of import and export demand functions for 15 LDCs were made by Khan (1974) using two-stage least squares and 19 annual observations. Khan's sample of countries, 8 of them Latin American, represented both a fairly wide geographical coverage and the use of consistent data for the variables in the estimations. Khan's approach attempted to take into account potential sources of bias by introducing "disequilibrium equations" as a partial adjustment mechanism for imports (exports) in which the change in imports (exports) is related to the difference between the demand for imports (exports) in the present period (t) and actual imports (exports) of one period previous (t-1). In order to account for the role of quantitative restrictions, Khan specified a first-order autoregressive process and considered the coefficient of autocorrelation as an indicator of restrictions.

Khan's estimated equilibrium equation of the demand for imports was:

$$(24) \quad \ln Qm = \alpha_0 + \alpha_1 \, l_n \, y + \alpha_2 \frac{P_m}{P_d}$$

where

Q_m = quantity of imports

y = real GNP of importing country

P_m = import prices in 1958 dollars

P_d = domestic prices

α_0 = regression constraint

α_1 = income elasticity for import demand (y_m)

α_2 = price elasticity for import demand (ε_m)

This estimated disequilibrium equation of the demand for imports was:

$$(25) \quad \ln Q_m = \gamma\alpha_0 + \gamma\alpha_1 \ln y + \gamma\alpha_2 \frac{P_m}{P_d} + (1-\gamma) \ln Q_{m-1}$$

where

$0 \leq \gamma \leq 1$ (to account for difference between present and one period previous imports)

Q_{m-1} = one period lagged quantity of imports

$\gamma\alpha_0$ = regression constraint

$\gamma\alpha_1$ = income elasticity for export demand (y_x)

$\gamma\alpha_2$ = price elasticity for export demand (ε_x)

Table 4-13 contains the numerical estimates of income and price elasticities for import demand of the eight Latin American countries based on the equilibrium equation (24) and the disequilibrium equation (25).

For the case of aggregate export demand, the estimated equilibrium equation was:

$$(26) \quad \ln Q_x = \beta_0 + \beta_1 \ln W + \beta_2 \frac{P_x}{P_x W}$$

where

Q_x = quantity of exports

P_x = export prices in 1958 dollars

W = real GNP of OECD countries

$P_x W$ = index of export prices for the OECD countries

β_0 = regression constraint

Table 4-13: Equilibrium and Disequilibrium Income and Price Elasticities (ε_m) of Import Demand, 1951-1969

Country	Equilibrium			Disequilibrium			
	Constant	Elasticity		Constant	Elasticity		Lagged Imports
		Income	Price		Income	Price	
Argentina	-1.4	.14	-.85	1.487	.08	-.6	.31
Brazil	2.53	.11	-1.69	-.4	.15	-1.32	-1.15
Chile	.18	.004	-.63	.11	.02	-.25	.73
Colombia	-5.15	.21	-.76	-5.63	.29	-1.2	-.28
Costa Rica	-10.01	2.05	-1.98	-10.2	1.94	-1.84	-.15
Ecuador	-4.44	.56	-1.17	-2.36	.41	-.98	.31
Peru	2.82	-.15	-1.78	3.05	-.28	-1.84	.11
Uruguay	.28	-.21	-1.23	0.44	-.31	-1.39	-.06

Source: Khan (1974).

β_1 = income elasticity of export demand (y_x)

β_2 = price elasticity of export demand (ε_x)

For the disequilibrium solution, Khan's estimated export demand equation was:

$$(27) \quad \ln Q_x = \gamma\beta_0 + \gamma\beta_1 \ln W + \gamma\beta_2 \ln \frac{P_x}{P_x W} + (1-\gamma) \ln Q_{x-1}$$

where

$0 \leq \gamma \leq 1$ (to account for the difference between present and one period previous exports)

Q_{x-1} = one period lagged quantity of exports

$\gamma\beta_0$ = regression constant

$\gamma\beta_1$ = income elasticity of export demand (y_x)

$\gamma\beta_2$ = price elasticity of export demand (E_x)

Table 4-14 gives Khan's numerical estimates of income and price elasticities for export demand of eight Latin American countries using equations (26) and (27).

Khan felt that his estimated income elasticities for imports and exports were relatively low but were fairly similar in several countries. Price elasticities tended to be larger than expected a priori and were generally similar for a number of countries. Khan also found that more import equations, as compared with export equations, showed statistically significant autocorrelation coefficients. He explains this by the omission of quantitative restrictions, confirming the view that these restrictions are more important in the determination of imports than of exports.

Table 4-14: Equilibrium and Disequilibrium Income and Price Elasticities (ε_x) of Export Demand, 1951-1969

Country	Equilibrium			Disequilibrium			
		Elasticity			Elasticity		Lagged Exports
	Constant	Income	Price	Constant	Income	Price	
Argentina	3.73	.47	-.24	4.2	.49	-.4	-.12
Brazil	4.19	.45	-.08	5.16	.57	-.13	-.24
Chile	1.89	.62	-.11	2.79	.93	-.12	-.5
Colombia	4.77	.22	-.26	2.67	.02	-.23	.56
Costa Rica	.84	.53	-1.25	-1.51	.51	-.15	.57
Ecuador	-1.82	.45	-.62	3.46	.99	-1.08	-1.08
Peru	-1.66	1.12	-1.25	-.49	.56	-.72	.06
Uruguay	3.11	.24	1.04	5.01	.36	1.65	-.29

Source: Khan (1974).

Although somewhat outdated, Leamer and Stern (1970) discussed in detail the estimation of import and export demand functions, the measurement of the elasticity of substitution, and factors determining international capital movements. These authors also discussed forecasting and policy analysis of the balance-of-payments using econometric models and the relationship between international trade and welfare.

Quarterly estimates of the aggregate demand equation for 12 industrial countries were calculated by Goldstein and Khan (1976) using data from 1955 to 1973. These authors found that the size of relative price changes would not affect differently (nonproportionately) the import demand. There does not seem to be empirical support for Orcutt's (1950) hypothesis that the price elasticity of import demand and the speed at which actual imports adjust to the desired level are dependent on the size of the relative price change of the import price elasticity is independent of the size of a devaluation, then a small or a large devaluation does not mean that different elasticity estimates are required to calculate its initial effects.

The Goldstein-Khan (1976) study showed that quarterly estimates of income elasticity tended to be smaller than annual ones, while price elasticity estimates give similar values whether quarterly or annual data were used. Their estimated time lags in the response of aggregate imports to a devaluation were substantially shorter than is sometimes assumed, an average of one to three quarters. Goldstein and Khan concluded from their work that the Marshall-Lerner conditions for a successful devaluation were apt to be satisfied for most of 12 countries in their sample due to the favorable effect of a devaluation on the quantity of imports demanded.

In a more recent study, Goldstein and Khan (1978) specified simultaneous export demand and supply equations which were estimated for eight industrial countries. The numerical results proved to be considerably larger than those obtained in other studies using annual data. A linear full-information maximum likelihood estimator with quarterly data from 1955 to 1970 was used for the equilibrium equations while a non-linear full-information likelihood estimator was used for the disequilibrium equations. The two studies by Goldstein and Khan are complementary because the first one covers elasticities of import demand equations while the second one covers elasticities of export demand equations. Both studies use quarterly data for industrial countries. The Marshall-Lerner condition requiring that the absolute values of these two elasticities be greater than unity was easily satisfied for almost all the industrial countries in their sample.

The implication of large price elasticities of import and export demand is the fulfillment of the Marshall-Lerner condition for a successful devaluation. Houthakker and Magee (1969) first and later Goldstein and Khan (1976, 1978) provided empirical evidence for industrial countries. Khan (1974) did the same for LDCs.

2) <u>Devaluation by LDCs</u>

Diaz-Alejandro (1965) analyzed the impact of a devaluation on the Argentine economy and its balance-of-payments. He surveyed the literature on the theory of devaluation and suggested modifications for it to be useful in LDCs. His main point was the need to take into account the impact of devaluation on income distribution. Although Diaz-Alejandro recognized that the best approach for his task was to have a system of equations describing the entire Argentine economy, data and time limitations forced him to rely on independent estimates of several key relationships for his analysis. Diaz-Alejandro's main conclusion, under a combination of elasticity and absorption approaches to devaluation analysis, with regard to the 1958 devaluation in Argentina was that "it does not follow that the remedy for imbalances caused by years of neglect of market signals (as well as by the failure to devise a system of rational planning) is a return to a complete reliance on the price mechanism as the sole guide for resource allocation. To expect that a reintroduction of free prices will significantly improve the structure and level of production in the short run requires great optimism plus an enormous faith in the entrepreneurs at the country."

Cooper (1971a) generalized from the experience of 24 devaluations in 19 different countries, seven of which were Latin American, that took place during the period 1959-1965. Cooper makes a conceptual difference between nominal and effective devaluation, the former being the change in the par value of a currency and the latter "the amount of local currency that purchasers must actually pay for a dollar's worth of imports and the amount of local currency that an exporter actually receives for a dollar's worth of exports". Effective devaluation was usually less than nominal devaluation because of policies which accompanied the devaluation: either exchange reform (elimination of multiple exchange rates to a unitary rate) or import liberalization (reduction of quantitative restrictions on the flow of imports), or both together. These policies explain why devaluation for imports was typically larger than that for exports. In his empirical analysis Cooper looks at the effects of devaluation on: 1) balance-of-payments, 2) terms of trade, 3) aggregate demand, 4) wage-price spiral, and 5) political costs.

His major conclusions were: 1) devaluation is successful in improving the trade balance, 2) devaluation initially tends to depress economic activity because of the shift in the distribution of income from low to high savers and the drain on domestic purchasing power, 3) not even large devaluations seem to worsen the terms of trade of the devaluating country, 4) devaluation stimulates increases in local prices of foods and services closely linked with foreign trade accompanied by larger than normal wage increases (rarely do such increases nulify the effects of devaluation), and 5) devaluation seems to be associated with a somewhat higher likelihood of a change of government. Cooper also points out four limitations to his study: 1) poor quality data, 2) data reflect many economic changes other than the devaluation under examination, 3) none of the 24 devaluations of the sample were studied in any depth, and 4) only the period immediately following devaluation was considered while many effects require more than a year to take place.

In another paper Cooper reviewed the three main approaches to devaluation analysis and suggested several modifications that are necessary for applying devaluation analysis to LDCs (1971c). Devaluation in LDCs is more complex than a simple exchange rate adjustment; other type of adjustments must also be taken into account. Four types of devaluation "packages" can be distinguished 1) straight devaluation (a discrete change in the principal exchange rate), 2) devaluation with a stabilization program of contractionary monetary and fiscal policy, 3) devaluation accompanied by liberalization (less restraint on imports), and 4) devaluation accompanied by partial or full unification of exchange rates. He supported the view of low elasticities, at least in the short run. He also agreed that devaluation will have an initial deflationary impact on the domestic economy in that it will reduce purchasing power available for expenditure on domestic output. Six effects on the level of total domestic expenditure in LDCs were identified by Cooper: 1) a speculative effect, 2) a powerful short-run distributive effect, 3) a rise in the domestic cost of servicing the external debt, 4) a domestic credit squeeze due to the lack of countervailing monetary action, 5) an inducement for both foreign and domestic investment in the country due to improved earning opportunities in the export industries, and 6) a money-demand effect due to the reduction in real value of money holdings.

Cooper's general policy prescription was that it may be desirable to accompany devaluation with modestly expansionary policies due to the initial deflationary effect of devaluation. In his words "managing a devaluation through the transition phase to final success requires both judgment and delicacy in handling".

The collection of essays edited by Frenkel and Johnson (1976) contained several case studies of tests and empirical verifications of the monetarist propositions. The authors recognized the limitations of econometric tools but also argued that the criticism of these methods is rarely accompanied by alternative methods for quantification of economically relevant parameters. Country studies for Australia, Sweden, Japan and Spain are included. In the case of Australia, it was found that monetary policy affects the country's international reserves instead of the credit market and money supply variables that usually is assumed to be under control of central bankers. Swedish prices and interest rates were shown to depend on world levels. Japanese central bank authorities have controlled the composition of its portfolio by varying the rate of growth of domestic credit to avoid the depletion of international reserves; alternatively, discretionary credit-creation policies could have minimized the impact of reserve flows on the economy. The conclusion in the case study of Spain was that devaluations are not effective unless accompanied by appropriate credit policies. It was established that domestic credit expansion was the major determinant of the evolution of the balance-of-payments. Furthermore, there seemed to be no tradeoff between devaluation and restrictive credit policies but instead between devaluation and the degree of restrictiveness of domestic policies.

In a more recent collection of essays edited by Frenkel and Johnson (1978) one of the papers discussed the effects of a devaluation on trade flows and domestic prices. A general equilibrium econometric model of 18 equations was developed. Next, a 10% unilateral devaluation of the U.S. dollar was simulated and the actual numerical size of the effects of such devaluation on U.S. trade and prices were calculated. The results of the simulation indicated that devaluation does have substantial real effects (real exports increase and real imports decrease, which improves the trade balance) which tend to persist for a relatively long period. The model took 13 years to reach long-run equilibrium in relative prices.

Miles (1978, 1979) considered the effects of variables including devaluation on the trade balance and the balance-of-payments. He wanted to determine if devaluation improves the trade balance and the balance of payments; once government policies and growth rates are taken into account. Several statistical techniques were used to explore thie relationship. His results show that the balance-of-payments clearly improves (temporarily) after devaluation takes place. Government consumption tends to exert a negative effect on the trade balance. Finally, monetary variables were found to have a strong negative effect on balance-of-payments. The author concluded that devaluation initiates portfolio adjustment, a result that is consistent with the monetarist approach. The little evidence found of an improvement in the trade balance along with strong evidence of an improvement in the balance-of-payments establishes that the capital account must be improving.

Numerical Application

The simplest approach toward the quantification of the short-run or impact effect of devaluation is to use formula (16) presented in this section. This formula requires values for supply and demand elasticities of imports and exports as well as the levels of import and exports to determine the change in the trade balance after a devaluation. Unfortunately, no empirical estimates on supply elasticities are available due to the simplifying assumption that all supply functions of imports and exports are infinitely elastic. This assumption along with the assumption of zero trade balance (equality between the value of imports and the value of exports) leads to the Marshall-Lerner condition for the success of a devaluation, where success is understood as an improvement in the trade balance.

What is needed is the fulfillment of the Marshall-Lerner condition in Latin American countries. Its assumptions imply that these countries are price-takers for their exports ($\eta_x = \infty$) and that their import suppliers have unitilized capacity ready to initiate production when required ($\eta_m = \infty$). The demand assumption is unrealistic for Latin American countries that play an important individual role in given commodity markets, e.g., Argentina in beef, Brazil and Colombia in coffee, Bolivia in tin, Ecuador in bananas, Mexico and Venezuela in oil, Peru in fishmeal. Unlimited supplies of imports is a more acceptable assumption. Equal values of imports and exports contradicts the usual situation of trade imbalance on current account in Latin America. At best the "small-country" assumption is only partially valid for Latin American countries.

Table 4-15 reproduces estimates price elasticities of the import and export demand functions for eight Latin American countries. These numerical values shows that the Marshall-Lerner condition($|\varepsilon_m + \varepsilon_x| > 1$) is satisfied for all but one country, Chile. If the Marshall-Lerner condition is valid, Latin American countries can devaluate with high probability of improving their trade balance at least in the short run.

Table 4-15: Marshall-Lerner Condition for Latin American Countries

Country	Equilibrium Price Elasticities			Disequilibrium Price Elasticities		
	Imports ε_m	Exports ε_x	Sum $\lvert\varepsilon_m+\varepsilon_x\rvert$	Imports ε_m	Exports ε_x	Sum $\lvert\varepsilon_m+\varepsilon_x\rvert$
Argentina	-.85	-.24	1.09	-.6	-.4	1.
Brazil	-1.69	-.08	1.77	-1.32	-.13	1.45
Chile	-.63	-.11	.74	-.25	-.12	.37
Colombia	-.76	-.26	1.02	-1.2	-.23	1.43
Costa Rica	-1.98	-1.25	3.23	-1.84	-.15	1.99
Ecuador	-1.17	-.62	1.79	-.98	-1.08	2.06
Peru	-1.78	-1.25	3.03	-1.84	-.72	2.56
Uruguay	-1.23	1.04	2.27	-1.39	1.65	3.04

Source: Khan (1974).

Note: See text for meaning of equilibrium and disequilibrium price elasticities.

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CHAPTER 4 ANNEX

ANNOTATIONS FOR KEY REFERENCES ON INTERNATIONAL TRADE POLICIES

Balassa, Bela (1971)

"Concepts and Measurement of Protection"
In: The Structure of Protection in Developing Countries by B. Balassa and Associates, pp. 3-25.
Baltimore: The John Hopkins Press for the IBRD and the IDB

The nominal rate of protection of a given product is defined as the percentage excess of the domestic price over the world market price due to the application of protective measures. The effective rate of protection is defined as the percentage excess of domestic value added, obtainable because of the protective measures on the product and its inputs, over the world market value added. The effective rate of protection is shown to depend not only on tariffs on inputs and outputs but also on the share of value added in the product price. Effective rates of protection will be higher, equal, or lower, depending on whether product tariffs or subsidies are greater than, equal to, or less than, the average rate of tariffs on material inputs. If tariffs raise the cost of material inputs by a larger absolute amount than they raise the price of the product, the effective rate of protection can be negative.

A protective structure permits domestic industries to operate with a value added higher than that under free trade, and provides incentives for the movement of domestic resourses (land, labor, and capital) into protective industries. A ranking of activities by effective rates of protection will indicate the relative incentives provided by protection. The concept of net effective protection is introduced to adjust for the difference between the actual and the free-trade exchange rate. The exchange rate observed under protection tends to overvalue the domestic currency (the imposition of tariffs permits balance of payments equilibrium at a lower exchange rate), and thus effecting rates to overstate the extent of protection. An overvalued exchange rate also discriminates against export activities since export producers would be receiving fewer domestic currency units (pesos) per foreign currency unit (dollar) than they would receive under free trade. This bias against exporting (favoring production for the domestic market, or import substitution) is measured by the percentage excess of domestic value added in import substitution over that obtainable in exporting.

Information on the value of output, the value of material inputs, and the value added in individual industries under protections was obtained from the domestic input-output tables of the countries studied. The need for world market (free trade) values rises because of the distortions introduced by protective measures which induces substitution among inputs or between inputs and primary factors, resulting in different physical input-output coefficients.

Non-traded inputs, such as construction, gas, electricity, banking, water, communications and insurance, are treated differently than material inputs when evaluating the rate of protection. The difference comes from the assumptions made with respect to their domestic price elasticity. Two alternative assumptions were made. First, the Corden method, which assumes that the basic primary factors used in producing non-traded inputs are also used in producing traded inputs, so that the available amount of these factors limit both kinds of activities. This method includes value added in the production of non-traded input with value added in processing in the industry in question. Secondly, the Balassa method assumes that non-traded inputs are supplied at constant costs and that their prices vary by the amount by which protection increases or decreases the cost of material inputs used in their production. This method considers that non-traded inputs have a zero effective rate of protection.

Three major areas of application of the effective protection measure were mentioned by Balassa: first, as an indicator of incentive effects based on ranking each industry by its effective rate of protection; second, as a measure of the cost of protection indicated by the excess of domestic over foreign processing costs; and third, in the evaluation of alternative investment projects. Project appraisal would reflect the ranking of the projects according to the domestic cost of foreign exchange saved in import substitution or earned in exporting.

Balassa, Bela (1971)

"The Effective Rate of Protection: Theoretical and Methodological Issues". In: The Structure of Protection in Developing Countries by B. Balassa and Associates, pp. 315-339.
Baltimore: The John Hopkins Press for the IBRD and the IDB

Balassa defined the concepts of nominal and effective protection in the framework of a partial equilibrium model assuming: 1) zero elasticity of substitution among inputs, 2) production subject to constant returns to scale, 3) factor prices are given, 4) pure competition, 5) no transportation cost, and 6) infinite foreign demand elasticity for the country's exports and the foreign supply elasticity of its imports.

Formulas are presented to calculate the effective rate of protection using either domestic or free trade input-output coefficients. Another formula is presented to take account of differing indirect taxes on the domestically produced variety and on imports of the same good.

Formulas for the Corden and Balassa methods for treating non-traded goods are presented. The difference in the Corden and Balassa methods is the cumulated value added elements of non-traded inputs in the denominator of the equation.

Formulas to evaluate the net effective protection rate by estimating the extent of overvaluation of the exchange rate are also presented. The extent of overvaluation requires the calculation of the changes in exports and imports due to the elimination of protection measures and then the proportional devaluation necessary to cover the deficit in the balance of payments. Foreign trade elasticities are crucial for the devaluation ratio formula although their assumed values seem not to affect drastically the results.

Another formula is presented to calculate the bias against exports using free trade input-output coefficients. Input substitution is discussed in a partial equilibrium framework mentioning the direction of the bias, if any, in estimating the effective protection rate when substitution occurs between primary factors and material inputs, among material inputs, or among primary factors. In a general equilibrium framework, protection effects will take place not only through changes in product prices but also through changes in factor prices. Balassa concluded that in LDCs the product price effects are large enough not to be reversed by factor price effects and leave the ranking by effective rates unchanged.

Finally, a formula to calculate the cost of foreign exchange due to protective measures is presented in terms of the sum of direct and indirect domestic resource costs incurred in domestic production divided by the difference between the foreign price of the product and the foreign exchange cost of direct and indirect imported inputs.

Balassa, Bela (1971)

"Trade Policies in Developing Countries," American Economic Review (Papers and Proceedings) Vol. 61, No. 2, May pp. 178-187.

The author analyzed the effects of trade policies followed by Argentina, Chile, Brazil, Mexico, Western Malaysia, Pakistan, the Philippines, Taiwan and Korea. These countries have employed many trade policies including import tariffs and surcharges, export taxes and subsidies, multiple exchange rates, and quotas and licenses. The allocation of resources are influenced by these measures which affect relative prices of inputs and outputs and provide incentives--or disincentives--to import-substituting and export activities. The protection of manufactured goods and discrimination against primary exports usually go hand-in-hand. The trade policies followed, together with changes in world market conditions, largely explain intercountry differences in the rate of growth of primary exports. Less than 3 percent of manufactured output and at most 10 percent of total exports is accounted for by manufactured goods in countries where there is a substantial bias against them.

The expansion of exports contributes to economic growth directly by raising national income and indirectly by providing foreign exchange for the import needs of the domestic economy. An export-oriented policy also permits specialization according to comparative advantage. Firms lower costs by using large-scale production methods, reducing product variety, and participating in the international division of the production process. Incentives for technological change and product improvement arise from participation in foreign markets. Import substitution can be a source of economic growth in particular cases by replacing the imports of nondurable consumer goods and their inputs by domestic production. This requires mainly unskilled and semi-skilled labor rather than sophisticated technology and many inputs from auxillary industries. The limited size of national markets is not an important handicap in this case. The main drawback comes when all such goods are replaced and then intermediate products and capital goods are to be replaced. This is much more difficult due to the characteristics of such products. Balassa concludes, after considering the different country experiences, that the protection of the manufacturing sector may permit rapid growth at an early stage of import substitution, but will eventually have adverse consequences for economic growth. Also, once an industrial structure is established by import substitution, changing it becomes increasingly difficult.

Guidelines for better trade policies by LDCs are given. In the case of traditional primary exports--where LDC do affect international prices--the revevant decision rule is to equate marginal costs to marginal revenue of exports. This can be accomplished by an export tax set at a rate depending on the elasticity of world demand, the country's share in world exports, and the possible reactions of foreign competitiors. Infant industry protection is often the justification for favoring manufacturing industries over nontraditional primary production. Although production subsidies have advantages in theory over protection, budgetary constraints may explain the use of the latter in LDCs. When a particular distortion or cost disability needs to be corrected, the preference for subsidies over protection is yet stronger; that is, specific action dealing directly with the problem is always better. There seems to be some advantages that manufacturing offers over primary production in the form of labor training as well as in encouraging the expansion of related industries. This justifies the promotion of industry in LDCs both by protecting production for domestic markets as well as assisting firms in exporting manufactured goods. Balassa specifically suggests that the net effective protection rate of manufacturing in LDC should be reduced to approximately 10 percent as it is in Denmark and Norway. At most, the rate should be no more than double that for mature industries.

The scheme described above may be implemented by using a basic exchange rate for nontraditional primary products, export taxes on traditional primary exports, and a combination of tariffs and subsidies on manufactured goods. The same result could be achieved by applying differential exchange rates to the three groups of commodities, with further adjustments made for differences in the elasticity of demand among traditional primary exports. Political and administrative feasibility need to be considered when deciding which of these alternatives to follow.

Balassa, Bela (1973)

"Tariffs and Trade Policy in the Andean Common Market", Journal of Common Market Studies, Vol. 12, No. 2, December pp. 176-195.

Existing tariffs in the individual member countries of the Andean Group represent the historical result of actions taken at different times and for different purposes. Their tariff structures show a considerable degree of haphazardness and much dispersion. The Andean Common Market is considered to have a unique opportunity to set a rational tariff structure that would appropriately serve the objective of acceleration of economic growth or alternatively to minimize the long-term domestic cost of earning (saving) foreign exchange (equating, on the margin, the domestic cost of foreign exchange in all activities--whether in exporting or in import substitution).

The conditions for free trade are not fulfilled in the countries of the Andean Group given that not all export demand from member countries is infinitely elastic. The optimal use of market power will involve either taxing exports that face less than infinitely elastic foreign or applying a tariff-subsidy scheme on other activities. Besides the elasticity condition, other reasons for differential incentives to manufacturing industries are the indirect benefits in the form of external economies and the infant industry argument, but on a temporary basis only. Discrimination against exports will provide incentives for the expansion of high-cost import substituting industries.

The optimal export tax will depend on a variety of factors, and not just the elasticity of foreign demand. The effective rates rather than the nominal rates (tax as a proportion of the export price) are relevant since they express the margin of protection on value added in the production process rather than on price alone. Equal effective protection to all industries is a good general rule since little information is available on external economies in manufacturing industries.

In practice it is complicated to calculate optimal nominal tariffs and export subsidies on particular products that will provide effective protection at equal rates to all manufacturing industries. The minimum common external tariff set for the Andean Group has been derived by setting tariffs for nine stages of processing. The calculations required information on material input and value added coefficients for individual commodities which were not available for the Group's country members. "Borrowed" coefficients from Belgium and the Netherlands were used and supplemented by information from the U.S. and UNIDO. Technically two approaches were combined to obtain nominal rates: one on a commodity-by-commodity basis from lower to higher stages of processing and the other by inverting the complete input-output matrix which incorporates the desired effective rates. Both approaches are subject to considerable errors which suggests limiting the dispersion of tariff and subsidy rates.

The adoption of common tariffs, export taxes and export subsidies, the abolition of quantitative restrictions and other protective measures, and the application of flexible exchange rate arrangements supported by guidelines on tax, credit and expenditure preferences is recommended for the Andean Group to succeed in accelerating its economic growth; that is, remove the sources of distortion that lead to a misallocation of resources in the member countries.

Balassa, Bela (1977)

"Reforming The System of Incentives in Developing Countries"
In: Policy Reform in Developing Countries by Bela Balassa, pp. 7-29.
Oxford: Pergamon Press

After World War II, a number of LDCs adopted a strategy of import-substitution industrializattion (ISI) behind high protective barriers. The measures applied contributed to the expansion of manufacturing industry but often at a considerable cost to the national economy in the form of inefficiencies in the allocation of economic resources, including new investments. Inefficiencies resulted from distortions in product and factor (capital and labor) prices that created a wedge between the private and the social profitability of particular products and production techniques.

Distortions in <u>capital markets</u> may be due to governmental action or their own imperfections, reflected in the dispersion of rates of return on alternative investments. The sources of these distortions are: 1) high and unstable rates of inflation, 2) the tendency to keep nominal interest rates low, and 3) credit rationing. These distortions can be eliminated by a monetary reform.

Distortions in <u>labor markets</u> where high wages and social benefits in large-scale industry may also adversely affect agricultural production as migration takes place in response to the adverse wage differences. This difference between market and shadow wages could be solved by subsidies to the use of unskilled labor in the production process.

<u>Public utilities</u> are often underpriced in LDCs in the sense that the price does not cover the social long-run marginal cost adjusted for consumer surplus; its rationalization will contribute to increase employment and improve income distribution as well as to efficient resource allocation.

Protective measures employed within the ISI scheme, apart from the bias against exports, lacked coordination. An optimal policy of protection would require taking account of the interdependence of the measures as well as their effects on resource allocation and the balance of payments. For purposes of protection, <u>tariffs</u> are superior to quantitative restrictions, the latter being used with advantage only in case of an emergency. Tariffs are automatically applied with lower administrative cost and contribute to government revenue; they also minimize the inducements for bribery that exists in a quota system. Export earnings will be maximized by levying an export tax so that marginal revenue in exporting becomes zero. Preferential treatment for <u>manufacturing activities</u> should be granted only when they generate external economies. A tariff cum export subsidy scheme is preferable to production subsidies when the adverse budgeting effects of the latter are considered, despite the distortions of the former on consumption patterns.

It will generally be preferable to accord special treatment to certain industries in the form of direct subsidies rather than higher rates of protection, the cost of protection representing a loss in productive efficiency. Equal protection at relatively low effective rates should be granted to all manufacturing industries and let competition do the rest. The effective rates of protection on an industry should not be over 10%. Infant industry protection, due to imperfect capital markets and the risk of bankruptcy, is acceptable only on a temporary basis to avoid indefinitely protecting inefficient activities.

For countries with an already established industrial base, reform of the protection system is to be carried out in two parts: 1) a compensated devaluation accompanied by the imposition of optimal export taxes, and 2) a longer-term reform of tariffs and subsidies with changes according to a time table determined in advance. This second part will simplify and rationalize the structure of protection. Targets and annual changes should be made public in advance. A flexible exchange rate policy to keep the real exchange rate constant is also suggested.

These measures would improve the efficiency of resource allocation and the growth performance of the economy while increasing employment through a shift from relatively capital-intensive import substitution to labor-intensive exports. Higher employment, reductions in excess profits in protected industries, and higher prices to small-scale producers in agriculture, would also bring improvements in the distribution of incomes.

Bhagwati, Jagdish and Krueger, Anne O. (1973)

"Exchange Control, Liberalization, and Economic Development"
American Economic Review (Papers and Proceedings), Vol. 63, No. 2, May, pp. 419-427.

The National Bureau of Economic Research (NBER) sponsored a major project on quantification and analysis of individual developing countries' experiences with exchange control regimes and attempts at liberalizing those regimes, focusing equally on the interaction between the country's trade and payments regime and its economic development. The countries included in the NBER project were: Brazil, Chile, Colombia, Egypt, Ghana, India, Israel, South Korea, Philippines, and Turkey. This paper synthesizes the overall results of the individual studies.

Each country study attempted to identify: 1) when and why the exchange control regime was adopted and how it was intended to relate to the country's economic goals, 2) the evolution of the quantitative restrictions (QR) after their initial imposition, 3) efforts to ameliorate the undesired results of the payments regime, 4) experience with attempts at liberalization and the timing of the economy's response to those attempts, and 5) the resource-allocational, income-distributional, and growth effects of the country's experience. The authors were surprised at the degree of similarity among seemingly diverse countries. Initial adoption of exchange controls was generally an ad hoc response to external events. Within this process, the internal working of the QR systems generally frustrated, at least partially, the very domestic goals they were designed to achieve. Countries which have had export-oriented development strategies appear, by and large, to have intervened virtually as much as "chaotically" on the side of promoting new exports as other countries have on the side of import subsitution.

There are four theoretical reasons why export promotion (EP) may be a superior strategy compared to import substitution (IS): 1) the costs of EP are more visible to policymakers; 2) an EP strategy entails relatively greater use of direct interventions; 3) exporting firms must face price and quality competition in international markets; and 4) with an EP strategy, firms are able to reach adequate size when there are significant indivisibilities or economies of scale.

A wide dispersion in effective exchange rates (the amount of domestic currency paid when a good is landed per dollar of c.i.f. value) by commodity categories is the result of QR regimes. Even without a formal devaluation there are many degrees of partial devaluation in QR regimes. Changes in the parity, as reported by the IMF, do not necessarily reflect adequately the economically relevant magnitude of the devaluation.

Liberalization may be said to occur when the official price of foreign exchange assumes an increased role in the allocation of resources, whereas devaluation occurs whenever nominal exchange rates are altered. Liberalization works only insofar as imports of noncompetitive goods are involved and the degree of protection to import-using industries may even increase as imported intermediates are liberalized. The effect of liberalization is often to induce a recessionary tendency rather than the traditionally feared inflationary impact. The interaction between the payments regime and economic growth is complex and depends on a host of other factors in individual countries.

It is always true that every quota has a non-negative tariff equivalent at each point in time for every recipient of an import license. But it is not always true that there is a single tariff-equivalent for a quota for a given homogenous import commodity. And it is generally false that the resource-allocational effects of a quota are the same as those of the tariff-equivalent. The reason for the latter is that resale of imports is usually illegal.

The method of <u>license</u> allocation has important effects on resource allocation and income distribution. The difference between the c.i.f. price and the domestic price is the costs incurred by the actual importer and the premium that accrues to the recipient of the import license. The precise allocation of the licenses determines who receives the premium: 1) direct producers or imports. The calculation of effective protection must allow for the fact that some imports may be obtained at both premium-inclusive and premium-exclusive prices.

OR regimes have an internal, self-contradictory logic. The tariff equivalent of existing quotas tends to fluctuate widely and the unintended side effects of QR's tend to force other changes. Once a QR regime is established, quotas start to be used to accomplish purposes other than the initial one of restraining <u>ex ante</u> payments inbalances. OR's have been used to provide powerful profitability incentives for production capacity regardless of the social opportunity costs. Not all IS firms were found to be inefficient but the major defect of the QR system seems to be its inevitably indiscriminate nature.

Most QR systems have tended to become increasingly actual-user oriented to avoid speculation with licenses. The problem appears when firm capacity is used as the allocation criteria, which then encourages excess capacity and little competition. The industry's output is closely tied to the imports of intermediate goods allocated by licenses. Investment licensing is then used to limit excess capacity but it insures the growth of efficient and inefficient firms alike. This inability of QR systems to foster relatively more rapid growth of more efficient firms may well be one of the gravest drawbacks of the QR-IS development pattern.

Corden, W. M. (1966)

"The Structure of a Tariff System and the Effective Protective Rate" Journal of Political Economy, Vol. 74, No. 3, June, pp. 221-237.

Corden makes the following assumption: 1) physical input-output coefficients are all fixed; 2) elasticities of demand for all exports and supply of all imports are infinite; 3) all tradable goods remain traded even after tariffs and other taxes and subsidies have been imposed; 4) appropriate fiscal and monetary policies maintain total expenditure equal to full employment income; and 5) all tariffs and other trade taxes and subsidies are non-discriminatory as between countries of supply or demand.

The effective protection rate is defined a percentage increase in value added per unit in an economic activity which is made possible by the tariff structure relative to the situation in the absence of tariffs but with the same exchange rate. It depends not only on the tariff for the commodity produced by the activity, but also on the input coefficients and the tariffs on the inputs. The nominal protection rate on a final good is a weighted average of its own effective rate and the tariff rate on its inputs. Tariffs on inputs of inputs of a product do not affect its effective protect rate. Effective protection rates can be calculated both for importable as well as exportable goods. Taxes and subsidies on domestic production or consumption of tradable goods also affect effective protection rates. Once the effective protection rate for each activity is calculated, they are ordered on a continuous scale that, with the production-substitution elasticities, determine the production effect. The consumption effect depends on the nominal tariffs on final goods and consumption-substitution elasticities. The exchange rates need to be considered in the analysis when non-traded goods are introduced to keep balance among the relative prices of traded and non-traded goods.

Corden identified four different concepts of industry protection: 1) if its nominal tariff is positive, 2) if its effective rate is positive, 3) if its net effective rate (taking into account the exchange-rate) is positive, and 4) if the value added in an activity rises due to the protecttion structure after an appropriate exchange-rate adjustment.

Corden, W. M. (1975)

"The Costs and Consequences of Protection: A Survey of Empirical Work"
In: International Trade and Finance Frontiers for Research, edited by
Peter B. Kenen, pp. 51-91
Cambridge: Cambridge University Press

After World War II, protection by import quotas and exchange control has been more important in LDCs than in MDCs. The cost of protection consists of a production cost and a consumption cost. Relevant points for empirical work on the cost of protection are: 1) the use of a constant-utility demand curve for the consumer's surplus calculation; 2) alternative meanings of cost; 3) the assumption of given terms of trade, valid only for the small country case or under reciprocal tariff reductions; 4) the assumption of balance-of-payments equilibrium at all times or at least a constant deficit or surplus; 5) consideration of the practical implications of the multi-commodity case where tariffs are not uniform; 6) market demand and supply curves cannot be used when studying the effects of some tariffs or quotas while others are held constant; 7) adjustment must be made in the presence of any divergence (distortion) between private and social costs or benefits; 8) calculations are static while the "cost-reduction effect" of trade is dynamic; and 9) static costs always seem to come out "small".

The effective rate of protection concept is attractive because it allows a single figure to sum up the net result of various trade and other taxes and subsidies affecting any particular activity. Several aspects are to be considered when effective protection is calculated: a) when quotas are the principal method of protection, comparisons between domestic and world prices must be made in order to obtain implicit nominal rates of protection; b) even when tariffs alone are used, there may be much tariff redundancy, requiring price comparisons; c) available input-output coefficients in most countries are rarely sufficiently disaggregated; d) all effective-rate calculations involve tariff averaging of some kind; and e) the treatment of non-traded inputs has been shown to make a considerable difference in the results. The treatment of indirect taxes is also important.

Estimation of effective rates of protection gives an indication of the direction of resource pulls of the protection structure and since factor intensities differ between activities, also of functional or sectoral income distribution effects. The extent of protection--the size of the bias against exports as shown by average effective rates for import-competing manufacturing--is also important.

The main argument about optimal trade intervention in the presence of domestic distortions is that, when there are divergences between private and social costs or benefits that are domestic in nature, first-best policy is never to use trade intervention but rather to tax or subsidize directly at the point of the divergence. The only first-best argument for tariffs is the optimum tariff (terms of trade) argument. This really suggests that, if there is any valid basis for intervention at all, subsidies of various kinds should generally replace tariffs.

Two arguments provide some basis for assisting manufacturing industries in LDCs: 1) the infant-industry argument based on either internal or external dynamic economies, the former rests on imperfections either of private information or of the capital market while the latter rests on the inability of firms to retain the labor they train, 2) the wage-differentials argument that rests on the difference between the shadow wage and the actual wage faced by the firm. In both situations, a tariff is not the first-best solution and subsidies would be better solutions.

Trade liberalization needs to take account of "dynamic" effects of trade and protection such as economies of scale, X-efficiency, and competitiveness. Four hypothetical reasons are given by Corden as to why do countries actually protect their industries: 1) some LDCs want industrialization for its own sake; 2) it reflects the triumph of producer over consumer interests, of the tightly organized small group over the diffused larger group; 3) in the U.S. tariffs seem to protect the "scarce" factor; and 4) through history the aim of protective policies has been to maintain sectoral incomes.

Corden, W. M. (1980)

"Trade Policies"
In: Policies for Industrial Progress in Developing Countries, edited by J. Cody, H. Hughes and D. Wall, pp. 39-92.
New York: Oxford University Press for the World Bank.

Industrial growth requires large imports of capital goods that create pressures on the balance of payments. On the other hand, a weak balance of payments situation may require measures such as devaluations, quotas, and others that contribute to industrial development. Corden assumes in his chapter that a current account deficit needs to be reduced through monetary and fiscal policies.

A switching of pattern of output and expenditure accompanies these policies since a reduction of expenditure also reduces the demand for nontradable goods, and resources of this sector have to move into the tradable goods sector (import-competing and export goods). This switching in pattern of expenditure can be brought about by market forces through changes in relative prices and wages due to the gap between supply and demand. The devaluation of the exchange rate helps in this process by changing the relative prices of tradable goods with respect to nontradable goods. Devaluation has a "protective" effect, according to Corden, in the sense that the industrial sector will expand at expense of the nontradable sector. Devaluation is neutral among import-competing and export sectors since both belong to the tradable goods sector; it is the nontradable goods sector which carries the expense of the exchange rate devaluation. There is a combination of a uniform tariff and a uniform export subsidy that is equivalent to a given devaluation. An import quota system is an alternative switching device for moving resources from imports to import-competing goods and nontradables.

Devaluations are preferable switching devices to accompany a expenditure reduction required to cover a deficit in the balance of payments of an economy working at full capacity to import quotas. Devaluation is a price mechanism which is neutral with respect to imports or exports while import quotas only affect the former. Import quotas protect the import-competing sector relative to the nontradables sector and the export sector while devaluation does so only relative to the nontradables sector. However, devaluation may have the short-term effect of worsening the terms of trade of an economy with exports that respond only slowly to price changes. Both devices have inflationary aspects by raising the cost of living. The main difference among them is that devaluation causes profits in the export industries to rise, while quotas generate extra profits for holders of import licenses.

Corden discusses the principal instruments of protections under the assumption that the balance of payments is maintained in equilibrium by expenditure adjustment and exchange rate policy. The main protection instrument is the import tariff, which increases the production of import-competing industries, increases the prices domestic consumers pay, increases the profits of import-competing industries, decreases total amount of consumption and imports, and creates a revenue to the treasury. A consumption or sales tax on consumers, the revenue of which goes partly to the treasury and partly to finance a subsidy to import-competing industry would be equivalent. The basic argument is that protections means favoring some industries relative to other industries. Tariffs cause the reshuffling of resources and also of real incomes; it is necessary to take into account the whole system of tariffs, and not just one tariff on its own.

Import quotas have similar effects to tariffs since they limit the quantity of imports and raise their prices. Exchange controls differ from import controls because they apply to all demand for foreign exchange and also because they are administered by the central bank and the banking system. Export subsidies are another instrument of protection. They raise prices received by exporters. They are financed by the treasury for exports and by consumers for domestic sales. These subsidies may be granted through several forms such as a multiple exchange system, preferential export credits, or even giving exporters preferences in the award of import licenses. Export taxes are not protective because they reduce exports although they raise government revenue, which probably is the main reason for imposing them. Export subsidies on exported inputs will provide negative protection for input-using industries. Export taxes on these inputs would provide positive protection for those industries which use them. Multiple exchange rate systems may have either protective or anti-protective effects and can be shown to be equivalent to a set of taxes and subsidies on imports and exports. Equilization levies, tariffs that vary as world prices change so as to maintain a desired level of domestic prices, is another protective device used by some countries. Finally, pooling or home-price schemes and domestic-content schemes are also mentioned by Corden as protective devices used by LDCs. The author stresses that protection is not the only road to industrial development, and trade policies can foster such development by making the economy work more efficiently.

Corden discusses the arguments that justify the protection of manufacturing industries at the expense of other sectors of the economy. Some countries have a protection structure set up where vested interests may not permit a change towards a more efficient approach. Other countries may find it feasible to make gradual changes in such systems. A third type of country does not yet have any protection system set up, and still has the options open.

Corden points out that a country that decides to protect its manufacturing sector relative to other sectors of the economy with trade policies will have to deal with three fundamental decisions: 1) import substitution versus export promotion, 2) uniform protection versus made-to-measure protection, and 3) import quotas versus tariffs. Import-restricting measures hamper exports in several ways. The net result of protecting manufacturing by import substitution (tariffs and quotas) is to introduce a home-market bias. Such bias is undesirable because the benefits of comparative advantage and economies of scale are foregone. The size and stage of development of an economy conditions the importance of the home-market bias. On the other side, an export promotion approach through export subsidies confronts the difficulty of countervailing duties from importing countries.

Corden discusses the concept of effective protection which he defines as the "net protection provided for value added in an activity by tariffs or similar measures affecting output and input values". Effective protection indicates the percentage increase in value added afforded by protection over value added which would prevail in a nonprotected situation. The relative rates of effective protection among the different sectors are the relevant figures on which decisions should be taken.

With a <u>uniform</u> protectionist system, the same rates of protection are provided for all activities in manufacturing so that there is no discrimination other than that which comes naturally out of the price system. The advantages of this approach is that it applies the principle of comparative advantage and is simple for administration. Uniform protection implies equal rates of effective protection for all manufacturing activities. Although the principle of uniform effective protectionism is simple, its practice is complex because very different nominal rates of tariff and export subsidies may be required to obtain equality of effective rates. For complete uniformity, effective protection rates for export goods and import-competing goods also must be the same.

An alternative to uniform protection is made-to-measure protection which consists in protecting industries only as much as is "needed". An important pitfall of the made-to-measure approach is that it lacks an automatic selection process of which industries to protect and this has to be decided subjectively. Other difficulties of this approach are the adverse effects it can have on firms' incentives to keep their costs down, the great deal of detailed judgment about costs of firms that must be estimated by tariff authorities, and the additional uncertainty it can introduce into business planning.

The third type of decision Corden discusses is the use of import tariffs versus quotas. Quotas have the advantage of creating greater certainty to the industry. The disadvantages of quotas are: 1) they do not provide a criterion for the selection of industries to protect; 2) they create monopoly situations by eliminating import competition completely; 3) they isolate the domestic economy from foreign developments (changes reflecting new technological advances); 4) they create the need to allocate import licenses which will have a scarcity value that yields potential profits; and 5) those who wish to obtain licenses are tempted to use corruption.

Many countries make use of antidumping duties which the GATT code permits if a foreign supplier is selling the same or similar products to consumers in his domestic market at a higher price and if the dumping causes material injury to domestic import-competing producers. Corden mentions two points in this respect. First domestic producers often feel it is unfair if foreigners sell at lower prices, although the effect of this competition benefits the nation as a whole by providing cheap imports. Second, predatory dumping is serious, since short-term price cutting is an instrument of monopoly. The main difficulty is for a government to assess whether a price change is temporary or permanent, and if it wishes to isolate its producers from foreign influences. Protection measures can also be taken to avoid adverse movements in the terms of trade. Corden considers that protection of manufacturing is only an indirect way of improving terms of trade by affecting export and import prices and that better alternative policies are usually available for the purpose.

Dardis, Rachel and Learn, Elmer W. (1967)

Measures of the Degree and Cost of Economic Protection of Agriculture in Selected Countries.
Technical Bulletin-U.S. Department of Agriculture, No. 1384, pp. 1-69.

The authors point out that the degree of protection, which is equal to the difference between producers' prices (adjusted for marketing margins) and trade prices, and the cost of protection should be considered complementarily when analyzing trade restraints in international trade.

The first part of the paper considers the measurement of the degree of protection using the method of equivalent tariffs suggested by Harberler. Among the advantages of this method are the inclusion of transportation costs, export subsidies, and non-tariff barriers to trade.

The degree of protection was estimated for grain, livestock, and dairy products for 1959-1961 (all prices were averaged for the three-year period) for Canada, Denmark, France, Italy, the Netherlands, the United Kingdom, the United States, and West Germany. Trade price as a percentage of producer price was used as a measure of the degree of protection. Changes in this measure were examined for some of the countries. Milk was the most protected of all commodities. Other than milk, the margin of protection was generally higher for the importing countries than for the exporting countries, which had either negative or low margins of protection. The degree of protection appeared to have increased for grain and milk and remained relatively constant or decreased for livestock and eggs during 1950-1961.

The second part of the study dealt with the welfare cost of agricultural protection. Using a simple two-good model, the effects of protection and of an export subsidy on the world price of the import good was examined assuming that no changes occurred in the price of the country's export good.

The formulas used for calculating the cost of protection showed that the <u>same</u> absolute cost of protection can be obtained from different combinations of elasticities and tariffs (high tariffs with low elasticities or low tariffs with high elasticities). The authors concluded that even though the degree of protection is an incomplete measure of protection, its knowledge is essential in computing the cost of protection. Furthermore, the cost of protection is sensitive to the particular demand and supply elasticities used, which is not true for the degree of protection.

Dean, Gerald W. and Collins, Norman R. (1966)

"Trade and Welfare Effects of EEC Tariff Policy: A Case Study of Oranges" Journal of Farm Economics, Vol. 48, No. 4, Part I, November, pp. 826-246.

This article estimated quantitatively the trade and welfare effects of alternative policies which might be adopted by the EEC for oranges. The specific object of the article was to evaluate price, trade, and welfare implications of three alternative policy situations: 1) a shift from continuance of pre-EEC tariffs on oranges to prospective EEC tariffs, 2) elimination of the EEC tariffs on oranges and, 3) free access to the EEC. Methodologically the author used a spatial equilibrium model to quantify the changes in world prices, consumption, and trade flows for alternative EEC policies and the solutions are evaluated in terms of welfare effects measured by the concept of economic surplus.

The conclusions were: 1) shifting to prospective EEC tariffs will result in a net welfare gain to the EEC block (at expense of producer groups in the non-EEC countries), assuming that the income redistribution within the EEC is accepted; 2) the elimination of EEC tariffs on oranges would result in a net loss to the block unless compensating reciprocal tariff reductions on other commodities could be obtained from other countries; and 3) allowing another producer inside the tariff wall would cause substantial losses to the EEC countries. There appeared to be little incentive (in fact, a disincentive) for the EEC either to reduce its tariffs on oranges unilaterally or to permit special access to the EEC by outside producing countries. Hence, reductions in tariffs on oranges were though likely to come about only as part of more general tariff negotiations involving mutual concessions.

Munk, Bernard (1969)

"The Welfare Costs of Content Protection: The Automotive Industry in Latin America"
Journal of Political Economy, Vol. 77, No. 1, Jan./Feb. pp. 85-95

LDCs have approached the goal of industrialization emulating the pattern of production of MDCs. Argentina, Brazil and Mexico are the largest countries in Latin America and supply their respective automotive markets with domestic production. In all these countries there are national "content" programs. The more domestic content required of the foreign-controlled firms that have located their manufacturing facilities in the country, the more expensive these programs are in terms of resource costs. The justification for these programs is foreign exchange savings and the "spillover" benefits (backward linkages). Looking also at market size, the author stated that low volumes of passenger vehicle output in Latin America countries give rise to greater excess production costs per unit than do low volumes of commercial vehicle output. The ability to plan for large volumes of output is a crucial aspect.

Defining excess cost as the difference between the wholesale price to dealers of a vehicle produced domestically and the c.i.f. cost of the same vehicle ported from the U.S., the author calculated the cost of content protection. Excess costs as a proportion of respective c.i.f. costs of vehicles are considered as an implicit tax that corresponds to a tariff. His estimate for consumer welfare cost, (deadweight loss of consumer's surplus) was 30% of c.i.f. costs. This estimate was valid only for the initial stages of content protection since Brazil showed that costs may fall over time.

Prebisch, Raul (1959)

"Commercial Policy in the Underdeveloped Countries"
American Economic Review (Papers and Proceedings), Vol. 49, No. 2, May, pp. 251-273.

The author contends that the uneven spread of technological progress has contributed to the division of the world economy into industrial centers and peripheral countries (engaged in primary production), with differing income growth rates. The spread of technological progress brings with it the need for industrialization. A common alternative to industrialization has been expanding primary exports through technical progress. But this increase in productivity creates redundant manpower that needs to be absorbed in some way; without industrialization this is not possible. Industry and technical advance in primary production are thus complementary aspects of the same growth process.

Import substitution (IS), defined as an increase in the proportion of goods that is supplied from domestic sources, is the only way to correct the effects of disparities in foreign trade elasticity on peripheral growth. IS, or the expansion of industrial exports added to the primary ones, or both combined, are necessary to bridge the gap the differing trade elasticities create.

Improvements in productivity cause the use of a declining proportion of the continuously increasing active population for the growth of existing activities for the internal market. A surplus manpower, composed by those redundant due to technological progress (spillovers) and those marginal workers of low productivity (poorly paid, disguised unemployment), need to be absorbed.

The cause of the deterioration in terms of trade is the great disparity in technological densities. Assuming realistically that income elasticity of demand for industrial products is higher than for primary commodities, a combination of disparities in income elasticities of demand and in technological densities put the periphery in a weaker position vis-a-vis the center, as regards the terms of trade. General improvements in productivity tend to be fully reflected in the increment of the wage rate at the center, while at the periphery a part of these improvements is transferred by the fall of export prices (more severely if productivity in export production increases faster than marginal productivity of industry). Interference through export taxes or protective duties can counteracts this tendency.

Protection has different meanings in the peripheral countries and in the industrial centers. In the former it does not hamper the growth of world trade while in the center it does. The reduction or elimination of such protection at the centers has an element of <u>reciprocity</u>, since the resultant increase in exports of primary commodities from the periphery is followed by a corresponding increase in its imports of industrial goods, in response to their higher income elasticity of demand, and there is no need for any reduction or elimination of duties to obtain this result. The development process requires a continual change in the composition of imports and what is needed is a policy to encourage such changes.

<u>Mulilateral trade</u> is the result not so much of adherence to a principle as to trade policies of the most important countries. Latin America has not benefited from specialization and economies of scale from industrialization due to its fragmentation into any country. Mutual trade within the region has been very weak. Each country has tried to produce everything under the sheltering wing of very high protection. The response

should be the enlargement of national markets through the gradual establishment of a common market.

CHAPTER 5

ANALYSIS OF FOOD SUBSIDY AND DISTRIBUTION POLICIES

Introduction

The purpose of this chapter is to examine and evaluate the various policy options directed at increasing the nutritional intake of a target group. Public distribution of food has emerged as an important method of food management in a host of developing countries. It can be carried out through various means. The two principal types of policies are those which offer universal coverage, called countrywide policies, and those which are solely directed at a specific target group. These different policy options require a determination of the variables that explain the behavior of the typical low-income household in relation to its intake of different nutrients. Once these variables have been determined, a choice needs to be made of those that are amenable to management via policy instruments in the short-run and in the long-run. An evaluation of the cost effectiveness of inducing the desired changes in food intake by the different policy alternatives should then follow.

Countrywide Versus Target-Group Policies

A countrywide policy which reaches the target group but at the same time affects all segments of the population is a general food price subsidy. The object of the policy is to increase the consumption in the target group of a given commodity by a fraction λ by reducing its price to consumers through a price subsidy (Δ_d).

Target-group oriented programs reach the particular group without subsidizing the rest of the population. A host of programs can be oriented to specific groups, for example; distribution of food at a price discount, food stamp programs for selected families, free food rations for selected families, and straight income transfers. This chapter focuses on three of these programs: a food price subsidy, a food stamp plan, and a straight income transfer.

The objective of a target-group oriented program is to raise the initial level of recipients' food consumption to a specified higher level. As mentioned above, there are several ways to produce this result. Under a food price subsidy, beneficiaries can purchase as much food as they wish at a reduced price. A food stamp program, on the other hand, gives participants the opportunity to purchase a fixed amount of food at lower than market prices. A variant of the latter program, in use in several developing countries, is a system of rationing. A separate analysis of rationing as part of a food distribution system is presented due to its prevalence and uniqueness of the several target-group oriented programs. A direct income transfer to a recipient group is also an option which can be used to raise their level of consumption.

The relative merits of these various programs must be taken into consideration when deciding among them as methods for assisting low-income households. Cash transfer programs utilize the principle of consumer sovereignty by which people are assumed to know what is best for themselves. On the other hand, food stamp proponents claim benefits for society as a whole, over and above the benefits accruing to program beneficiaries. The benefits might take a variety of forms: (1) Since the working poor are eligible for the program, and because nutritional status affects performance on the job, society's output might be increased and so will the society's general level of well being. The food stamp program can then be viewed as investment with the economic return accruing to all members of society. (2) Taxpayers--donors--might derive more satisfaction from knowing that they are increasing food consumption (food stamps) among low-income recipient households than from knowing that they are increasing consumption of food <u>and</u> non-food items (cash transfers) for these same recipients. (3) Increasing the demand for food benefits all those participating in every step of the food production and distribution process.

Proponents of rationing feel that one of the important strengths in this type of system is its almost universal coverage. This characteristic has been responsible to a certain extent for the minimization of leakages and the stability of the system.

For target-group-oriented programs to be effective it must be possible to identify a homogeneous population with the characteristics described. Furthermore, it must be possible to implement the programs in a way that the benefits reach only the intended population. In reality these conditions are unlikely to be met because in most instances it is difficult to determine who should be eligible for the program. The cost-effectiveness will then tend to be less than maximum and minimum food consumption targets may not be reached.

Clearly, if the target group is fairly homogeneous with respect to income, its relative poverty is the decisive factor in making a choice between the programs. When the group is extremely poor, the price elasticity and the marginal propensity to consume food tend to approach unity, and the three programs are almost equally cost effective. Food stamps are more difficult to implement because participants would have to accumulate sufficient cash to purchase a month's or even a week's supply. If the target group's income and food consumption falls short only by a small fraction of adequate nutrition, the food stamp program might be twice as cost effective as the other programs.

If the target population is heterogeneous, some additional considerations enter. A price subsidy program aimed at the average income level is bound to lead the better-off members of the target group to consume beyond minimal nutritional requirements and to leave the poorest inadequately fed. A food stamp program in which everyone is charged the same amount for the stamps may have the result of preventing those in greatest need from participating, whereas it is less than fully cost effective for those with higher incomes. To avoid neglecting poorer members of the target group, charges for food stamps will have to be set liberally, which means the program will be less cost effective.

Still other factors must be considered when choosing among alternative programs. First, the foregoing comparisons of cost effectiveness do not take into account the value of additional nonfood expenditure induced by the transfer payment. For example, an income transfer might not be as cost effective as a food stamp program but, would give the target population additional means for nonfood expenditure. Additional income might induce better health and lower fertility, both of which are complementary to food in reducing malnutrition.

Second, no food assistance can be expected to be totally efficient in the sense that the subsidized food reaches only the target group. Participating beneficiaries may not reveal the full truth of their circumstances and may receive unintended assistance. Middlemen and administrators may take illegal cuts and target-group beneficiaries may resell food intended to augment their own consumption. Thus, political and administrative problems may be as important as minor difference in cost effectiveness in determining the choice of an optimum program.

Analytical Framework

The following analysis of the food subsidy and distribution policies utilizes standard microeconomic theory which assumes that households maximize utility by choosing the most preferred within their set of attainable consumption opportunities.

A General Food Price Subsidy (Countrywide Policy)

In order to develop this model, assume that there are two groups of urban consumers: the target, or poorer, group (p) and the richer group (r). For a given commodity the price elasticity of demand (η_T) can be expressed as the weighted average of the elasticities of demand of both groups. That is

$$\eta_T = \alpha \ \eta_p + (1-\alpha)\eta_r$$

Therefore, the increased consumption for the target group (λ) can be denoted by

$$(1) \quad \lambda = \eta_p \cdot \Delta_d$$

Aggregate equilibrium requires that increased demand be met by increased supply, then

$$(2) \quad \eta_T \ \Delta_d = \varepsilon \Delta_s$$

where ε represents price elasticity of supply, Δ_s represents percentage change in the supply price and Δ_d represents percentage change in the demand price.

Substitute to obtain

$$(3)\ \Delta_s = \left(\eta_T/\eta_p\right)\left(\lambda/\varepsilon\right)$$

<u>Cost of a General Food Price Subsidy</u>

The fiscal cost of the subsidy(s) can be denoted as a fraction of the initial expenditure on the commodity, hence

$$(4)\quad s = (\Delta_s + \Delta_d)\ \cdot (1 + \eta_T\ \Delta_d)$$

Substituting for Δ_s and Δ_d gives

$$(5)\quad S = \left[\left(\eta_T/\eta_p\right)\left(\lambda/\varepsilon\right) + \lambda/\eta_p\right] \quad \left[1 + \left(\eta_T/\eta_p\right)\ \lambda\right]$$

$$(6)\quad S = \left(\lambda/\eta_p\right) \quad \left[\left(\eta_T/\varepsilon\right) + 1\right]\left[1 + \left(\eta_T/\eta_p\right)\ \lambda\right]$$

If the food item is partly imported its supply elasticity is infinite ($\varepsilon=\infty$) then S must be interpreted as a general consumption subsidy. When only the imported fraction of the commodity is subsidized the fiscal cost of the policy diminishes. At the same time, form income falls and production efficiency decreases because imports replace cheaper domestic production. In this situation the fiscal cost of the policy will become

$$(7)\quad S = \left(\lambda/\eta_p\right) \quad \left[\left(1 + \lambda\ \left(\eta_T/\eta_p\right)\right) - \Pi\left(1 - \lambda\ \left(\varepsilon/\eta_p\right)\right)\right]$$

In equation (7) Π denotes the initial fraction of domestic consumption satisfied by domestic production and ε represents the domestic supply elasticity.

The efficiency loss of domestic production due to subsidizing the import component of the commodity can be written as a function of the initial expenditure on that commodity, thus

$$(8) \quad L = 1/2 \left(\lambda / \eta_p \right)^2 \cdot \Pi \cdot \varepsilon$$

The cost effectiveness of this policy can be understood as the cost per additional unit of food consumed by the target group as a ratio of food's preprogram price. It can be represented by

$$(9) \quad CE = S/\lambda\alpha$$

In countries where there exists a large share of the population (1–α) already receiving adequate nutrition and food supply is inelastic, the fiscal cost of a general subsidy program per added unit of consumption in the target group becomes very expensive. The opposite will occur if the food supply is relatively elastic and a large proportion of the population is inadequately fed.

Target Group Policies

The budget line X_oY_o in Figure 5-1 illustrates the opportunities a consumer has for allocating a fixed amount of income to food and nonfood purchases. Given the indifference curve AB, the initial equilibrium of the consumer is P, with an initial consumption of food equal to F. The curve OZ, the income-expenditure line, illustrates the consumer's preference for allocating increasing levels of income to food and nonfood purchases when the budget line has the same slope as X_oY_o: that is, the price ratio of food and nonfood remains constant.

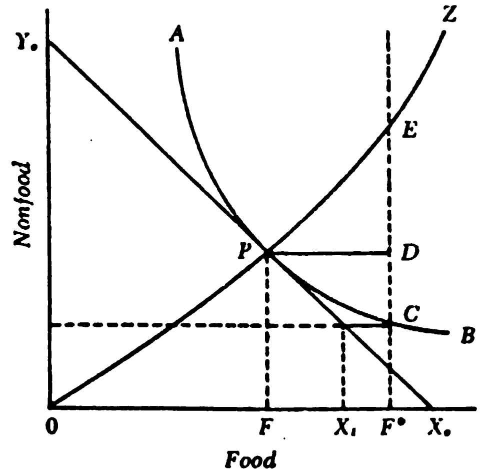

Figure 5-1: Analysis of the Cost
of a Food Stamp Program

As stated earlier, the objective of a target-group oriented program is to increase the consumer's food consumption from his initial level, F, to a higher level, F°. The costs of alternative programs to reach this objective can now be illustrated.

A Food Stamp Program

A food stamp program can be implemented to provide the participants with food with a market value of F* at a charge of OX_1. In this case the participant not only consumes the full amount of the subsidy in food (X_1F*) but in addition spends some income previously devoted to nonfood items (FX_1) on food. (See Figure 5-1).

Devising this program presupposes knowledge of the participants utility function. A more realistic program will set the cost of the stamps for the participants at OF which is the consumer's expenditure for food without the program. The consumer will be in equilibrium at "D" and the cost of the program becomes FF*.

A basic condition for implementing a cost-effective food stamp program is differential costing of the stamps for participants in accord with their expenditures on food (and as a proxy of their income levels). Otherwise, those with the greatest need will refuse to participate in the program and participants who have higher-than-average incomes will use only a fraction of the subsidy for added food consumption.

<u>An Income Transfer Program</u>

To analyze the effectiveness of income transfers as a means of increasing food consumption, Figure 5-2 is used. Assume that the income-consumption curve is represented by PZ. This curve indicates how much food is consumed as the income of the participant increases. It indicates that if we desire the participant to consume food at amount F* he must be given X_2F^* of extra income so that his budget becomes Y_oRET. With this income level the consumer will be demanding the target amount of food.

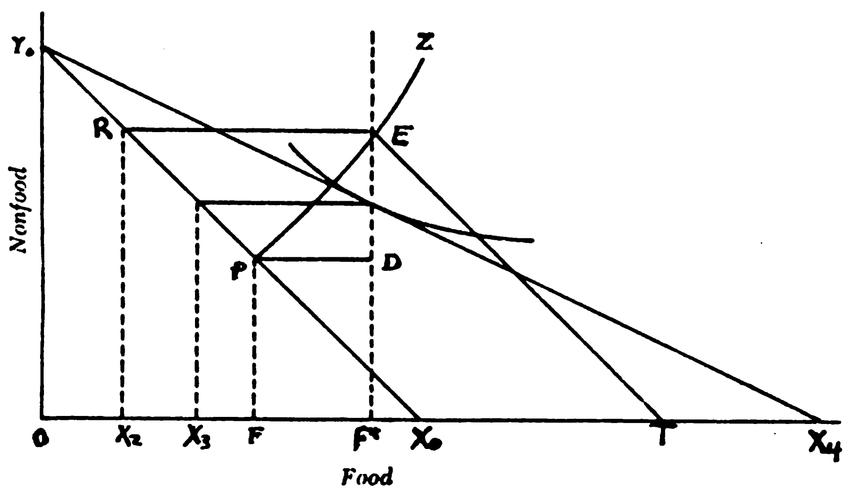

Figure 5-2: Analysis of the Cost of a Food Price Subsidy

Normally, the higher the income level of the target group, the lower the marginal propensity to consume food. Hence, an income transfer is relatively less cost effective. It is also noteworthy that the marginal propensity to consume food of desirable nutritional quality is usually lower in urban than in rural areas for a given food-nonfood price ratio and that the relative price of food is usually higher in urban areas. Consequently, income transfers are likely to be less cost effective for urban dwellers, and for all but the poorest among them.

A Food Price Subsidy

An alternative way of increasing food consumption from F to F* is by subsidizing the price of food. A food price subsidy is illustrated in Figure 5-2 by the new budget line Y_oX_4. The cost of inducing food consumption to increase from F to F* is equal to X_3F^*.

The extent of the price subsidy (that is, the required slope of the new budget line Y_oX_4) needed to induce food consumption at a level F° depends on the curvature of the indifference map. Because it is safe to assume, however, that added food consumption has positive utility and the price elasticity for food is less than 1, the new price line must cross the F° level of consumption between E and D^1. This means that the cost of a food price subsidy, $X_3F°$, will be less than the cost of a straight income transfer and more than the cost of a food stamp program.

Cost of Programs Oriented to Target Groups

The cost of each one of the target-oriented programs will be explained using Figure 5-3. In this figure D_p represents the demand by the target group as a function of initial income Y and S_p represents the supply faced by the target group. The supply is equal to total supply (S_T) minus the demand of the nontarget group.

Assume that the goal is to increase food consumption by ΔF. This goal can also be represented by an increase in food consumption equal to $\lambda = \Delta F/F$.

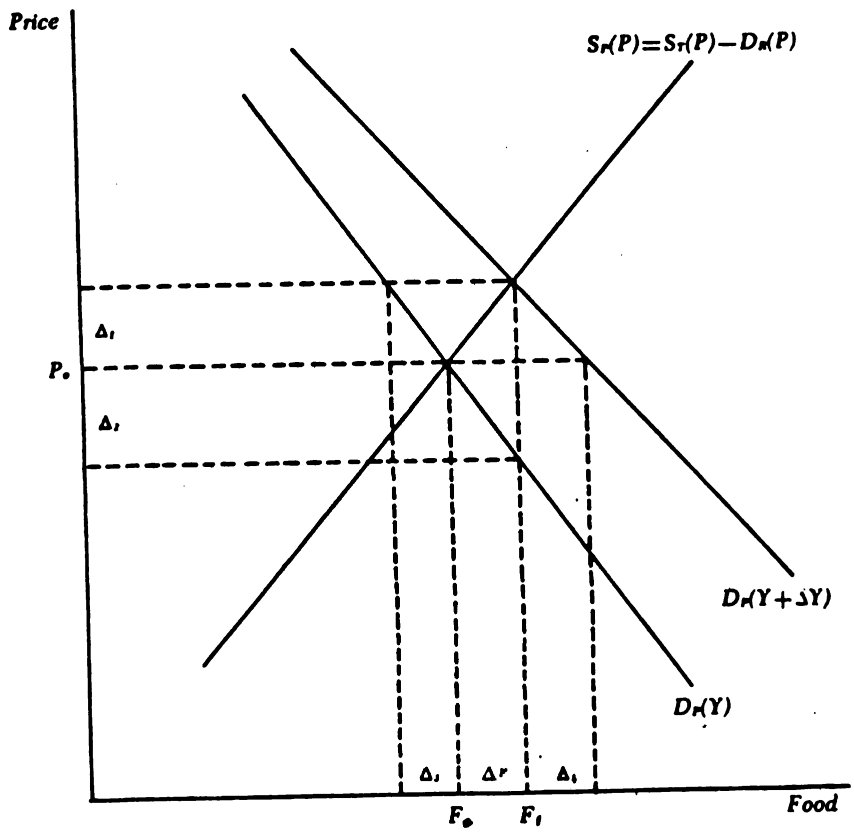

Figure 5-3: Analysis of Target-Group Programs

Denote by Δ_1 the increase in price necessary to induce an increment in supply equal to ΔF. Let ε_p be the elasticity of supply faced by the target group. The following expression can then be defined:

$$(10) \quad \frac{\Delta_1}{P_o} = \frac{\lambda}{\varepsilon_p}$$

The equivalence of the ratio can be explained as follows:

$$\lambda = \Delta F/F$$

$$\varepsilon p = \frac{\frac{\Delta F}{F}}{\frac{\Delta P_o}{P_o}}$$

Therefore

$$\frac{\lambda}{\varepsilon} = \frac{\Delta F/F}{\frac{\Delta F/F}{\Delta P_o P_o}} = \frac{\Delta P_o}{P_o}$$

but

$$\Delta P_o = \Delta_1, \text{ hence } \frac{\lambda}{\varepsilon_p} = \frac{\Delta_1}{P_o}$$

Denote by Δ_2 the decline in price necessary to induce the target group to increase consumption by λ. Let η_p be the price elasticity of demand of the target group. The following expression may be defined:

$$(11) \quad \frac{\Delta_2}{P_o} = \frac{\lambda}{\eta_p}$$

The equivalence of the two expressions is shown as follows:

$$\lambda = \Delta F/F$$

$$\eta_p = \frac{\Delta F/F}{\frac{\Delta P_o}{P_o}}$$

and $\frac{\lambda}{\eta_p} = \frac{\Delta F/F}{\frac{\Delta F/F}{\Delta P_o/P_o}} = \frac{\Delta P_o}{\Delta P_o}$ but $\Delta P_o = \Delta 2$

hence $\lambda/\eta = \Delta 2/P_o$

Denote by Δ_3 the decline in consumption because of the increase in price (Δ_2) necessary to increase supply of output (ΔF). Define

$$(12)\quad \frac{\Delta_3}{F_o} = \lambda \cdot \eta_p/\varepsilon_p$$

Cost of a Food Stamp Program

Assume that the value of the additional food consumption is equal to the fiscal cost of the program. In this case it is necessary that the food stamp program be able to pay for the additional supply at the new supply price ($P_o + \Delta_1$) in addition to the increased cost of old consumption, that is

$$(13)\quad FS = \Delta F\ (P_o + \Delta_1) + F_o\ \Delta_1$$

Remember that $\Delta_1 = \lambda/\varepsilon_p \cdot P_o$

Divide by ΔF and note that $F_o/\Delta F = 1/\lambda$

giving

$$\text{(13a)} \quad \frac{FS}{\Delta F} = P_o \cdot \lambda/\varepsilon_p \left(1 + \frac{F_o}{\Delta F}\right) + P_o$$

Cost of an income Transfer

What is the increase in income that will increase consumption by a fraction λ?

Let m represent the marginal propensity to spend on food, then we want to determine

$$m \cdot \Delta Y = P_o \; (\Delta F + \Delta_4) \text{ (Figure 5-3)}$$

$$\Delta Y = \frac{P_o}{m} (\Delta F + \Delta_4)$$

Multiply and divide by $F_1 = \Delta F + F_o$

then

$$\text{(14)} \quad \Delta Y = \frac{P_o}{m} (F_o + \Delta F) \left[\frac{\Delta F}{F_o + \Delta F} + \frac{\Delta_4}{F_1}\right]$$

For small changes, $\frac{\Delta_4}{F_1} \simeq \frac{\Delta_3}{F_o}$ and $\frac{\Delta 3}{F_o} = \lambda \cdot \frac{\eta_p}{\varepsilon_p}$

hence

$$\Delta Y = \frac{P_o}{m} (F_o + \Delta F) \left[\frac{\Delta F}{F_o + \Delta F} + \lambda \cdot \eta_p/\varepsilon_p\right]$$

Multiply the bracket by $(F_o + \Delta F)$ and divide both sides by ΔF

$$\frac{\Delta Y}{\Delta F} = \frac{P_o}{m} \left[1 + \left(\frac{F_o}{\Delta F} + \frac{\Delta F}{\Delta F}\right) \left(\lambda \cdot \eta_p/\varepsilon_p\right)\right]$$

$$\frac{\Delta Y}{\Delta F} = \frac{P_o}{m}\left[1 + \left(\frac{1}{\lambda} + 1\right)\left(\lambda \cdot \eta_p/\varepsilon_p\right)\right]$$

giving

$$(15) \quad \frac{\Delta Y}{\Delta F} = \frac{P_o}{m}\left[1 + (1 + \lambda)\ \eta_p/\varepsilon_p\right]$$

Equation (15) represents the cost of the income transfer per unit increase in food consumption induced by that transfer.

Cost of a Price Subsidy

In this situation the consumption of the target group is subsidized. The cost of the subsidy is equal to

$$PS = (F_o + \Delta F)\ (\Delta_1 + \Delta_2)$$

substitute

$$\Delta_1 = \lambda/\varepsilon_p \cdot P_o \text{ and } \Delta_2 = \lambda/\eta_p \cdot P_o$$

and obtain

$$PS = (F_o + \Delta F)\ \lambda P_o \left[1/\varepsilon_p + 1/\eta_p\right]$$

Divide by ΔF and note that $F_o/\Delta F = 1/\lambda$

$$\frac{PS}{\Delta F} = (F_o/\Delta F + 1)\ \lambda P \left[1/\varepsilon_p + 1/\eta_p\right]$$

$$\frac{PS}{\Delta F} = (1/\lambda + 1)\ \lambda P \left[1/\varepsilon_p + 1/\eta_p\right]$$

$$(16) \quad \frac{PS}{\Delta F} = P\ (1 + \lambda) \left[1/\varepsilon_p + 1/\eta_p\right]$$

Equation (16) represents the cost to the government of the subsidy per unit increment in food consumption by the target group, which can also be expressed as

$$(17) \quad \frac{PS}{\Delta F} = P_o \left[\frac{1 + \lambda}{\varepsilon_p} + 1 \right]$$

Food Ration Programs

The analytical approach presented here tries to explain the interrelationship among the various components of a mixed (public and market) food distribution system. These components are: domestic production, imports, procurements, ration distribution, income, open market sales, consumption, and market prices.

The open market price of the rationed commodity (for example rice) is determined by the interaction of the market demand for and supply of local rice. When rationing is introduced in a system like this, two likely effects come about. In the first place an increase in ration rice will reduce the demand in the open market by the same amount. In the event that the rationed rice is imported, demand for local rice is diminished. The second effect is to increase the income of consumers receiving the ration by an amount equal to the difference between market and ration price for each unit of ration rice.

The interrelationships in the food distribution system can be analyzed using a simple model of supply and demand that incorporates food rations. The model can be structured as follows:

(18) $QS = mQ^* - QP$

(19) $QD = B_o + B_1P + B_2Y + B_3QR$

(20) $Y = \overset{*}{Y} + QR(aP - PR)$

(21) $QR = U_r + d(MP + QP)$

(22) $QP = U_q = aQ^*$

(23) $MP = U_m + c(Q^* - DD)$

(24) $D = QD + QR$

(25) $QS = QD$

Where

QS = Rice available for open market sale including that part of production consumed at home;

m = Proportion of gross production available for consumption;

Q* = Domestic gross rice production;

QP = Internal procurement;

QD = Consumption from market and home;

P = Real price of rice (retail, medium quality);

Y = Disposable income adjusted for rationing;

QR = Foodgrain ration distribution;

B_o, B_1, B_2, B_3 = Parameters to be estimated;

$\overset{*}{Y}$ = Disposable income without ration;

a = Marginal rate of substitution of ration foodgrains (rice and wheat) for local rice;

PR = Weighted average foodgrain price at ration shops in real terms;

MP = Import of foodgrains;

U_r, U_q, U_m, d, a, c = Parameters to be estimated;

DD = Consumption requirement used as a basis for import planning (15.5 ounces per capita per day); and

D = Total consumption of foodgrains.

All variables except prices are in per capita terms. The value of m is assumed to be 0.9.

Equation (18) represents the net availability of foodgrains for sale and is assurred to be a price inelastic supply function. The invariance of supply to market prices reflects the short run nature of the analysis as well as the dominance of weather factors in the supply of foodgrains from domestic sources. Equation (19) is a market demand function in which rationing has been included as a shift variable. Equation (20) provides a mechanism for adjusting income from rationing. Equations (21), (22), and (23) represent the main decision variables. Equations (24) and (25) are identities.

By substituting equations (18) and (19) into equation (25), the system of eight equations can be reduced to a system of six equations where D, QR, QP, MP, P, and Y are endogenous and Q*, Y^* and PR are exogenous. Since arbitrary decisions as well as uncertain factors can influence QR, QP, and MP, these potential policy variables are not entirely endogenous. The intercept terms--U_r, U_q, and U_m--reflect the effects of arbitrary changes in decisions on these variables. These can be treated as policy variables subject to completely arbitrary decisions by setting the values of d, a, and c at zero and working only through U_r, U_q, and U_m.

It should be noted that a negative QP is equivalent to an open market sale operation by the government; hence the consequence of such an operation can be evaluated. Simultaneously solving for the values of endogenous variables at given values of exogenous variables provides an opportunity to trace out policy implications.

Estimation of Data

A direct measure of the quantity consumed from the free market and at home (QD) is not available. An indirect estimate is therefore made that assumes that QD equals gross domestic production minus the quantity for seed, feed, and wastage and the quantity procured by the government.

Per capita disposable income (Y) is based on estimates of GNP at current market prices minus direct taxes. GNP at current market prices is obtained by adding indirect taxes to GNP at factor cost.

Estimation of Equations

Estimation of equation (19) requires previous knowledge of the marginal rate of substitution (MRS) of ration foodgrains for market rice. Theoretically, the MRS must equal the price ratio but given that in this situation there is restricted supply and arbritrary pricing we should expect it to be equal to or greater than the price ratio of market rice to ration foodgrains. An estimation method is to use the actual MRS as a lower bound and change it progressively until a good set of highly significant coefficients are obtained.

Empirical Applications of Food Subsidy Policies

Five studies are described in the following pages: the first two in India and Sri Lanka concentrate on distribution via ration shops only, while the last three examine the nutritional effects of food stamp programs. Although several developing countries are considering implementing food stamp programs, adequate documentation is available only on U.S. programs.

Public Distribution of Food Grains in Kerala[1]

The food distribution system in Kerala is carried out through ration shops which are linked with a chain of wholesale distributors licensed for this purpose. The system is supported jointly by the Central Government and the state government.

Part of the commodities distributed through ration shops come from local procurement. Imports complement the deficit and make available commodities not produced locally. For procurement purposes each county is classified into three categories based on their average yield of the commodity. Levy rates for these categories are fixed on a graded scale. Levy rates also increase according to the size of the holdings for areas with more than two acres.

The procurement price is determined on the basis of the price level fixed by the central government. In addition to the procurement price, farmers receive an incentive delivery bonus in some years. In most cases the procurement price realized by farmers is very much below the farm price of paddy.

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[1]Based on P. S. George (1979)

The procurement volume of a given commodity is influenced by a number of factors, among the most important we can mention: the gap between the open market and the procurement prices; production levels; administrative efforts to enforce the levy system.

The distribution of foodgrains takes the form of informal rationing. Eligible households can buy a maximum quantity from the ration shop at controlled prices. In the case of Kerala eligibility is determined by the size of the land holdings. The maximum quantity that each participant can buy accounts for only a fraction of the family needs. Participants must purchase their additional requirements in the open market. Since the government controls the interstate movement of food, the volume of foodgrain available in the open market is the local production left after levy requirements have been met. In general open market prices are much higher than the ration price.

The rationing system seems to work best when there is a small volume of foodgrains available through the system. This factor alone contributes to preventing misuse of the ration quota. Moreover, an adequate network of roads and transportation facilities enhances the accessibility to the distribution system.

The distribution system provides also some flexibility that contributes to its success. The ration quota is distributed weekly and installment purchases are feasible. This flexibility allows the participation of poor people who cannot accumulate enough money for making a once-a-month purchase of their ration quota.

The Impact of Ration Distribution

Local procurement efforts to stock the ration shops influences open market supply, farm price, farm income and thus agricultural resource allocation by farmers. On the other hand imports for rationing restrict availability of foreign exchange that can be devoted to other development activities, hence the rationing system influences the level of economic growth. At the consumer level, food rationing influences the consumption pattern through income and substitution effect.

Gains to Producers and Consumers

This approach measures the gains of rationing through income gains or losses. It does not consider the direct and indirect income distribution gains of rationing. It basically estimates the changes in farm income and consumer expenditures in the absence of rationing over their current levels under rationing.

The income gains accruing to producers as a result of abolition of rationing can be calculated as:

$$(26)\quad PG = \sum_{i=1}^{N} Qoi\ (P_{fo} - P_{fr}) + \sum_{i=1}^{N} Q_{1i}\ (P_{fo} - P_{e})$$

where

PG: Producer gain

Q_{oi}: Quantity sold in the open market by farmers belonging to ith area group.

P_{fo}: Farm level price of the commodity in the absence of ration.

P_{fi}: Farm level price under ration

Q_{li}: Quantity sold under levy in ith group

P_e: levy price

The gain to consumers as a result of the abolition of rationing can be estimated using the following formula:

$$(27) \quad CG = R_r (P - P_r) + Q_m (P_o - P_r)$$

where

CG: Consumer gain

R_r: Quantity of the commodity distributed through ration shops.

P: Ration price of the commodity

P_r: Market price of the commodity in the absence of ration

Q_m: quantity purchased from the open market

P_o: open market price of the commodity under rationing

In estimating producer's gain of the abolition of rationing the following prices can be used:

P_{fo}: national free market price level

P_{fr}: Actual farm level price

P_e: levy price paid

In the case of consumers a comparison between national prices and local prices is also used for estimation of gains resulting from the abolition of rationing.

Public Foodgrain Distribution in Sri Lanka[2]

A large part of the rice marketed in Sri Lanka is handled through the public sector. The distribution system began during World War II when the country faced severe food shortages due to disruption of supplies from overseas. The food to be distributed was obtained through procurement imposed on farmers.

After the War, procurement has taken a more voluntary tone. Each year the government announces the price at which it will buy rice from the farmers. There is no limit in the amount a farmer can sell to the government.

The guaranteed price scheme is administered by the Paddy Marketing Board which is in charge of handling supplies of rice. The procurement operations of the agents of the Paddy Marketing Board are financed by the branches of the People's Bank, a government corporation. The procuring agents of the Paddy Marketing Board are the branch societies of the multipurpose cooperative societies located in village areas. In 1978 there were approximately 3,100 branch cooperative societies that handle procurement. They also distribute goods, mainly rice, to the public. Before 1978 the main criterion for opening a paddy purchasing center was the distance the farmer has to transport paddy to the center, which was set at three miles or less. For the most part, paddy purchasing centers are located within three miles of all farms. In 1978 procuring agents were paid a commission of Rs 35.84 per ton of paddy. They are also reimbursed for the cost of transportation and handling by the Board.

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[2]Based on Gavan and Chandrosekara (1979)

Once the Paddy Marketing Board receives the rice, it makes arrangements to have it milled and sent to the district warehouses of the Food Commissioner's Department.

In early 1978 when the procurement price was Rs 0.87 per pound of paddy, the transfer price, which included the costs of storage, transportation, milling, commissions, profit, and the fixed costs of the Paddy Marketing Board, was Rs 1.45 for parboiled rice and Rs 1.41 for raw rice. At that time the rice ration cost for consumers was Rs 1.00 per pound.

The procurement price has been kept constant for long periods of time. There has been a tendency for it to be raised during periods of rising world rice prices and to be maintained in periods of lower world prices. Thus it was raised in 1952 and 1953 in response to high import prices during the Korean War, not again until 1967, and then in 1974 and 1975.

The Distribution System. Until recently the distribution system achieved almost universal coverage. The entire population was entitled to receive an allotment of rice at a subsidized price. In 1967 a portion of the allotment of rice was completely free of charge. Items other than rice (sugar, wheat) are also on occasions channelled through the ration.

The Food Commissioner's Department is in charge of administering the food distribution system. It obtains the food through domestic procurement and imports and issue the rationed commodities to the different types of wholesalers and retailers. Distributors of ration commodities must be licensed and are made up mostly of retail cooperatives. In 1976 these retail cooperatives were responsible for 80 percent of the volume of rice and sugar distributed.

Apart from the cooperative network, there are private authorized distributors who are licensed by the Food Commissioner's Department to distribute rationed items at stipulated prices. Since 1977 their numbers have expanded greatly--to about 3,900 in mid-1978, or 2.8 for every 10,000 people in Sri Lanka. In addition, there were 5.4 branch cooperatives for every 10,000 people, making a total of 8.2 outlets for distributing rice and sugar for every 10,000 people in Sri Lanka. Flour is distributed by authorized distributors as well as by ordinary retail outlets.

The branch cooperative societies receive their supplies of rice and flour from the multipurpose cooperative societies which, in turn, obtain their supplies from the 66 warehouses of the Food Commissioner's Department. Until early in 1978 the private authorized distributors also received their supplies from the multipurpose cooperative societies, which also received their supplies from the multipurpose cooperative societies, which also handled flour wholesaling. In early 1978 the 20-year wholesaling monopoly of rice and flour by these societies was elimintated and private distributors allowed to take part.

Operation of the Ration System. When the scheme began in 1942, rice rationing was introduced only in the rice-deficit areas. By 1943 the rice rationing scheme was extended to the rice surplus areas. Everyone three years old and older was entitled to an allotment. Substantial budget subsidies on rationed rice began in the late 1940s. By the early 1950s the age requirement for receiving rationed rice was reduced to one year.

The high import cost of rice during the Korean War led to attempts to reduce the burden by lowering the ration quota and raising prices. As a result, in 1953/54 the subsidy expenditure on rice was half of what it had been in 1952/53. By November 1954 ration quantities were increased for all groups of the population to four pounds per adult person per week. The increase was officially attributed to consistently declining rice prices in world markets.

From the period following the Korean War until 1966, the ration quota was four pounds per capita per week. Between 1954 and 1960 the price of ration rice was cut several times to levels well below the market level. In 1960, for example, the ration price was 12.5 cents a pound, whereas the market price was 37 cents. At the same time the prices of wheat and sugar were kept above their import prices. As a result of declining price and expanded coverage, the quantity of rice distributed increased steadily. By 1965 more than 75 percent of all rice consumed passed through the public system. Consumer purchases of rice from the open market and of wheat and wheat flour declined, but not enough to offset the increase in ration rice. Total cereal consumption rose significantly.

In November 1966 the ration was reduced to two pounds per person per week due to the rapidly growing cost of supporting the scheme. However, the quota was issued free of charge. By this time, the proportion of rice consumption distributed through the ration system fell to 46 percent.

The changes did not produce the desired result of decreasing the cost of the subsidy. Most of the savings from the reduction in the quantity distributed were offset by the loss of revenues resulting from free distribution. The cost of the food subsidy continued to rise under the impact of higher import and procurement prices.

In late 1970, after a change of political leadership in the island, the rice ration was increased to its old level of four pounds per person per week.

Two pounds continued to be issued free, but the additional two pounds were charged for. The price of the paid portion was triple what it had been prior to 1966, and for the first time, was also higher than the comparable price for wheat flour. During this period the costs of operating the system were kept down by low import price of rice, wheat and sugar.

In 1973 due to poor harvests and world scarcities the price of rationed rice increased rapidly. Some ration recipients were excluded in this period and the free portion of the rationed rice was reduced to one pound, bringing the total ration to three pounds per person per week.

Banning the transport of rice by private persons was an attempt to restrict the trade of rice to the public sector. As a result of this legislation the price of rice rose dramatically in rice-deficit areas. In all this period, total cereal consumption was more closely related to domestic production than to changes in the ration.

The open market price remained surprisingly stable during the poor harvest years. This situation suggests that the availability of an additional two pounds of rice through the ration may also have acted as a buffer against price speculation.

Impact of the Ration on Food Consumption. A simple model of the rice sector is presented here. DD is the demand curve for rice. It includes demand for home consumption by farmers, but not government procurement for the ration system. Qa is total rice available to the public. It equals domestic production (q) plus the quantity supplied through the ration (r). (Domestic production is a function of the previous year's price. However, because annual data were used and there are two harvests in the year, it may be somewhat responsive to current price.) It should be noted that imports do not enter into the picture because rice imports come through the public sector and are made available to the general public only as a component of the ration.

The supply curve (SS) is equal to Qa less Qp, the amount sold to the government at the guaranteed minimum price (Pg). Thus SS is equal to the rice offered to nonfarmers plus the amount farmers consumed from their own production. The amount procured by the government (Qp) is a function of the difference between the open-market price and the price offered by the government under the GPS. The lower the market price, the larger the quantity procured. At price P_g SS becomes infinitely elastic. At any price below P_g all rise would be sold to the procurement system.

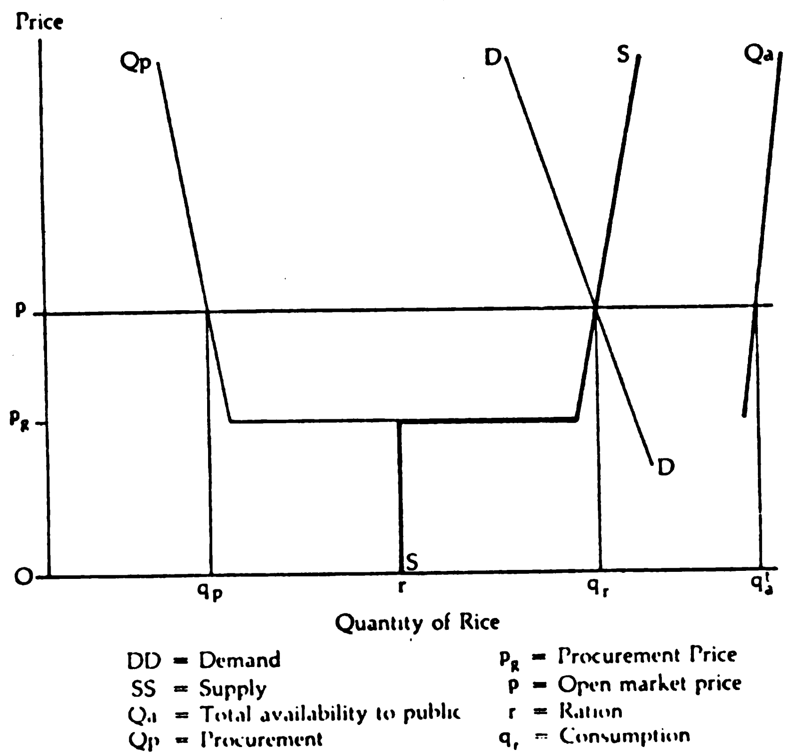

Figure 5-4: Impact of the Rice Ration on Consuption in Sri Lanka

The equilibrium price (p) is determined by the intersection of SS and DD. At that price the quantity consumed is given by q_r and the quantity procured q_p is the difference between q_r and q_a^t. An increase in domestic production or an increase in the quantity distributed through the ration would cause SS to shift to the right, the equilibrium price to decline, and the quantity of rice consumed to increase. The demand curve would also shift upward as a result of increased incomes. If the demand curve intersects the supply curve along its flat portion, there will be no change in price.

Some Analytical Results. The impact of the ration on food consumption was studied using time-series and cross-sectional data. The time-series data analysis used a regression approach to determine the relationship between food consumption and variables such as the market price of rice and other cereals, per capita income, and the value of the ration. Demand for rice was sensitive to price and the ration subsidy, nevertheless income failed to be significant. In the case of cereals income proved to be significant. This analysis indicated that a larger impact on food consumption can be expected from a unit of subsidy income (through the ration) than from a unit of general income (an outright money transfer).

According to standard ration theory a ration is effective if it affects consumption only by raising income. In evaluating an effective ration we then have to see if the groups receiving rations are also consuming significant quantities of the same commodity in the market. In the case of Sri Lanka ration recipients were found to be consuming open market rice.

When domestic rice production is incorporated into the regression approach it picks up much of the impact of price and income changes on consumption. This fact indicates that rice production changes have a greater impact on consumption than the indirect impact through price and income.

The analysis of cross-sectional data was undertaken with the main purpose of assessing the distributional effects among different groups in the society. All but the upper quartile of the population made use of their rice ration allotment. Also, ration use increased with income up to the middle-income groups and decreased at higher incomes. Low-income groups were found to make less use of the paid ration as well as the free ration. The reason seems to be that the very poor were selling their ration cards. At the same time income groups-including the poorest-continued to purchase the rationed commodity in the open market. This might indicate that free-market rice is regarded as superior to rationed rice.

The net increase in consumption due to the ration subsidy was estimated by calculating the proportion of increased income used to purchase calories at different income levels and applying these proportions to the cash value of the ration subsidy income accrued to ration recipients. For the tenth percentile of the population, the estimated impact of the ration was to raise total calorie consumption by 115 calories per person per day, or approximately 5 percent of total requirements. By the fiftieth percentile the contribution was approximately 60 calories.

Again looking at the tenth percentile, the ration income appeared to have increased rice consumption by 70 calories and cereal consumption by 80 calories, implying an increase in other cereals, mostly wheat, of 10 calories. Since total calories increased by 115, it is implied that noncereal calories rose by 35 calories per day.

To the extent that the ration/subsidy program was conceived of as a means of raising calorie and protein intake levels, the reduction in commercial purchases as a result of the ration is a form of leakage. Another form of leakage arises from the large portion of the ration--approximately two-thirds in 1969-1970--that went to those already consuming the recommended daily allowance of calories and protein. If the primary goal of the program is to increase the consumption of nutritionally deficient groups, the second type of leakage results in a very high cost per calorie effectively delivered.

Costs and Benefits of the Program. The most visible "cost" involved--the outlay incurred by the government-- is not a true economic cost at all; it is a transfer. It is the loss the government incurs on the distribution of subsidized commodities plus the operating costs of the agencies involved. In the case of the domestically procurred grain, the government distributional loss is proportional to the difference between the procurement price paid to the farmer and the price at which grain is sold to the consumer. For imported commodities, it is proportional to the difference between the import price converted at the official exchange rate and the ration price. Where the procurement price is above the world price (at the existing exchange rate), the fiscal cost rises in good crop years and falls in bad ones.

Using the official exchange rate for calculation purposes, it is easy to see that producers receive a large proportion of the benefits in some years and more than 50 percent of all benefits in another periods. This situation results from the domestic procurement price being kept above the import price at the official exchange rate. In 1972--a period of low import price--the consumer subsidy component was 11 million rupees, whereas the producer subsidy amounted to 360 million rupees. These data indicate that producers were being benefited in a public distribution system that is primarily consumer-oriented.

Because low-income consumers used more of the rationed commodities, the consumer subsidy favored the lower end of the income scale slightly more than the upper end. The subsidy as a proportion of income in the low-income groups and its impact on the relative distribution of real incomes were more significant. The lower-income deciles received as much as 16 percent of their real incomes from the rice ration.

The benefits of income redistribution via rationing are more significant if the extreme administrative and political difficulties of extending aid to low-income families is considered. Some indirect benefits also come about when, as a result of higher real incomes, poor families are able to make use of other social services such as education. The income distribution effects of this food distribution system are also increased when indirect effects on employment and returns to labor are considered.

The procurement aspect of the distribution system also has important effects. High guaranteed prices are necessary to ensure an adequate supply of foodgrains. The result is that the rice sector has been responsible for a large proportion of growth in employment. At the same time the ration system has played an important role in expanding the demand for rice.

The U.S. Food Stamp Program[3]

A general description of the U.S. Food Stamp Program is presented here since it is the only program of its kind which has been reviewed

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[3]Based on McDonald (1977).

extensively. The basic legislation that authorized food assistance for low-income persons in the United States was initiated during the Great Depression. It took the form of the Potato Control Act of 1935. This act allowed the government to buy surplus farm products for distribution to needy families and school church programs through the Federal Surplus Commodities Corporation (FSCC). The primary purpose of FSCC was to support farm price and not to meet the food needs of relief recipients.

The surplus commodities program was not well received by either recipients or retailers. Recipients complained that direct distribution did not allow them to plan their food consumption. Perishables had to be consumed as soon as received. Also, no regard was given to the nutritional needs of the recipients since the kinds of food depended on whatever was on surplus. Food retailers complained because the FSCC bypassed their normal trade channels.

The first food stamp program was then designed to increase domestic food consumption through regular business channels. Participants were to purchase a minimum number of orange stamps at face value. They would then receive free blue stamps on a given ratio to orange stamps (1 free blue stamp for 2 purchased orange stamps). The blue stamps were to be used to purchase food items appearing in a monthly list of surplus commodities. The structure of the program was intended to prevent income which was normally spent on food from being diverted to nonfood items.

The evaluation of Joseph D. Coppock of the two-stamp program revealed that the participants did not buy more food than they would have if the blue stamps were not issued; they simply did not use all their orange stamps. That is, normally purchased foods were purchased with blue stamps.

After several problems the food stamp program was revitalized in 1964 by the Food Stamp Act. This act proposed to achieve two goals: to utilize the nation's food and to promote the nutritional well-being of low income persons.

The administration of the food stamp program is shared by federal, state and local governments. At the federal level the USDA Food and Nutrition Service is in charge of: instituting program rules and structure; producing, handling, distributing, and refunding the food stamps; supervising data collection and quality control procedures; overseeing the program activities. State governments are responsible for informing the general public (specially low-income earners) about the program and collecting data on program characteristics. Local governments deal directly with the food stamp recipients.

A member of each applicant household can fill out an application for food stamps at a county welfare office. The application is processed by a food stamp caseworker who requests receipts for certain expenditures. These expenditures are then deducted from the household's income to determine the amount of benefits, if any, the household can receive. The caseworker informs the applicant that employable household members must register at the local employment office before the applicant is given the identification and authorization card which enables the bearer to purchase a stamp quota from an issuance center.

Food stamp users must repeat the entire food stamp application process at certain time intervals. Ordinarily, households not receiving any other federally funded aid are certified for 3 months. Shorter periods of eligibility are dictated if there is a possibility of change in income or household status. When changes are unlikely certification can be done for as long as 6 months. One-year certification is permitted for unemployable persons with very stable incomes or for households with readily predictable income from self-employment and for whom the food stamp agency does not expect change in the composition of the household.

Recertification is required when household income or deductible expenditures change for more than $25.00. In such a case the household must notify the food stamp agency which in turn will revise the purchase price of the stamps bought by the household in its next regular purchase.

To be eligible for food stamps the applicants must demonstrate that their household resources do not exceed either of two maximums, one for assets and one for net income. The assets maximum applies to households of every size, but the income maximums increase with household size.

These items are excluded from the computation of assets in the determination of program eligibility: the home, one car, household and personal goods, insurance policies, pension funds, and any property essential to self-support. Extra cars or recreational vehicles, cash, bank accounts, stocks and bonds and nonrecurring lump-sum payments are counted as assets. If the value of accountable assets exceeds $1500 the household is denied eligibility for food stamps.

The countable net income definition does not include: In-kind income, loans, nonrecurring lump sum payments and all earnings of children under 18 years of age. The computation of gross income includes earnings of all adult household members, returns from assets and self-employment, cash payments from welfare programs, pensions, veteran's benefits, farm subsidies, Worker's Compensation, unemployment compensation, scholarships, or training subsidies.

Once the gross income is computed, the following items are deducted: 10% of wages and salaries (not to exceed $30 a month), income taxes, social security taxes, union dues, any other mandatory payroll deductions, medical expenses in excess of $10 a month, payment for child care when it applies, tuition and education fees, and unusual expenses like funerals. There is also a deduction for all shelter costs such as: rent, utilities, property taxes and mortgage payments for homeowners in excess of 30% of gross income minus all other deductions.

Table 5-1

A Comparison of Poverty Thresholds and Annualized Net Income Maximums for Food Stamp Eligibility for 1975

Family size	Maximum net income for food stamp eligibility[a]	Poverty line[b] Nonfarm	Poverty line[b] Farm
1	$2,520	$2,590	$2,200
2	3,480	3,410	2,900
3	5,040	4,230	3,600
4	6,480	5,050	4,300
5	7,560	5,870	5,000
6	8,640	6,690	5,700
7	9,720	7,510	6,400
8	10,800	8,330	7,100
9	11,520	9,150	7,800
10	12,600	9,970	8,500

[a]Computed from USDA, Food and Nutrition Service (1975).
[b]Computed from Community Services Administration (1975).

Source: McDonald (1977)

Benefit Determination. The amount of free bonus stamps awarded to a given household depends on both the size of the household and its net income.

Table 5-2 gives an example of the food stamps benefit shcedule. It displays the maximum amount of bonus stamps available to households in the

Table 5-2

Food Stamp Benefit Schedule for January–July 1977

Monthly Coupon Allotments and Purchase Requirements—48 States and District of Columbia

Monthly net income	For a household of—							
	1 person	2 persons	3 persons	4 persons	5 persons	6 persons	7 persons	8 persons
	The monthly coupon allotment is—							
	$50	$92	$130	$166	$198	$236	$262	$298
	And the monthly purchase requirement is—							
$0–19.99	0	0	0	0	0	0	0	0
$20–29.99	1	1	0	0	0	0	0	0
$30–39.99	4	4	4	4	5	5	5	5
$40–49.99	6	7	7	7	8	8	8	8
$50–59.99	8	10	10	10	11	11	12	12
$60–69.99	10	12	13	13	14	14	15	15
$70–79.99	12	15	16	16	17	17	18	19
$80–89.99	14	18	19	19	20	21	21	22
$90–99.99	16	21	21	22	23	24	25	26
$100–109.99	18	23	24	25	26	27	28	29
$110–119.99	21	26	27	28	29	31	32	33
$120–129.99	24	29	30	31	33	34	35	36
$130–139.99	27	32	33	34	36	37	38	39
$140–149.99	30	35	36	37	39	40	41	42
$150–169.99	33	38	40	41	42	43	44	45
$170–189.99	38	44	46	47	48	49	50	51
$190–209.99	38	50	52	53	54	55	56	57
$210–229.99	40	56	58	59	60	61	62	63
$230–249.99	40	62	64	65	66	67	68	69
$250–269.99		68	70	71	72	73	74	75
$270–289.99		72	76	77	78	79	80	81
$290–309.99		72	82	83	84	85	86	87
$310–329.99		72	88	89	90	91	92	93
$330–359.99			94	95	96	97	98	99
$360–389.99			102	104	105	106	107	108
$390–419.99			111	113	114	115	116	117
$420–449.99			112	122	123	124	125	126
$450–479.99				131	132	133	134	135
$480–509.99				140	141	142	143	144
$510–539.99				142	150	151	152	153
$540–569.99				142	159	160	161	162
$570–599 99					168	169	170	171
$600–629.99					170	178	179	180
$630–659 99					170	187	188	189
$660–689.99					170	196	197	198
$690–719.99						204	205	207
$720–749.99						204	215	216
$750–779 99						204	224	225
$780–809.99						204	225	234
$810–839 99							220	243
$840–869.99							226	252
$870–899 99							226	258
$900–929 99								258
$930–959 99								258
$960–989 99								258
$990–1.019.99								258

Source: McDonald (1977)

lowest net income bracket. The monthly stamp allotment is based on the National Research Council Recommended Daily Allowances (RDA) of nutrients for persons in various sex-age categories.

The Thrifty Food plan was developed by looking at a 1955 survey in which urban households which comprised the lowest food costs per person quartile were examined. The food consumption patterns of these households were analyzed to discover dietary deficiencies. This food consumption pattern was revised so that it would satisfy all the Recommended Daily Allowances (RDA). The revision consisted in changing the mix of habitually consumed foods so that the costs per person would increase very little. This was accomplished by substituting lower-priced food with the same nutritional value for some higher-priced ones. The families following the food plan are assumed to select the kinds and amount of foods in the food groups that the urban survey households selected on the average. The plan cost is updated by the food price information collected by the Bureau of Labor Statistics.

For administrative convenience all food stamp allotments are tied to dollar cost of the plan for a family of four with school children. The stamp allotment for households of all other sizes were computed from a base of $162 (cost of the food plan for a family of four). For instance, the following formula was used to adjust for the estimated 10% increase in per person food expenditures for a two-person household relative to a four-person household.

$$(162/4)\ (2) + (.10)\ (162/4)\ (2) = 89.10$$

This method of benefit computation has the problem that it does not consider the fact that households of the same size often have differing sex-age composition. To take this fact into account a new method of benefit computation was devised. Table 5-2 can also be used for this purpose. Households have to pay a purchase price for their allotment of stamps which is less than the redemption value. The purchase price of the same allotment rises with increases in the net income bracket. Consider the monthly coupon allotment of $130.00 for under three-person households. Households with net income under $30.00 receive the entire allotment without spending any of their own cash. The same size household with net income bracket $120-129.99 must pay $30.00 for the same coupon allotment. The amount of the bonus they receive is thus reduced to $100.

Food stamp allotments are increased every 6 months to maintain the purchasing power of bonus food stamps. The size of the increase is tied to the Food Price Index. During periods of continuous food-price inflation, changes in the size of the allotment do not become effective until 6 months after the end of the period over which the rate of inflation is measured.

There exists another dimension to the food stamp benefit schedule: the variable purchase option. This option allows food stamp users to purchase any quarter-fraction of their food stamp bonus. As a result potential food stamp users do not have to decide each month whether to buy all or none of their bonus stamps. Now consider the three-person household having $30-39.99 of net income. They can choose to initially buy one-quarter (pay $1.00 to get $32.50 in bonus stamps) and later in the month to pay $3.00 for the remaining $97.50 of the $130.00 allotment.

Figure 5-5 depicts the process of coupon supply and redemption. After a requisition from a state for coupons, the food and nutrition service of the U.S. Department of Agriculture (FNS) orders coupons and ships them to a state issuance or inventory point. From there, the coupons go to the local food stamp agencies for sale to recipients. Grocers authorized to accept food stamps redeem them for cash at local banks. Then, the food coupons are deposited in the Federal Reserve system, and banks receive cash in return. Thereafter FNS buys the stamps from the Federal Reserve system, via a treasury account.

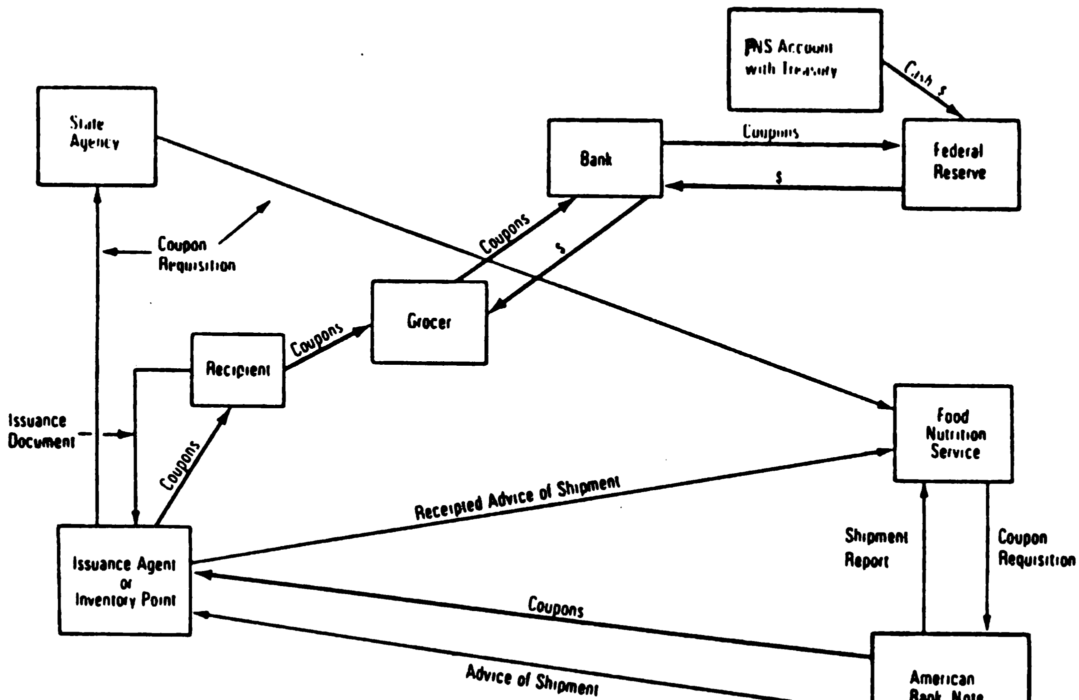

Figure 5-5: Coupon Supply and Redemption

Source: McDonald (1977)

Welfare Effects of Food Stamps Versus Income Transfers

Figure 5-6 displays budget constraints faced by households eligible for the Food Stamp program. Distance OC on the vertical axis represents the quantity of goods other than food consumed at home that can be consumed if the household spends its entire prestamp income on these other goods. Similarly, on the horizontal axis, OD represents the maximum quantity of food consumed at home that is obtainable from prestamp income. Therefore, the line CAD represents the prestamp budget constraint, as in the standard indifference curve diagram. This diagram can be used to demonstrate how eligible households choose the best of their set of attainable consumption opportunities with the food stamp program.

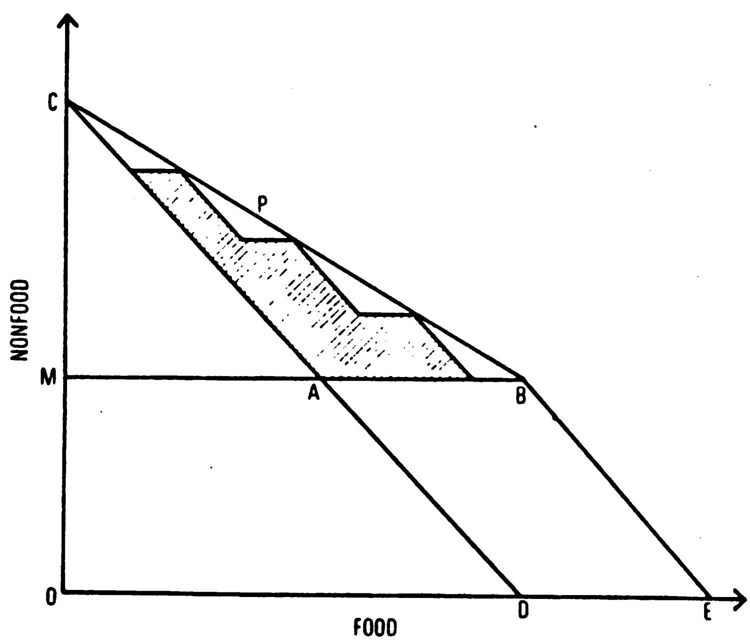

Figure 5-6: Pre- and Poststamp Budget Constraints

First, consider how consumption opportunities are expanded when the household buys an entire stamp allotment in 1 month. Distance CM represents the full purchase price of the allotment, and AB represents the resulting amount of bonus food stamps. After this exchange, the household's poststamp budget constraint is represented by the line segments joining points C, A, B, and E, and the household gains the opportunity to consume the bundles of goods signified by points in the area bounded by line segments joining A, B, D, and E.

Using the variable purchase option, the household can further expand its consumption opportunities to include all bundles in the shaded area bounded by the "sawtooth" line segment. This is accomplished by paying some quarter fraction of the full purchase price to get a corresponding quarter fraction of the entire stamp bonus. Since in any given month the household can choose its desired quarter fraction, it can obtain all of the bundles in the shaded area.

Furthermore, over an extended period, say 1 year, the household can time its stamp purchases and expenditures to expand its opportunities to include all points within the area bounded by line segments connecting points C, B, and E. This is possible because households can vary the amount of stamps purchased from month to month and because stamps purchased in one month can be spent in subsequent months. An example may help to clarify this point. Suppose the household buys one-half of the entire bonus one month and one-fourth of the bonus the next month, perhaps saving some of the bonus stamps purchased in the first month for use in the second month. Thus, over the 2 month period the household manages to obtain three-eighths of the available bonus, symbolized by point P in the diagram. Over a longer period, as the number of possible stamp transactions rises, the household can buy any fraction of the total bonus available during that same extended period. Hence, the relevant poststamp budget constraint for a food stamp eligible household is CBE.

Relative to a cash transfer of amount AB, the potential for food stamps to constrain recipient households arises because a cash transfer allows the household to obtain more consumption bundles, that is, "points" outside the area bounded by CBE. In Figure 5-7, the post-cash-transfer budget constraint is represented by the line connecting F, B, and E. Relative to the poststamp constraint, this post transfer constraint expands the set of

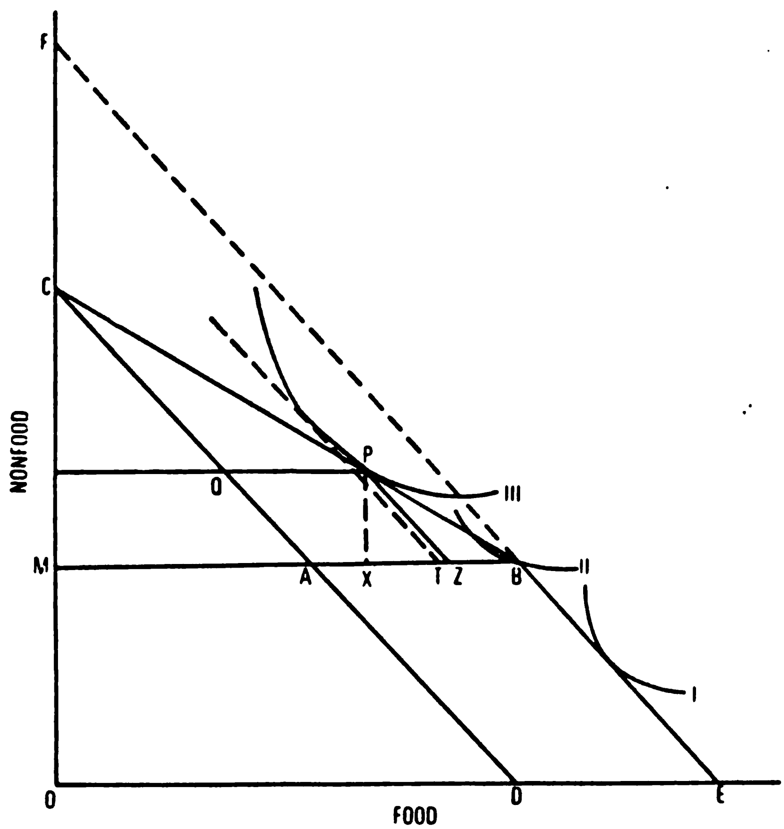

Figure 5-7: Deriving Lower-Bound Cash Equivalents

consumption opportunities to include all points in the area bounded by the triangle CFB. Provided some stamp recipients would prefer goods bundles within CFB to other available bundles, the in-kind transfer must constrain recipient consumption behavior relative to cash. Note also that another way to view the effect of the inkind transfer is to recognize that the program offers a food price subsidy for those whose food expenditures are constrained. In other words, the slope of line CB represents reduced food prices, relative to the prestamp situation.

At this point, it is useful to consider how three kinds of recipients are affected by these alternative programs. Recipients who buy more food than that made available by spending the entire stamp allotment (Group I) are not constrained by the program. In terms of Figure 5-7, these recipients maximize their satisfaction by choosing a package of goods on line BE, as represented by the tangency of indifference curve I to this line. Another group (Group II) consumes food in an amount equal to the stamp allotment, demonstrating the choice of goods bundle represented by point B. Except in the event that these households would prefer bundle B irrespective of the form of the transfer (in which case the indifference curve would be tangent to line FBE at point B), these households would choose bundle B on an indifference curve like II. Clearly, the substitution of AB in cash for AB in bonus stamps would allow these Group II households to obtain greater satisfaction than indicated by indifference curve II. A final group (Group III) consumes less food than it could if it bought the entire stamp bonus. These constrained households would choose some bundle on line CB. The figure depicts such a choice. Goods bundle

P maximizes a Group III household's satisfaction at a level indicated by indifference curve III, which is made possible by bonus stamps in an amount represented by QP.

Nutritional Effects of Food Stamps

A national sample suitable for examining the relationship between income status and nutritional well-being was conducted in 1971 and 1972 by the National Center for Health Statistics of the Department of Health, Education and Welfare (1974). This Health and Nutrition Examination Survey (HANES) collected measures of nutritional status for a sample representing the United States' civilian, noninstitutionalized population aged 1-74 years.

The published HANES tables restrict income comparisons to two groups--persons living in households with income below the official poverty level and those in households above it. As is appropriate for the official poverty definition, total household income for the last 12 months was recorded, including total cash income from any source, but excluding payments in-kind, such as food stamps. These income values provided the numerator for the poverty income ratio. The denominator was a multiple of the total income deemed necessary to maintain a family of given characteristics on a nutritionally adequate diet as constructed from the Department of Agriculture's Economy Food Plan. This denominator adjusts the income maintenance requirements by family size (incorporating scale economies), sex of family head, age of the head in families with one or two persons, and farm-nonfarm residence. When the household's poverty income ratio exceeds 1.0, that household's income is above the poverty threshold; when less than 1.0

it is below. For example, if a male-headed farm family of four persons had 1971 income less than $3528, this family was listed among the "below poverty income level" households. In reviewing the HANES results, it should be remembered that some food stamp eligibles are in the above-poverty income group.

A substantial proportion of all persons surveyed were found to have low caloric intakes. In both the below-and above-poverty-line income groups, intakes of less than 1000 calories were found for an average of about 14% of the white children aged 1-5 years, and about 23% of the black children of the same age and income statuses. Similarly, in both income groups, respectively, 20% and 36% of whites and blacks over 60 years of age had caloric intakes of less than 1000 calories. Hence, although calorie deficiencies do vary by age and race, they are found in both poor and non-poor income groups. With respect to protein intake, the HANES summary reported little variation by race or income within most age groups as measured by average protein intake per thousand calories. Based on these findings, one can conclude that income level does not substantially affect the intake of nutrients supplying energy and growth for members of most U.S. households.

In examining the results for calcium, iron, vitamin A, and vitamin C, however, a different conclusion emerges. There are nutritional deficiencies among both officially poor and nonpoor households, but in most instances, these deficiencies are greater among the officially poor. With only four exceptions, mean intake of nutrients, as a percentage of the RDA for calcium, iron, vitamin A, and vitamin C, was lower for the poor than for the nonpoor in all age-race-sex groups (National Academy of Sciences, 1974). Yet with the exception of calcium intake for black and white children of both sexes aged 1-5 years, more than 30% of persons in both poor and nonpoor groups always had nutrient intakes below the RDA. The most serious deficiencies by far were recorded for iron intake. Even the mean intake for most groups does not exceed the iron standard, poor or nonpoor. Based on biochemical tests as well as the evidence just discussed, the HANES report concludes there is an iron deficiency at all age levels among both income groups.

To summarize, the HANES study shows that nutrient deficiencies were observed for both officially poor and nonpoor households. However, these deficiencies are most serious among the poor, implying that income and nutritional well-being are positively correlated. This finding supports the general presumption that increasing a household's income has a positive impact on nutritional status. However, in order to evaluate the extent to which income transfers such as food stamps actually alter nutrient intakes, a somewhat more complicated view of the process of nutritional achievement is needed.

A second study looked at the effects of food stamps on families in Kern County, California. Averages relevant for assessing the monthly impact of the Food Stamp Program on food expenditures were computed separately for 151 food stamp participant and 178 nonparticipant program eligible households residing in Kern County, California. For all practical purposes, the average monthly cash incomes of the two groups were identical. However, the combined cash and in-kind income of participants exceeded that for nonparticipants by about $45 per month because participants' in-kind income averaged $51.02, including $43.70 in bonus food stamps, whereas nonparticipant in-kind income averaged less than $8 per month. The monthly value of food available to participants also exceeded the corresponding nonparticipant amount by $18 per month, although participants actually spent $25 less of their own cash on food than nonparticipants.

The $18 average increment in food expenditures among participant households was less than half of the additional purchasing power attributable to bonus food stamps, indicating that some income "freed" from allocation to food was spent on other goods and services. This finding is supported by empirical estimates of the cash equivalent value of food stamps, and it has a negative implication for the cost-effectiveness of food stamps in promoting nutritional improvement, because food stamp users do not devote all of their subsidy to food purchases. Still, some nutritional improvement could result from the portion of bonus stamp income that is spent on food, and there is some evidence of this among Kern County households.

Less than 85% of both Kern County participant and nonparticipant households obtained the RDA for seven nutrients. Moreover, only about half of both groups obtained the standard for calories, calcium, and vitamin C. Yet there were more participant households at 100 percent of the standards for calories, protein, calcium, thiamine, riboflavin, and niacin than nonparticipant ones. These findings suggest food stamps do have some positive influence on nutritional achievement. However, this evidence is not conclusive, because there may be important differences in the characteristics of participant and nonparticipant households that are unrelated to the food stamp program and yet actually account for the observed difference in nutritional achievement. Taking account of this possibility requires a multivariate analysis incorporating many explanatory variables.

Finally, a study by Madden and Yoder incorporated a number of explanatory variables and addressed the issue of variable nutritional efficiency. Participant and nonparticipant households in rural Pennsylvania were compared in a multivariate context that held constant income and food expenditure levels. Hence, observed effects on nutritional adequacy that are unique to food stamp users can presumably be attributed to stamp-related variations in nutritional efficiency.

Madden and Yoder concluded that the dietary impact of food stamps was significant and positive only under unfavorable conditions, such as more than 2 weeks since payday or receiving food stamps. Perhaps this impact through increased nutritional efficiency during temporary cash and food stamp shortages. There was no other evidence that nutritional efficiency varied between food stamp users and nonparticipants.

From a multiple regression analysis of monthly food expenditures per person, Madden and Yoder further concluded that food stamp usage typically does not increase food expenditure, net of the effects of income adequacy and the other control variables. Because income adequacy incorporates the bonus food stamp value, an important implication is that food stamp users in rural Pennsylvania did not purchase more food than nonparticipants at comparable income levels. Since total food expenditure ordinarily rises with income, this implication is not inconsistent with Lane's observation that food stamp recipients spend more on food than nonrecipients with lower average incomes.

Based on the evidence from surveys in Pennsylvania and California it would be hazardous, at best, to conclude that food stamps have a substantial impact on either nutritional efficiency or nutritional achievement. Although the Lane study of California households suggests there may be a positive impact on nutrient intake due to food stamp usage, one cannot rule out the possibility that some factor unrelated to food stamps caused the greater nutrient intakes of food stamp users. With respect to nutritional efficiency, the study by Madden and Yoder failed to find any positive impact of food stamp usage. However, because both studies rely on respondents to recall food intakes of every household member during a 24-hour period, and since these studies are severely restricted geographically, readers may wish to withhold final judgment about program effectiveness until other studies become available.

Taking the studies reviewed here at face value, the major finding is that food stamps may not be a very effective device for improving diets among low-income households. According to available evidence, programs to deliver cash seem unlikely to succeed where food stamps have failed. Instead, more direct intervention to change the nutritional efficiency of low-income households is needed. A number of programs that might accomplish these changes are already operated by USDA, albeit on a much smaller scale than the Food Stamp Program. They include the Supplemental Feeding Program for Women, Infants and Children (WIC), the Special Food Service (Day Care) Program for Children, the School Lunch Program, the School Breakfast Program, and Special Milk Program. Once it is recognized that the food stamp programs do not necessarily induce purchases that markedly improve nutritional adequacy, the program's role as a provider of general purchasing power comes into focus.

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Gavan, James D. and Indrani Sri Chandrasekara. The Impact of Public Foodgrain Distribution on Food Consumption and Welfare in Sri Lanka. Int'l Fool Policy Research Institute, Research Report 13, December 1979.

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CHAPTER 5 ANNEX

ANNOTATIONS FOR KEY REFERENCES ON FOOD SUBSIDY AND DISTRIBUTION POLICIES

Ahmen, Raisuddin

Foodgrain Supply, Distribution and Consumption Policies Within a Dual Pricing Mechanism, International Food Policy Research Institute, Washington D.C.

Domestic foodgrain production has been highly unstable and lags behind growth in demand. *This paper analyzes policies that determine the consumption and distribution of foodgrains in Bangladesh, first by examining the food system itself and then the interaction of the various elements within the system. The relative efficiency of price support vs. fertilizer subsidy policies to increase rice production is also presented.

*Appropriate distribution policies can cause an increase in consumption among the rural poor.

Clarkson, Kenneth W.

"Welfare Benefits of the Food Stamp Program," Southern Economic Journal 43(1). (July 1976):864-878.

As emphasis is increasingly placed on interdependent preferences in welfare economics, analysis of the net gains from transfer programs is difficult unless precise recipient constraints are recognized. This paper identifies the welfare benefits of the federal food stamp program as it was in operation in 1972-73. It includes estimates of recipient benefits, the nature and extent of external joint consumption benefits, and administrative costs of the program.

Gavan, James D. and Indrani Sri Chandrasekara

The Impact of Public Foodgrain Distribution on Food Consumption and Welfare in Sri Lanka. Int'l Food Policy Research Institute, Research Report 13, Washington D.C., December 1979.

Sri Lanka has achieved remarkable social progress even though it has a modest economic base and relatively low per capita income. This is partially the result of social policies which have been put into practice, particularly the food distribution programs operating since World War II. This paper examines Sri Lanka's public food distribution system, its effect on the price and availability of foods, and its impact on the food intake levels and nutrition of various income groups in the country.

George, P. S.

Public Distribution of Foodgrains in Kerala--Income Distribution Implications and Effectiveness. International Food Policy Research Institute, Washington D.C., Research Report 7, March 1979.

The public foodgrain distribution system in Kerala State is thought to be the best program in India. This paper analyzes its operation, including the benefits of rationing on consumption levels of low income consumers, consumer and producer benefits, and income distribution. It also examines the relative efficiency of public distribution over direct income transfers.

Kumas, Shubh

Impact of Subsidized Rice on Food Consumption and Nutrition in Kerala. International Food Policy Research Institute, Washington D.C., Report No. 5 January 1979.

This paper empirically analyzes the impact of a food price subsidy program on levels of food consumption and nutrition of a low income population in India's Kerala State. The food price subsidy program considered is rationed rice distribution. A simple model to test for the significance of identified factors that determine rationed rice consumption is presented. Effects of rationed rice consumption on household nutritional and caloric intakes is investigated.

Findings include the following: Middle income groups had more ration rice available to them, although without ration rice lower income households would experience a net decline in caloric and protein supply; a higher marginal propensity to consume additional foods from subsidy income and a positive relationship between ration rice consumption and child nutritional status was found.

Reutlinger, Shlomo and Marcelo Selowsky

Malnutrition and Poverty: Magnitude and Policy Options, World Bank Staff Occasional Papers 23, (Baltimore: Johns Hopkins University Press, 1976).

The authors assess the nature and magnitude of undernutrition in developing countries, placing particular emphasis on income distribution. An analysis of the cost effectiveness of alternative policies aimed at improving nutritional status is presented. Target-group oriented programs, such as a food price subsidy, a food stamp program or a straight income transfer are found to be more cost effective than countrywide policies (e.g. a general price subsidy). The authors conclude that only policies designed to allocate food or income can eliminate undernutrition.

Mellor, John W. (1978)

"Food Price Policy and Income distribution in Low-Income Countries", Economic Development and Cultural Change, 27(1), October 1978, 1-26.

The purpose of the paper is to delineate the component parts of a general equilibrium analysis of the relation of food price policy to income distribution.

A given change in foodgrain prices causes a larger percentage change in the real income of low income consumers and a larger absolute change in the real income of high income consumers.

As far as producers is concerned, the effect of a given change in foodgrain prices falls on the producer with the largest marketing. When prices and output are changing a policy of price stabilization will destabilize small producers' income and stabilize consumers' income and large producers' income.

Change in relative prices play a limited role in the short run in increasing agricultural production. It should be used in conjunction with technological change in agriculture.

CHAPTER 6

ECONOMETRIC CONCEPTS AND TECHNIQUES

Introduction

Generating information as a basis for economic policy-making requires more than just a good grasp of economic theory. Theory may point out that the incidence of a per-unit tax depends upon the relative elasticities of supply and demand of a commodity, but it offers few clues as to what the values of the elasticities actually are. In order to obtain estimates of these and other economic parameters, the analyst must turn to the realm of econometrics. The purpose of this chapter is to familiarize the reader with some common econometric methods required for analyzing price and market intervention policies and to offer a list of references for more in-depth study.

The chapter is organized into eight sections. Major topics covered include the estimation of demand, supply, production functions, and input demand functions. In addition, there is a discussion of the identification problem, the choice of data, projections, and statistical estimation methods. A list of books and articles which the reader should find useful for examples and discussion is included at the end of each section.

Estimation of Demand

Single Commodity Demand Equations

The simplest method of estimating a demand curve is the single equation approach. This involves estimating one equation of the general form:

$$X_1 = X_1\ (P_1,\ P_2, \ldots, P_n,\ Y,\ u_1)$$

where

X_1 = the quantity of the good in question per period of time (frequently measured as per capita consumption)

P_1 = the price of the good in question

$P_2, \ldots, P_n$ = Prices of substitutes and complements

Y = Income (often measured as total expenditures)

u_1 = A stochastic term included to account for omitted variables, measurement errors, and random errors.

In estimating such an equation, the first step is to specify a particular functional form. The simplest types are linear, and can be written:

$$X_1 = a_1 + b_1 P_1 + b_2 P_2 + \ldots + b_n P_n + c_1 Y + u_1$$

The regression coefficients from this equation may be used to estimate demand elasticities as follows:

$$\text{Own-price elasticity*} = \hat{b}_1 \frac{\bar{P}_1}{\bar{X}_1} = \frac{\partial X_1}{\partial P_1} \cdot \frac{\bar{P}_1}{\bar{X}_1}$$

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*The superscript ^ is used to refer to the estimates of the regression parameters and the superscript — is used to designate mean values.

$$\text{Cross-price elasticities} = \hat{b}_i \frac{\bar{P}_i}{\bar{X}_1} = \frac{\partial X_1}{\partial P_i} \cdot \frac{\bar{P}_i}{\bar{X}_1} \qquad i = 2, 3, \ldots n$$

$$\text{Income elasticity} = \hat{c}_1 \frac{\bar{Y}}{\bar{X}_1} = \frac{\partial X_1}{\partial Y} \cdot \frac{\bar{Y}}{\bar{X}_1}$$

Note that the above elasticities are measured at the mean values of the variables in question. However, elasticities can also be calculated using other values, such as current year prices and quantity. Similarly, when calculating income elasticities one might use various income classes instead of the overall average.

Another common functional form is the log linear or double log equation. (It is also referred to as the constant elasticity form). It is written:

$$\ln X_1 = a_1 + b_1 \ln P_1 + b_2 \ln P_2 + \ldots + b_n \ln P_n + c_1 \ln Y + u_1$$

In this case, the regression coefficients are themselves estimates of elasticities:

$$\text{Own-price elasticity} = \hat{b}_1 = \frac{\partial \ln X_1}{\partial \ln P_1} = \frac{\partial X_1}{\partial P_1} \frac{P_1}{X_1}$$

$$\text{Cross-price elasticities} = \hat{b}_i = \frac{\partial \ln X_1}{\partial \ln P_i} = \frac{\partial X_1}{\partial P_i} \frac{P_i}{X_i} \qquad i = 2, 3, \ldots, n$$

$$\text{Income elasticity} = \hat{c} = \frac{\partial \ln X_1}{\partial \ln Y} = \frac{\partial X}{\partial Y} \frac{Y}{X}$$

A third functional form is the semi-log function:

$$X_1 = a_1 + b_1 \ln P_1 + b_2 \ln P_2 + \ldots + b_n \ln P_n + c_1 \ln Y + u_1$$

In this case, the formulas for the elasticities are:

$$\text{Own-price elasticity} = \frac{\hat{b}_1}{\hat{a}_1 + \hat{b}_1 \ln\bar{P}_1 + \hat{b}_2 \ln\bar{P}_2 + \ldots + \hat{c}_1 \ln\bar{Y}}$$

$$\text{Cross-price elasticities} = \frac{\hat{b}_i}{\hat{a}_1 + \hat{b}_1 \ln\bar{P}_1 + \hat{b}_2 \ln\bar{P}_2 + \ldots + \hat{c}_1 \ln\bar{Y}}$$

$$i = 2, 3 \ldots n$$

$$\text{Income elasticity} = \frac{\hat{c}_1}{\hat{a}_1 + \hat{b}_1 \ln\bar{P}_1 + \hat{b}_2 \ln\bar{P}_2 + \ldots \hat{c}_1 \ln\bar{Y}}$$

Once again, the elasticities are often calculated using mean values of the variables in question, but alternative values may also be used.

A priori, there is generally no reason to prefer one functional form to another. The "correct" form is the one that best fits the data and most closely corresponds to a priori theoretical specifications. A few examples of fitted equations are listed below:

U.S. demand for food (from Maddala, see below)

1927-1941:

$$\ln q \quad 1.98 - \underset{(.02)}{.24} \ln P + \underset{(.02)}{.24} \ln y \qquad R^2 = .907$$

1948-1962:

$$\ln q \quad 2.19 - \underset{(.15)}{.24} \ln P + \underset{(.05)}{.14} \ln y \qquad R^2 = .874$$

where

q = food consumption per capita

p = deflated retail prices, and

y = deflated per capita disposable income

The number in parentheses are standard errors.

U.S. demand for sugar (from Schultz, see below)

1896-1914:

$$X_t = 92.9 - \underset{(1.01)}{3.34}P_t + \underset{(.15)}{.92}t$$

where

X_t = per capita sugar consumption

P_t = sugar prices relative to a general price index, and

t = an annual time trend (often included to account for changes in tastes over time)

For further examples see:

Fox, Karl A., (1958), Econometric Analysis for Public Policy, Iowa State University Press, Ames. (All of Part I, but especially Chapters 4 and 5)

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Systems of Demand Equations

When one is concerned about the interdependence of demand among several different goods, it is frequently advisable to estimate a whole system of demand equations. This approach stems from the utility maximization problem:

$$\text{Max } U = U(X_1, X_2 \ldots X_n)$$

$$\text{Subject to } \sum_{i=1}^{n} P_i X_i = Y$$

where

X_i = quantities of the various commodities

P_i = the prices of those goods, and

Y = total expenditures

In other words, the individual (or group) is hypothesized as maximizing utility, which is a function of n commodities, subject to a budget constraint. This maximization problem generates n demand equations of the form:

$$X_i = X_i(P_1, P_2 \ldots P_n, Y) \qquad i = 1, 2, \ldots, n$$

There are a variety of specific functional forms that may be considered in estimating a system of demand curves. One approach is to simply specify a set of demand equations in an analogous manner to the way in which single demand curves are specified. In other words, instead of having one linear equation, there might be a whole system of linear equations of the form:

$$X_i = a_i + \sum_{j=1}^{n} b_{ij}P_j + c_iY + u_i \qquad i = 1, 2, \ldots, n$$

Or, a log linear form might be specified in the same fashion:

$$\ln X_i = a_i + \sum_{j=1}^{n} b_{ij}\ln P_j + c_iY + u_i \qquad i = 1, 2, \ldots, n$$

The elasticities would, in these cases, be obtained for each equation as they were for the single-equation cases.

There are, however, three major alternative methods of specifying systems of demand equations. The most popular of these is the linear expenditure system, and is written:

$$P_iX_i = P_i\gamma_i + \beta_i(Y - \sum_{j=1}^{n} P_j\gamma_j) \qquad i = 1, 2, \ldots, n$$

Here, γ_i represents some amount of X_i which is assumed to be the minimum amount that the consumer will purchase under any circumstances. It is, in a sense, the subsistence amount of X_i. Therefore, $Y - \sum_{j=1}^{n} P_j\gamma_j$ defines the total amount of income the consumer has above subsistence income (i.e., the total amount of discretionary income.) Hence, β_i is the fraction of discretionary income that is devoted to the purchase of X_i.

A second popular functional form for demand system estimation is the Rotterdam differential demand model. This system is written:

$$d(\log X_i) = N_i\, d(\log Y) + \sum_{j=1}^{n} \beta_{ij}\, d(\log P_j) \qquad i = 1, 2, \ldots, n$$

where

> N_i is the income elasticity of the ith good, and
>
> β_{ij} is the compensated cross price elasticity of good i with respect to the jth price.

If we define W_i as each commodity's expenditure share such that $W_i = P_iX_i/Y$, then, by multiplying through by W_i, the Rotterdam system becomes:

$$W_i \, d(\log X_i) = U_i \, d(\log Y) + \sum_{j=1}^{n} \pi_{ij} \, d(\log P_j)$$

where

> U_i is the income elasticity of the ith good weighted by its expenditure share (i.e., the derivative of expenditure on the ith good with respect to income), and
>
> π_{ij} is the compensated cross price elasticity weighted by the expenditure share.

However, in order to actually estimate this equation, the differentials must be approximated by discrete differences. It is therefore modified to read:

$$W^*_{it} \, D_{x_{it}} = U_i \, D_{x_t} + \sum_{j=1}^{n-1} \pi_{ij}(D_{p_{jt}} - D_{p_{nt}}) + a_{it}$$

$$(i = 1, 2, \ldots n-1, \; t = 1, 2, \ldots T)$$

where

> $W^*_{it} = 1/2(W_{it} + W_{it+1})$, the average value share in successive periods,
>
> D = log differences, e.g., $D_{x_{it}} = \log X_{it} - \log X_{it-1}$

$D_{x_t} = \sum_{i=1}^{n} W^*_{it} D_{x_{it}}$, a value weighted average of the logarithmic differences of the quantities demanded. In other words, it is a measure of changes in real income.

a_{it} = a random disturbance term.

Note that there are only $n-1$ equations. That is because it can be shown that one of the n original equations is redundant.

Finally, we come to the indirect addilog model, which is a system of demand equations derived from the specific indirect utility function:

$$V = \sum_{i=1}^{n} a_i \left(\frac{Y}{P_i}\right)^{b_i}$$

The demand curves derived from this utility function are:

$$X_i = \frac{a_i b_i m^{b_i} P_i^{-b_i - 1}}{\sum_{j=1}^{n} a_j b_j m^{b_j - 1} P_j^{-b_j}} \qquad i = 1, 2, \ldots, n$$

or

$$Z_{it} = \frac{a_i b_i m_t^{b_i} P_{it}^{-b_i} e^{\varepsilon_{it}}}{\sum_{j=1}^{n} a_j b_j m_t^{b_j - 1} P_{jt}^{-b_j}} \qquad i = 1, 2, \ldots n; \; t = 1, 2, \ldots T$$

where

Z_{it} = the expenditure on commodity i in period t,

$e^{\varepsilon_{it}}$ = a stochastic factor, and

m = real income.

The demand curves are estimated by taking logarithms of pairs of equations. Hence, the estimated equations are:

$$\log Z_{it} - \log Z_{jt} = \log(\frac{a_i b_i}{a_j b_j}) + b_i \log(\frac{Y}{P_{it}}) - b_j \log(\frac{Y}{P_{jt}}) + u_{ijt}$$

$(i = 1, 2, \ldots n: \quad j = i + 1, i + 2, \ldots n: \quad t = 1, 2, \ldots T)$

where

U_{ijt} is a random disturbance term, and all but n-1 equations are redundant.

Richard Parks (see below) has applied the three major systems of demand equations to data from Sweden for the period 1861-1955. Eight different sectors were included in the study.

For the Rotterdam system, his estimates for the μ_i and π_{ij} were as follows:

UNCONSTRAINED GENERALIZED LEAST SQUARES ESTIMATES OF THE ROTTERDAM DEMAND MODEL. SWEDISH DATA, 1861-1955

Commodity Group i	μ_i	π_{i1}	π_{i2}	π_{i3}	π_{i4}	π_{i5}	π_{i6}	π_{i7}	π_{i8}
1. Agriculture	.0707	−.0810	.0169	−.0076	−.0460	.1375	−.0167	.0181	−.0212
	(.0294)[a]	(.0283)	(.0158)	(.0135)	(.0872)	(.0668)	(.0215)	(.0218)	(.0136)
2. Manufacturing	.3394	.0241	−.0539	−.0050	.0875	−.1068	.0287	.0432	.0177
	(.0298)	(.0286)	(.0161)	(.0137)	(.0883)	(.0677)	(.0218)	(.0221)	(.0139)
3. Transportation	.0212	.0103	.0004	−.0101	−.0149	.0053	.0072	−.0017	.0035
	(.0048)	(.0046)	(.0026)	(.0022)	(.0143)	(.0110)	(.0035)	(.0036)	(.0022)
4. Commerce	.2912	.0421	.0385	.0142	−.1353	−.0138	.0160	.0028	.0356
	(.0148)	(.0142)	(.0080)	(.0068)	(.0438)	(.0336)	(.0108)	(.0110)	(.0069)
5. Domestic Services	.0084	.0022	.0018	.0037	.0103	−.0235	.0045	.0005	.0005
	(.0027)	(.0026)	(.0014)	(.0012)	(.0079)	(.0061)	(.0020)	(.0020)	(.0017)
6. Housing	.0226	−.0264	−.0113	−.0091	.1158	−.0239	−.0465	.0011	.0003
	(.0143)	(.0137)	(.0077)	(.0065)	(.0422)	(.0324)	(.0104)	(.0106)	(.0066)
7. Public Services	.0369	.0191	−.0090	.0044	.0018	.0379	.0025	−.0616	.0049
	(.0154)	(.0147)	(.0083)	(.0070)	(.0454)	(.0348)	(.0112)	(.0114)	(.0071)
8. Imports	.2096	.0096	.0166	.0096	−.0191	−.0128	.0044	−.0024	−.0058
	(.0245)	(.0235)	(.0132)	(.0112)	(.0724)	(.0203)	(.0179)	(.0181)	(.0114)

[a] Numbers in parentheses are standard errors.

Parks' estimates of the β_i and γ_i of the linear expenditure system for the same commodity groups were:

Linear Expenditure System With and Without Trend
Estimated Coefficients for Per Capita Expenditure, Sweden 1861-1955

Commodity i	Without Trend[a] β_i	γ_i	With Trend[a] β_i^*	β_i^{**}	γ_i^*	γ_i^{**}
1	−.00241	100.935	0.1691	−0.00219	76.205	0.2538
	(.00730)	(12.852)				
2	.37333	72.282	0.3708	0.00014	59.373	0.1231
	(.01904)	(8.087)				
3	.05185	6.514	0.1354	−0.00086	−0.522	0.0587
	(.00525)	(1.943)				
4	.34259	57.562	0.2656	0.00077	52.158	0.1003
	(.01268)	(9.608)				
5	.00444	10.323	0.0208	−0.00025	7.667	0.0662
	(.00268)	(3.124)				
6	.01721	60.539	−0.0189	0.00054	53.635	0.1481
	(.01150)	(8.011)				
7	.14392	17.998	0.0140	0.00164	15.812	0.1527
	(.01376)	(5.921)				
8	.06907	27.775	0.0432	0.00021	33.583	−0.0746
	(.00652)	(4.571)				
Σ	1.000	353.928	1.0000	0.00000	297.910	0.8283

[a] Estimates for both versions of the model were computed using the modified Stone procedure. Standard errors for the no trend version were computed using the inverse of the information matrix. Standard errors for the trend version were not computed.

For the indirect addilog model, a_i and b_i were estimated as follows:

Indirect Addilog Model, Generalized Least Squares Estimates of a_i and b_i Coefficients

Index j	A. Assuming Contemporaneous Correlation of Disturbances: b_1 unconstrained (estimated with commodity j)	b_j	b_j (with b_1 constrained)	B. Assuming Serial and Contemporaneous Correlation of Disturbances: b_1 unconstrained (estimated with commodity j)	b_j	b_j (with b_1 constrained)	a_j
1			−1.11			−0.96	1.04
			(0.16)			(0.09)	
2	−1.13	0.06	0.10	−0.99	−0.09	−0.06	0.09
	(0.14)	(0.12)	(0.10)	(0.09)	(0.07)	(0.07)	
3	−1.76	0.26	0.62	−1.07	−0.06	−0.01	0.11
	(0.15)	(0.09)	(0.09)	(0.10)	(0.06)	(0.06)	
4	−0.87	0.31	0.09	−0.93	−0.01	−0.01	0.62
	(0.05)	(0.05)	(0.05)	(0.06)	(0.07)	(0.07)	
5	−1.17	−0.92	−0.86	−0.98	−0.84	−0.82	0.06
	(0.08)	(0.08)	(0.08)	(0.04)	(0.05)	(0.05)	
6	−1.00	−0.68	−0.81	−0.88	−0.78	−0.78	0.32
	(0.05)	(0.04)	(0.04)	(0.08)	(0.06)	(0.06)	
7	−1.45	0.06	0.44	−0.85	−0.11	−0.12	0.02
	(0.08)	(0.09)	(0.10)	(0.09)	(0.09)	(0.09)	
8	−0.82	−0.25	−0.50	−0.84	−0.29	−0.34	0.03
	(0.28)	(0.23)	(0.52)	(0.08)	(0.16)	(0.11)	

Finally, Parks compared the models on the basis of how well they fit. Values for $1 - R^2$ for each of them were:

COMPARISON OF DEMAND MODELS ON THE BASIS OF FIT TO THE SAMPLE DATA

Values of $1 - R^2 = \sum_{t=1}^{T} (y_t - \hat{y}_t)^2 / \sum_{t=1}^{T} (y_t - \bar{y})^2$

Commodity	Naive	Rotterdam	Indirect Addilog	Linear Expenditure Without Trend	Linear Expenditure With Trend
Agriculture	.06545	.02195	.02969	.01874	.01815
Manufacturing	.00259	.00158	.00176	.00141	.00140
Transport	.01396	.00722	.01331	.01483	.01744
Commerce	.00078	.00054	.00064	.00048	.00052
Domestic Service	.01645	.00795	.00934	.00964	.00826
Housing	.01248	.00207	.00171	.00184	.00123
Public Services	.00803	.00538	.00823	.00775	.00697
Imports	.08535	.05156	.07359	.07379	.07558

For more examples of estimating systems of demand equations see:

Barten, A. P., (1968), "Estimating Demand Equations," Econometrica, Vol. 36, #2. (Pages 213-251)

Deaton, Angus, (1975), Models and Projections of Demand in Post-War Britain, Chapman and Hall, London. (Chapters 3, 4 & 5)

Intriligator, Michael D., (1978), Econometric Models, Techniques, and Applications, Prentice-Hall Inc., Englewood Cliffs, New Jersey. (Pages 225-230)

Lluch, Constantino, (1971), "Consumer Demand Functions, Spain 1958-1964," European Economic Review, Vol. 2, #3. (Pages 277-302)

Parks, Richard W., (1969), "Systems of Demand Equations," Econometrica, Vol. 37, #4. (Pages 629-650)

Pollak, Robert A., and Terence J. Wales, (1969), "Estimation of the Linear Expenditure System," Econometrica, Vol. 37, #4. (Pages 611-628)

Powell, Alan A., (1974), Empirical Analytics of Demand Systems, Lexington Books, D. C. Heath & Co., Lexington, Mass. (Chapters 3 & 4)

Stone, J. R. N., (1954), "Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand," Economic Journal, Vol. LXIV, #25. (Pages 511-527)

Indirect Calculations of Price Elasticities

Sometimes it is difficult to make reliable estimates of price elasticities because of a lack of data. With this problem in mind, Ragnar Frisch has developed a method of estimating own and cross price elasticities from information on budget proportions and income elasticities. (Such information is frequently available when price and quantity data are not.)

Frisch's technique begins with two strong assumptions. The first is that there is "want independence" among the commodities in question. This means that the marginal utility of consuming more of good i is independent of the amount of good j consumed. This assumption is reasonably valid when the commodities are defined with a fairly high level of aggregation, and becomes less valid as the commodity definitions become more specific. The second assumption is simply that the behavior of a "representative individual" can be used to describe market behavior.

The first order conditions for utility maximization imply that

$$\frac{U_1}{P_1} = \frac{U_2}{P_2} = \dots = \frac{U_n}{P_n} = W$$

where

U_i = the marginal utility of good i $\qquad$ (i = 1, 2, ... n)

P_i = the price of good i, and

W = the marginal utility of money

According to Frisch, W changes as total expenditure (Y) changes. This implies that there is a "money flexibility" coefficient, $\check{W}$ such that

$$\check{W} = \frac{\partial W}{\partial Y} \frac{Y}{W}\text{, all prices constant}$$

From this, Frisch is able to derive the own price elasticity of good i:

$$e_{ii} = -E_i\left(\alpha_i - \frac{1-\alpha_i E_i}{\overset{v}{W}}\right)$$

and the cross price elasticity of good i with respect to good j:

$$e_{ij} = -E_i\alpha_j\left(1 + \frac{E_j}{\overset{v}{W}}\right)$$

where

E_i = the income elasticity of good i, and

α = the budget share of good i

In order to use the above equations, three things are needed: information on budget shares, estimates of the money flexibility coefficient, and income elasticities. The budget share data is usually obtained directly through budget surveys (see Phlips below). Individual households representing all income classes are requested to write down all of their expenditures over a given time period. There is typically a payment made to these households for their cooperation.

The money flexibility coefficients must be estimated since they cannot be observed directly. Frisch himself suggested that $|\overset{v}{W}|$ decreases as income increases, and roughly follows the following pattern:

$\overset{v}{W}$ = -10 for the extremely poor

$\overset{v}{W}$ = -4 for those that are poor, but a little better off

$\overset{v}{W}$ = -2 for the middle income group

$\overset{v}{W}$ = -.7 for the fairly well off, and

$\overset{v}{W}$ = -.1 for the rich.

More recent work has focused on using existing demand parameter estimates for different countries to estimate $\check{W}$. Cappi et al (see below) made three different estimates of the money flexibility coefficients for Central America. The first was based on the relationship

$$\ln(-\check{W}) = 1.591 - .5205 \ln \frac{Y^*}{P}$$

where Y* is per capita real income and P is an overall price index. Their second estimate came from the equation

$$\log_{10}(-\check{W}) = 1.434 - .331 \log_{10} Y$$

where Y is GNP per capita. Finally, an equation derived from a system of demand equations and a cardinal utility function was used. It was of the form

$$\ln(-W) = 1.795 - .5127 \ln Y/P \ .$$

Their results were as follows:

Computed Money Flexibility Coefficient Values, by Income Strata

Income Stratum	Country	(1) Per Capita Income (1970 CA$)	(2) w^1	(3) w^2	(4) w^3	(5) Average w
Low Income	Guatemala	79	-5.5494	-6.5558	-6.3957	-6.1670
	El Salvador	82	-5.4428	-6.4317	-6.3172	-6.1639
	Honduras	59	-6.4600	-7.6142	-7.0445	-7.0396
	Nicaragua	105	-4.7856	-5.6660	-5.0208	-5.4241
	Costa Rica	193	-3.4960	-4.1470	-4.7586	-4.1306
Middle Income	Guatemala	247	-3.0659	-3.6543	-4.3855	-3.7019
	El Salvador	227	-3.2037	-3.8160	-4.5098	-3.8432
	Honduras	187	-3.5438	-4.2147	-4.8086	-4.1890
	Nicaragua	286	-3.8407	-3.3897	-4.1778	-3.4694
	Costa Rica	466	-2.3033	-2.6391	-3.5544	-2.7989
High Income	Guatemala	589	-1.9504	-2.3405	-3.2892	-2.5267
	El Salvador	605	-1.9234	-2.3085	-3.2602	-2.4973
	Honduras	458	-2.2232	-2.6627	-3.5748	-2.8202
	Nicaragua	723	-1.7538	-2.1078	-3.0734	-2.3111
	Costa Rica	954	-1.5174	-1.8278	-2.8039	-2.0497
Very High Income	Guatemala	2,194	-0.98367	-1.1926	-2.1284	-1.4349
	El Salvador	1,538	-1.1835	-1.4308	-2.3940	-1.6694
	Honduras	1,540	-1.1827	-1.4299	-2.3929	-1.6685
	Nicaragua	1,895	-1.0616	-1.2856	-2.2341	-1.5271
	Costa Rica	3,153	-0.81447	-0.99025	-1.8877	-1.2308
Total	Guatemala	311	-2.7194	-3.2472	-4.0635	-3.3434
	El Salvador	278	-2.8830	-3.4394	-4.2172	-3.5132
	Honduras	231	-3.1747	-3.7820	-4.4838	-3.8135
	Nicaragua	348	-2.5961	-3.1021	-3.9453	-3.2145
	Costa Rica	537	-2.0465	-2.4540	-3.3914	-2.6306

Income elasticities are generally obtained by estimating Engel curves. These curves are of the form

$$Z_1 = f(Y, N)$$

where

Z_1 = expenditures on good 1

Y = income or total expenditures, and

N = the number of people in the household

As with demand curves, Engel curves may be estimated commodity by commodity or in a system. For single commodity Engel curves, common forms are:

<u>Linear</u>*:

$$Z_1 = a_1 + b_1 Y + C_1 N$$

and estimated income elasticity = $\hat{b}_1 \dfrac{\bar{Y}}{\bar{Z}_1}$

(Note that the above elasticity is calculated at the mean values of Y and Z. Frequently, one may want to use the values of Y and Z that correspond to particular income classes.)

<u>Log Linear</u>:

$$\ln Z_1 = a_1 + b_1 \ln Y + C_1 \ln N$$

and estimated income elasticity = $\hat{b}_1$

<u>Semi-log</u>:

$$Z_1 = a_1 + b_1 \ln Y + C_1 \ln N$$

and estimated income elasticity = $\dfrac{\hat{b}_1}{\hat{a}_1 + \hat{b}_1 \ln \bar{Y} + \hat{C}_1 \ln \bar{N}}$

For systems of commodities, the linear expenditure system is typically employed (see section on systems of demand equations above). Here, the relevant equations are:

$$Z_i = P_i X_i = (P_i \gamma_i - \beta_i \sum_{j=1}^{n} P_j \gamma_j) + \beta_i Y \qquad i = 1, 2, \dots n$$

where

---

*It should be noted that experience indicates that <u>typically</u> the linear form is inferior to the other forms.

All prices are assumed to be constant, and γ_i refers to the (fixed) base amount of commodity X_i (i.e., the subsistence amount.) Cappi, et. al., derived the following income elasticities for Central America:

Income Elasticities for Central America[a]

Product	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica
Wheat (flour)	0.60	0.70	0.70	0.70	0.40
Sorghum (meal)	0.20[b]	0.20	0.20[b]	0.20[b]	--
Rice	0.60	0.60	0.60	0.40	0.30
Maize	0.10	0.10	0.10	0.10	0.10
Root crops	0.50	0.50	0.50	0.50	0.20
Plantain	0.30	0.20	0.20	0.20	0.20
Guineos	0.30	0.20	0.20	0.20	0.20
Sugar	0.50	0.50	0.60	0.40	0.10
Lump molasses	0.20	0.20	0.20	0.20	0.20
Beans	0.40	0.40	0.40	0.20	0.30
Fresh vegetables	0.50	0.60	0.60	0.80	0.60
Fruits	0.60	0.70	0.60	0.40	0.40
Bananas	0.30	0.30	0.30[c]	0.20	0.20[d]
Beef	0.80	0.80	0.80	0.70	0.70
Pork meat	0.50	0.50	0.50	0.50	0.50
Poultry	1.00	1.00	1.00	1.00	1.00
Eggs	0.80	0.80	1.00	0.80	0.70
Seafood	1.00	0.60	0.80	0.60	0.60
Milk and derivatives	0.80	0.70	0.70	0.40	0.50
Vegetable oils	0.80	0.70	0.80	0.60	0.60
Animal fats	0.40	0.50	0.40	0.50	0.50
Coffee	0.50	0.80	0.70	0.50	0.50
Alcoholic beverages	0.80	1.00	0.70	0.80	0.80
Total, nonfood[e]	0.81	0.81	0.81	0.81	0.81

[a]Elasticities estimated for 1965.
[b]The elasticity for this product was assumed to be equal to the corresponding elasticity for El Salvador.
[c]Elasticity taken from Guatemala.
[d]Elasticity taken from Nicaragua.
[e]Elasticity for nonfood expenditures estimated by Musgrove for Colombia.

These elasticities were then combined with the estimates of $\overset{v}{W}$ cited previously and utilized in Frisch's equations for price elasticities. The results are given below:

Direct Price Elasticities for Food, Central America

Product	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica
Wheat (flour)	0.19	0.21	0.20	0.23	0.16
Sorghum (meal)	0.06	0.06	0.05	0.06	0.08
Rice	0.18	0.17	0.16	0.13	0.12
Maize	0.03	0.03	0.03	0.03	0.04
Root crops	0.15	0.14	0.13	0.16	0.08
Plantain	0.09	0.06	0.05	0.06	0.08
Guineos	0.09	0.06	0.05	0.06	0.08
Sugar	0.15	0.15	0.17	0.13	0.04
Lump molasses	0.06	0.06	0.05	0.06	0.08
Beans	0.12	0.12	0.11	0.07	0.12
Fresh vegetables	0.16	0.19	0.18	0.27	0.24
Fruit	0.21	0.30	0.20	0.18	0.18
Bananas	0.09	0.09	0.08	0.06	0.08
Beef	0.28	0.25	0.23	0.25	0.31
Pork meat	0.15	0.15	0.14	0.16	0.19
Poultry	0.30	0.29	0.27	0.31	0.38
Eggs	0.25	0.24	0.27	0.26	0.27
Seafood	0.30	0.17	0.21	0.19	0.23
Milk and derivatives	0.26	0.22	0.22	0.15	0.21
Vegetable oils	0.25	0.21	0.22	0.19	0.23
Animal fats	0.12	0.14	0.11	0.16	0.19
Coffee	0.15	0.24	0.19	0.16	0.19
Alcoholic beverages	0.28	0.33	0.26	0.30	0.33

For more examples of the Frisch technique and Engel curves see:

Cappi, C., L. Fletcher, R. Norton, C. Pomareda, and M. Wainer, (1978), "A Model of Agricultural Production and Trade in Central America," in W. R. Cline and E. Delgado (editors), Economic Integration in Central America, Brookings Institution, Washington, D.C. (Pages 317-370)

Cramer, J. S., (1969), Empirical Econometrics, North-Holland Publishing Co., Amsterdam. (Chapters 3 & 7)

De Janvry, A., J. Bieri, and A. Nuñez, (1972), "Estimation of Demand Parameters Under Consumer Budgeting: An Application to Argentina," American Journal of Agricultural Economics, Vol. 54, #3. (Pages 422-430)

Frisch, Ragnar, (1959), "A Complete Scheme for Computing All Direct and Cross Demand Elasticities in a Model with Many Sectors," Econometrica, Vol. 27, #2. (Pages 177-196) (This article has also been reprinted in Zellner, Arnold (editor), (1968), Readings in Economic Statistics and Econometrics, Little, Brown & Co., Boston, pages 133-154).

Houthakker, H. S., (1957), "An International Comparison of Household Expenditure Patterns, Commemorating the Centenary of Engel's Law," Econometrica, Vol. 25, #4. (Pages 532-551)

Intriligator, Michael D., (1978), Econometric Models, Techniques, and Applications, Prentice-Hall Inc., Englewood Cliffs, New Jersey. (Pages 216-230)

Lluch, Constantino, (1971), "Consumer Demand Functions, Spain 1958-1964," European Economic Review, Vol. 2, #3. (Pages 277-302)

Phlips, L., (1974), Applied Consumption Analysis, North-Holland Publishing Co., Amsterdam. (Pages 100-115)

Prais, S. J. and H. S. Houthakker, (1971), The Analysis of Family Budgets, Cambridge University Press, Cambridge (the whole book).

Schultz, Henry, (1938), The Theory and Measurement of Demand, University of Chicago Press, Chicago. (Chapter 3)

Stone, Richard, (1954), The Measurement of Consumers' Expenditure and Behavior in the U. K., 1920-1938, Cambridge University Press, Cambridge.

Supply Estimation

General Remarks

Compared to the number of studies on demand, there are relatively few papers on the estimation of supply curves. The work that has been done deals almost exclusively with agriculture. The reasons for this are twofold: first, only competitive industries have true supply curves, and agriculture is perhaps the only industry that approaches a regime of perfect competition. Secondly, agriculture is basic to almost all economies, and has therefore attracted the attention of both economists and policy-makers.

One other item should be mentioned, and that is simply that with regards to international markets, many countries are, as consumers, perfect competitors. Hence, they have no influence over price, and the supply curve that they face is perfectly elastic.

The Distributed Lag Model

Without a doubt the most popular method of estimating agricultural supply is to use the distributed lag model made famous by Marc Nerlove. Strictly speaking, the model estimates the relationship between acres planted in a particular crop and expected price. It should be recognized that acres planted is not quite the same thing as supply. Weather and technology affect yields per acre, and hence total output. But over time good and bad weather periods average out, and technology is typically assumed to be exogenous. More importantly, the policymaker can hope to influence the number of acres planted, but has no control over the weather.

The basic equation to be estimated is

$$X_t = a_0 + a_1 P_t^* + U_t \qquad (1)$$

where

X_t = acres of the crop planted

P_t^* = expected price, and

U_t = a disturbance term

Obviously, P_t^* cannot actually be observed. Nerlove argues that expected price is a function of all past prices, with the most recent prices having the greatest influence. In addition, farmers are assumed to revise their expectations of the price that will prevail in the coming year in proportion to the error they made in predicting this period's price. That is,

$$P_t^* = P_{t-1}^* + \beta[P_{t-1} - P_{t-1}^*] \qquad (2)$$

where

P_{t-1}^* = Price expected in period t-1 (i.e., last period's expected price)

P_{t-1} = Actual price in period t-1, and

β = The "coefficient of expectation", where $0 < \beta < 1$

From this equation it can be shown that (See Nerlove (1956), below):

$$P_t^* = \beta P_{t-1} + (1 - \beta) \beta P_{t-2} + (1 - \beta)^2 \beta P_{t-3} + \ldots \qquad (3)$$

When $\beta = 1$, we have the so called "naive" version of the model in which only the most recent price influences expectation (as all other terms equal zero).

By recognizing that the number of acres planted last period (X_{t-1}) was determined by P^*_{t-1} and making the appropriate substitutions, equation (1) can be rewritten as:

$$X_t = a_0 \beta + a_1 \beta P_{t-1} + a_2 (1 - \beta) X_{t-1} + V_t$$

where V_t is a disturbance term different from U_t. Nerlove used the above equation to estimate the supply curves of cotton, wheat, and corn in the United States for the period 1909-1932. He compared this model to the naive version where $\beta = 1$, and obtained the following results:

A COMPARISON OF TWO METHODS (SPECIAL AND GENERAL) FOR ESTIMATING THE ELASTICITY OF SUPPLY AS MEASURED BY THE RESPONSE OF ACREAGE TO EXPECTED PRICE FOR COTTON, WHEAT AND CORN (1909-32)

Crop and Magnitude Compared	Special Method [Restricted β: ($\beta = 1$)]	General Method [Unrestricted β]
(1)	(2)	(3)
Cotton:		
Elasticity	0.20	0.67
Coefficient of expectation (β)	1.0	0.51
		(±.17)
R^2	0.59	0.74
Trend	0.48	0.18
	(±.10)	(±.12)
Wheat:		
Elasticity	0.47	0.93
Coefficient of expectation (β)	1.0	0.52
		(±.14)
R_2	0.64	0.77
Trend	1.03	0.53
	(±.17)	(±.17)
Corn:		
Elasticity	0.09	0.18
Coefficient of expectation (β)	1.0	0.54
		(±.24)
R^2	0.22	0.35
Trend	0.21	0.16
	(±.10)	(±.11)

(The figures in parentheses below the estimates are the standard errors of the estimates.)

There have been attempts to elaborate on this basic model by including other related variables. A common approach is to estimate an equation of the following type:

$$X_t = a_0 \beta + a_1 \beta P_{t-1} + a_2 (1 - \beta) X_{t-1} + a_3 W_t + a_4 f_t + U_t$$

where

W_t = a weather index, perhaps the amount of rainfall at planting time, and

f_t = the amount of fertilizer applied.

Rachel Dardis (See below) used this type of model in estimating a grain supply model for the U. K., 1947-1963. Her results were as follows:

$$y = 574.1362 + \underset{(23.0258)}{28.6959x_1} + \underset{(3.7171)}{23.6234x_3} - \underset{(3.8038)}{8.1335x_4} - \underset{(450.98)}{1141.64x_7}$$

$$R^2 = 0.92 \quad d = 2.46$$

$$y' = 0.9266 + \underset{(0.3432)}{0.7255x'_1} + \underset{(0.1711)}{0.9778x'_3} - \underset{(0.0511)}{0.1182x'_4} - \underset{(0.0595)}{0.1629x_7}$$

$$R^2 = 0.91 \quad d = 2.63$$

$$y' = 3.4683 + \underset{(0.3325)}{0.4896x'_1} + \underset{(0.1591)}{0.8792x'_3} - \underset{(0.0958)}{0.2323x'_5} - \underset{(0.0575)}{0.1526x_7}$$

$$R^2 = 0.91 \quad d = 2.97$$

$$y = 4642.5022 + \underset{(25.8504)}{49.3398x_2} + \underset{(4.1558)}{17.1596x_3} - \underset{(4.5119)}{8.1100x_4} - \underset{(46.6128)}{48.8438x_6}$$

$$R^2 = 0.90 \quad d = 2.11$$

$$y' = 5.8790 + \underset{(0.3694)}{0.7452x'_2} + \underset{(0.1805)}{0.6255x'_3} - \underset{(0.0635)}{0.1224x'_4} - \underset{(0.5906)}{0.6875x'_6}$$

$$R^2 = 0.88 \quad d = 2.20$$

where

y is grain production (wheat, barley, oats) in the United Kingdom, with no lag;

x_1 is the cereal price index deflated by the wholesale price index (WPI), with a 1-year lag;

x_2 is the cereal price index deflated by WPI, with a 2-year lag;

x_3 is nitrogen consumption, a 3-year moving average ending in time t-1;

x_4 is fall rain, September to November, in England and Wales;

x_5 is the aridity index in England and Wales;

x_6 is the net agricultural price index deflated by WPI, a 3-year moving average ending in time t-1; and

x_7 equals zero for the years 1947-48 to 1956-57 and equals one otherwise.

The equations with the primed variables (e.g. y') are in log form.

Despite the popularity of this approach, it is not without its critics. Brandow for example (see below) claims that it produces biased estimates, and there is some doubt that the influence of past prices actually declines in a precise geometrically diminishing lag. But the simplicity of the models together with their high explanatory power make them an extremely useful tool.

For further examples of estimating supply equations see:

Bateman, Merrill J., (1965), "Aggregate and Regional Supply Functions for Ghanaian Cocoa, 1946-1962," Journal of Farm Economics, Vol. 47, #2, (pages 384-401).

Behrman, Jere R., (1966), "Price Elasticity of the Marketed Surplus of a Subsistence Crop," Journal of Farm Economics, Vol. 48, #4, (pages 875-893).

Brandow, G. E., (1958), "A Note on the Nerlove Estimate of Supply Elasticity," Journal of Farm Economics, Vol. 40, #3, (pages 719-722).

Cowling, K. & T. W. Gardner, (1963), "Analytical Models for Estimating Supply Relations in the Agricultural Sector: A Survey and Critique," Journal of Agricultural Economics, Vol. 15, #3, (pages 439-450).

Dardis, Rachel, (1967), "The Welfare Cost of Grain Protection in the United Kingdom," Journal of Farm Economics, Vol. 49, #3, (pages 597-609).

Dean, G. W., & E. O. Heady, (1958), "Changes in Supply Response and Elasticity for Hogs," Journal of Farm Economics, Vol. 40, #4, (pages 845-860).

Gardner, T. W., (1962), "The Farm Price and the Supply of Milk," Journal of Agricultural Economics, Vol. 15, #1, (pages 58-73).

Heady, E. O., C. B. Baker, H. G. Diesslin, E. Kehrberg, & S. Staniforth, (1961), Agricultural Supply Functions, Iowa State University Press, Ames, (Chapter 4).

Krishna, Raj, (1963), "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region," The Economic Journal, Vol. LXXIII, #291, (pages 477-487).

Mangahas, M., A. E. Recto, & V. W. Ruttan, (1966), "Price and Market Relationships for Rice and Corn in the Philippines," Journal of Farm Economics, Vol. 48, #3, (pages 685-703).

Maddala, G. S., (1977), Econometrics, McGraw-Hill, New York, (Chapter 16).

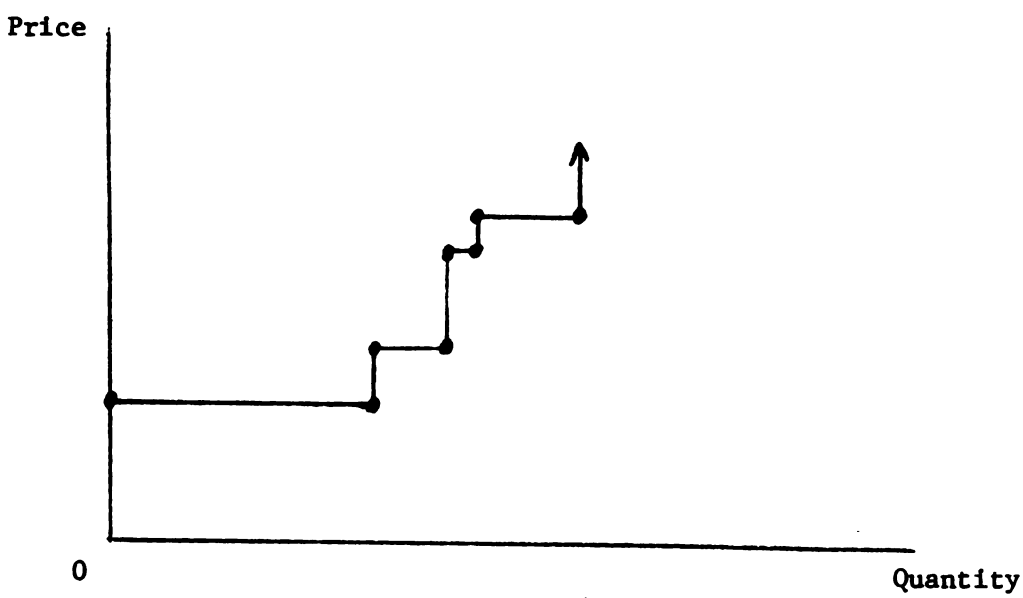
Nerlove, Marc, (1956), "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," Journal of Farm Economics, Vol. 38, #2, (pages 496-509).

Nerlove, Marc, (1958), The Dynamics of Supply: Estimation of Farmers' Response to Price, The Johns Hopkins Press, Baltimore.

Supply Estimates from Programming Models

Linear programming models can also be used to derive supply curve estimates. However, it should be emphasized that supply functions obtained in this manner are normative. In other words, linear programming techniques generate the optimal solution to a given problem, not necessarily the actual solution. Linear programs can tell you how much of a given product should be produced under various price regimes, but there is no guarantee that the optimal amount will in fact be produced. One can only hope that there is some definite correlation between what ought to be done and what is actually done.

Another peculiarity of supply functions derived from linear programming models is that they resemble step functions, as illustrated below:



This phenomenon arises because the production possibility curve used in linear programs is simply a series of linear segments. Hence, no marginal changes occur. If price changes sufficiently to cause a new plan to become optimal, a discrete quantity adjustment takes place.

The actual process of obtaining a supply curve is explained in great detail in a superb book by Heady and Candler (see below). Basically, what is done is to solve a linear program for an optimal plan under the assumption that the price of the good in question (X) is zero. The simplex method generates results that allows determination of how far the price of X must rise before this initial plan is no longer optimal. In other words, it is possible to determine the minimum price at which good X can profitably be produced. (Note that this avoids having to solve linear programs for every conceivable price). A new solution is then calculated using this minimum price, and the optimum quantity of X is determined. As before, one can also determine the price range in which this new plan is optimal. By choosing a price slightly above this range, the linear program can be solved for yet another optimal plan, and so forth.

An example taken from Heady and Candler may help illustrate the idea. Consider a farmer with two critical resource constraints, capital and labor. He has $5,000 worth of capital, and 200 hours of labor for the limiting month. His input-output matrix is as follows:

Input-Output Coefficients for Example of Variable-Price Programming

Item	Real activities					
	Corn A P_1	Corn B P_2	Hogs A P_3	Hogs B P_4	Dairy P_5	Hog selling P_6
Units	Acre	Acre	Fall litters	Fall litters	Cow	Litters
Resources and size of input units:						
Capital ($10)	20	39.5	100	105	3	0
Labor (10 hrs.)	1	2	2	1.5	2	.1
Corn (10 bu.)	0	0	1	2.5	1	0
Hogs (litters)	0	0	0	0	0	1
Outputs:						
Corn (10 bu.)	1	2.1	0	0	0	0
Hogs (litters)	0	0	1	2	0	0
Net revenue (c_k=0)($)	-10	-23	-80	-170	40	0
Net revenue (c_k=1.20)($)	2	2.2	-92	-200	28	0

Note that there are two corn growing activities (indicating two alternative technologies), two hog producing activities, one dairy activity and one hog selling activity. Note also that corn appears as both an input and an output. This is because corn is an intermediate good used in the production of hogs. The price of corn is indicated as c_k.

With the above information, the linear program is solved using profit maximization as the objective function, and with the assumption that the price of hogs is zero. The solution to this problem is summarized in the table below along the line marked plan 1. There should be 6.7 units of corn production and 6.7 units of dairy production. (In actuality, one would have either six cows fed slightly more than what the plan calls for or seven cows fed slightly less). There would be no hog production, and there would be $3,466.70 worth of capital unused. Note that this plan is optimal for any hog price below $118.50 per litter.

Plan Summary for One-Price-Variable Programming

Plan Number	Activities										Hog price range $	
	Corn A P_1	Corn B P_2	Hogs A P_3	Hogs B P_4	Dairy P_5	Hog selling P_6	Capital disposal P_7	Labor disposal P_8	Hog disposal P_9	Corn disposal P_{10}	Min.	Max.
1	6.7	0	0	0	6.7	0	3,466.7	0	0	0	0	118.50
2	9.8	0	0	2.8	2.7	5.6	0	0	0	0	118.50	153.91
3	0	4.8	0	2.9	2.8	5.8	0	0	0	0	153.91	200.00
4	0	3.9	0	3.3	0	6.6	0	6.6	0	0	200.00	infinite

To obtain a normative supply curve for hogs, one needs to repeat the process using higher and higher hog prices. For example, for hog prices between $118.50 and $153.91 per litter, plan two is optimal, and hog production rises to 2.8 units. If hog prices go up into the range between $153.91 and $200.00, hog production should rise to 2.9 units. Should prices rise above $200.00, plan 4 would become the most profitable. The reader should notice that no matter how high hog prices go above $200.00, hog production will not be increased beyond 3.3 units. This is because of the resource constraints built into the problem which make it physically impossible to produce more hogs.

For further examples and discussion see:

Candler, Wilfred, (1957), "A Modified Simplex Solution for Linear Programming with Variable Prices," Journal of Farm Economics, Vol. 39, #2, (pages 409-428).

Heady, E. O., and W. Candler, (1958), Linear Programming Methods, Iowa State University Press, Ames, (Chapter 8).

Heady, E. O., C. B. Baker, H. G. Diesslin, E. Kehrberg, and S. Staniforth, (1961), Agricultural Supply Functions, Iowa State University Press, Ames, (Chapters 5 and 8).

Hildreth, Clifford, (1955), "Economic Implications of Some Cotton Fertilizer Experiments," Econometrica, Vol. 23, #1, (pages 88-98).

Toussaint, W. D., (1958), "Programming Optimum Firm Product Supply Functions," Southern Cooperative Series Bulletin, No. 56, (pages 62-75).

The Identification Problem and Simultaneous Equation Estimation

Consider the following simple supply and demand relationship:

$$Q_d = a_1 + b_1 P + \mu$$

$$Q_s = a_2 + b_2 P + v$$

$$Q_d = Q_s$$

where

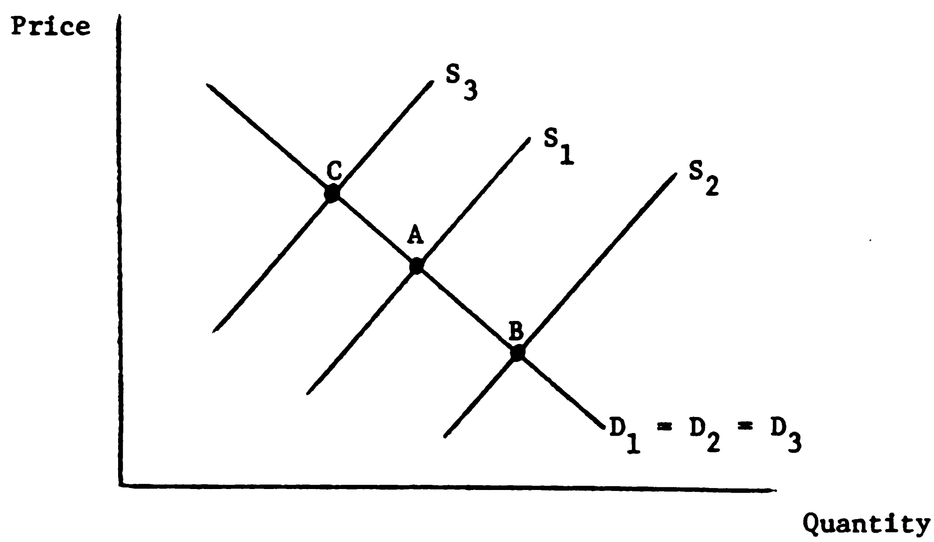
Q_d = quantity demanded

Q_s = quantity supplied

P = price, and

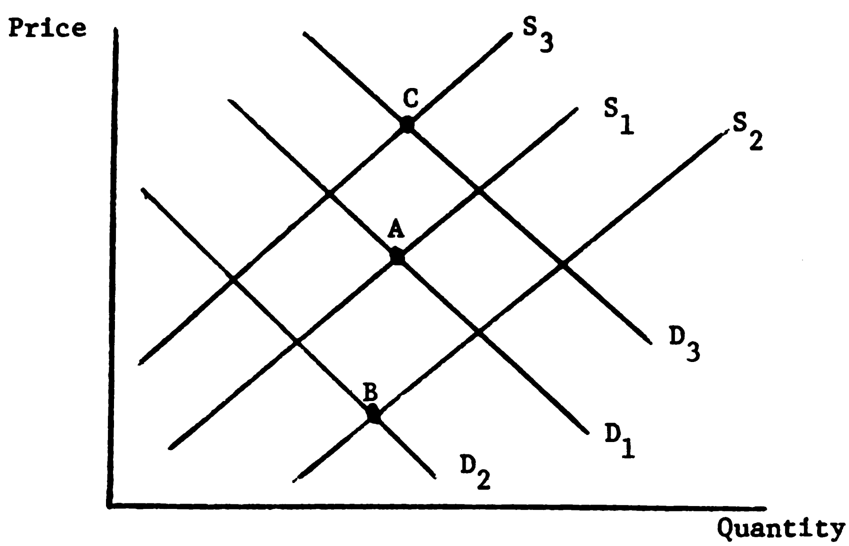
μ & v = disturbance terms

Suppose that the demand equation is fairly constant over time, but that the supply equation shifts frequently due to a variable not included in the supply equation (e.g. rainfall). For example, for three periods the situation might be as follows:



Points A, B, and C represent the equilibrium price/quantity combinations for the three periods. The fact that the demand curve is stable and the supply curve is not allows us to trace the demand curve, and hence estimate it. The demand curve has in fact been identified (though the supply curve has not been identified). It is sometimes argued that this situation approximates agricultural markets where demand is fairly stable, but supply fluctuates with the weather.

But now suppose that both equations shift over time so that the situation is:



Clearly, on the basis of an econometric study using the simple supply and demand model presented above, neither the supply or the demand curve could be accurately estimated. The system is not identified.

Let us hypothesize that the shifts in the demand curve are due to variations in income, and that the shifts in the supply curve are due to variations in the amount of rainfall. Our model now becomes:

$$Q_d = a_1 + b_1 P + c_1 Y + \mu$$

$$Q_s = a_2 + b_2 P + c_2 R + v$$

$$Q_d = Q_s$$

where

Y = income, and

R = rainfall

The system now contains two jointly determined or endogenous variables (price and quantity) and two exogenous variables (income and rainfall). Note that Y and R each occur in only one of the equations. They explain the shifts of the functions, and allow the system to be identified. However, estimating these equations by means of ordinary least squares will generate inconsistent estimators for the parameters. This is because the price variable is correlated with both disturbance terms. Hence, an alternative estimation technique is required.

There are a variety of simultaneous equation estimation methods available. The first step in these methods is to solve for the "reduced form" equations. In other words, solve the simultaneous system for Q and P to obtain:

$$Q = \frac{a_1 b_2 - a_2 b_1}{b_2 - b_1} + \frac{c_1 b_2}{b_2 - b_1} Y - \frac{c_2 b_1}{b_2 - b_1} R + m$$

$$P = \frac{a_1 - a_2}{b_2 - b_1} + \frac{c_1}{b_2 - b_1} Y - \frac{c_2}{b_2 - b_1} R + n$$

where m and n are residuals. Then define:

$$\pi_1 = \frac{a_1 b_2 - a_2 b_1}{b_2 - b_1}$$

$$\pi_2 = \frac{c_1 b_2}{b_2 - b_1}$$

$$\pi_3 = \frac{c_2 b_1}{b_2 - b_1}$$

$$\pi_4 = \frac{a_1 - a_2}{b_2 - b_1}$$

$$\pi_5 = \frac{c_1}{b_2 - b_1}$$

$$\pi_6 = \frac{c_2}{b_2 - b_1}$$

So the reduced form equations become

$$Q = \pi_1 + \pi_2 Y + \pi_3 R + m$$

$$P = \pi_4 + \pi_5 Y + \pi_6 R + n$$

By estimating these reduced form equations, estimates of the original parameters may be found:

$$\hat{b}_1 = \frac{\hat{\pi}_3}{\hat{\pi}_6}$$

$$\hat{b}_2 = \frac{\hat{\pi}_2}{\hat{\pi}_5}$$

$$\hat{c}_1 = \hat{\pi}_5(\hat{b}_1 - \hat{b}_2)$$

$$\hat{c}_2 = \hat{\pi}_6(\hat{b}_1 - \hat{b}_2)$$

$$\hat{a}_1 = \hat{\pi}_1 - \hat{b}_1 \hat{\pi}_4$$

$$\hat{a}_2 = \hat{\pi}_1 - \hat{b}_2 \hat{\pi}_4$$

Karl Fox (see below) used a simultaneous system to estimate consumption and production of pork in the U.S., 1922-1941. His estimated reduced form equations were

$$\ln q = -.06 \ln Y + .84 \ln Z \qquad R^2 = .91$$
$$(.06) \qquad (.07)$$

$$\ln p = .97 \ln Y - .96 \ln Z \qquad R^2 = .92$$
$$(.10) \qquad (.11)$$

where

q = per capita pork consumption

p = the retail price of pork

Y = per capita income, and

Z = pork production.

Using the relationships described above, the estimates for the structural equations were

Supply: $\ln q = 0.062 \ln p + .77 \ln Z$

Demand: $\ln p = -1.14 \ln q + .90 \ln Y$

Price and income elasticities of the demand for pork were obtained by taking the reciprocals of the coefficients in the price equation.

Therefore, the price elasticity was -1/1.14 = -.88, and the income elasticity was 1/.90 = 1.11.

For further discussion of the simultaneous equation problem and examples of estimation procedures see:

Beals, Ralph, (1972), Statistics for Economists, Rand McNally and Co., Chicago, (Chapter 14).

Cramer, J. S., (1969), Empirical Econometrics, North-Holland Publishing Co., Amsterdam, (Chapter 6).

Fox, Karl A., (1958), Econometric Analysis for Public Policy, Iowa State University Press, Ames, (Chapters 2-7).

Intriligator, Michael D., (1978), Econometric Models, Techniques, and Applications, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, (pages 230-233 and Chapters 10-11).

Leser, C. E. V., (1974), Econometric Techniques and Problems, Charles Griffin & Company Ltd., London, (Chapter 4).

Maddala, G. S., (1977), Econometrics, McGraw-Hill, New York, (Chapter 11).

Wallis, Kenneth, (1973), Topics in Applied Econometrics, Gray-Mills Publishing Ltd., London, (Chapter 4).

Walters, A. A., (1970), An Introduction to Econometrics, W. W. Norton & Co. Inc., New York (Chapter 7-8).

Production Functions

Production functions are mathematical expressions of the technological relationship between inputs and output. Their general form is represented by the expression:

$$Q = f(X_1, X_2, \ldots X_n)$$

where

Q = output, and

X_i = inputs.

In many econometric studies, only two inputs are specified. When the study is of an industrial output, the inputs typically chosen are labor and capital. Labor is usually measured in terms of man hours of a particular skill category. However, the measurement of capital raises complex problems which have no clear cut solution. These problems arise because "capital" is such a heterogeneous item, and because capital values are quite sensitive to depreciation and accounting practices. In practice, capital is sometimes measured in terms of net capital stock. When there is a situation in which only one type of machine is in use, capital can alternatively be measured in terms of numbers of these machines. For both labor and capital, both time series and cross section data can be used.

With respect to agriculture, the most important inputs may not be capital and labor. Heady and Dillon (see below), for example, used pounds of corn and soybean oilmeal in their production function for hogs on pasture. The point is that the "right" inputs to include depends upon the nature of the situation.

Often times a parameter of interest is the elasticity of substitution, which is a measure of the relative ease of substituting one input for another. If the production function is

$$Q = f(K, L)$$

then the elasticity of substitution is

$$\sigma = \frac{d \ln (K/L)}{d \ln (MP_L/MP_K)} = \frac{MP_L/MP_K}{K/L} \frac{d(K/L)}{d (MP_L/MP_K)}$$

where

K = amount of capital input

L = amount of labor input

$MP_L = \partial Q/\partial L$ = marginal productivity of labor, and

$MP_K = \partial Q/\partial K$ = marginal productivity of capital

If $\sigma = 0$, then no substitution between inputs is possible, whereas $\sigma = \infty$ implies that inputs are freely substitutable for each other.

The most popular form for empirical estimation of production functions is the Cobb-Douglas function:

$$Q = AL^{\alpha} K^{\beta}$$

where A, α and β are parameters. Note that α and β are the output elasticities of labor and capital, respectively.

The elasticity of substitution for the Cobb-Douglas production function is always equal to one. Moreover, the sum of α and β represent returns to scale, i.e.,

$\alpha + \beta = 1$ implies constant returns to scale

$\alpha + \beta > 1$ implies increasing returns to scale, and

$\alpha + \beta < 1$ implies decreasing returns to scale.

There are a couple of ways in which the Cobb-Douglas can be estimated. One is to simply estimate the production function itself in log linear form:

$$\ln Q = A + \alpha \ln L + \beta \ln K + \mu_i$$

where μ_i is a disturbance term.

If one is willing to assume constant returns to scale, then $\alpha + \beta = 1$ and $\beta = 1 - \alpha$. The above equation then becomes

$$\ln Q = A + \alpha \ln L + (1 - \alpha) \ln K + \mu_i$$

Dividing through by L, we get the "intensive" form of the Cobb-Douglas function, which is an alternative estimation form:

$$\ln \frac{Q}{L} = A' + (1 - \alpha) \ln \frac{K}{L} + V_i$$

A generalization of the Cobb-Douglas that allows for a non-unitary elasticity of substitution is known as the transcendental logarithmic or "translog" production function. It is of the form:

$$\ln Q = A + \alpha \ln L + \beta \ln K + \gamma \ln L \ln K + \delta (\ln L)^2 + \varepsilon (\ln K)^2$$

This function is obviously quadratic in the logs of the inputs, and reduces to the normal Cobb-Douglas if $\gamma = \delta = \varepsilon = 0$. For more than two inputs, the function is written:

$$\ln Q = A + \sum_{i=1}^{n} \alpha_i \ln X_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln X_i \ln X_j$$

A second major family of production functions is the constant elasticity of substitution or CES production functions. These functions are of the form:

$$Q = A\,[\alpha\, L^{-\rho} + (1 - \alpha)\, K^{-\rho}]^{-1/\rho}$$

In this case:

$$MP_L = \frac{\alpha}{A} \left(\frac{Q}{L}\right)^{\rho+1}$$

$$MP_K = \frac{1 - \alpha}{A} \left(\frac{Q}{K}\right)^{\rho+1} \text{, and}$$

$$\sigma = \frac{1}{1 + \rho}$$

It should be noted that the Cobb-Douglas is a special case of the CES where the elasticity of substitution is always equal to one. The CES, developed by Arrow, Chenery, Minhas and Solow (see below) is a more general approach in which σ may take on values from zero to infinity.

The CES is typically estimated under assumptions of profit maximization in the form:

$$\ln \frac{Q}{L} = \ln A' + \frac{1}{1 + \rho} \ln \frac{W}{P} = \ln A' + \sigma \ln \frac{W}{P}$$

where W/P is the real wage rate.

Other production function forms are the quadratic:

$$Q = a_1 + a_2 X_1 + a_3 X_2 - a_4 X_1^2 - a_5 X_2^2 - a_6 X_1 X_2$$

and the square root:

$$Q = a_1 + a_2 X_1 + a_3 X_2 + a_4 \sqrt{X_1} + a_5 \sqrt{X_2} - a_6 \sqrt{X_1} \sqrt{X_2}$$

where X_1 and X_2 are inputs. These equations are often associated with the "engineering" approach to production functions. This approach typically does not focus on capital and labor as inputs, but rather on more concrete and specific items. For example, if Q is the quantity of milk produced by a cow, X_1 and X_2 may refer to amounts of alfalfa and grain.

Heady and Dillon (see below) used the quadratic, the square root, and the Cobb-Douglas forms to estimate the production function of weight gain for hogs. The resulting equations were:

Quadratic:

$$Y = 1.7536 + .2988 C + .9828 P + .00003012 C^2 - .003880 P^2 - .0001684 C P$$

Square Root:

$$Y = -17.4939 + .2472 C + .03568 P + 1.425 a \sqrt{C} + .6.6133 \sqrt{P} - .08138 \sqrt{C} \sqrt{P}$$

Cobb-Doublas:

$$Y = .5493 C^{.8426} P^{.1604}$$

where

Y = pounds of gain

C = pounds of corn, and

P = pounds of soybean oilmeal.

Cramer (see below) reports the results of a study by Hildebrand and Liu using a Cobb-Douglas production function for the manufacturing sector. Two equations were employed, the first (numbered 10.28 by Cramer) was

$$X = AV_P^{\alpha_1} V_N^{\alpha_2} V_K^{\beta}$$

where

X = total output

V_P = production workers

V_N = non-production workers, and

V_K = capital.

The second equation (numbered 10.29) was

$$X = AV_1^{\alpha} V_K^{\beta}$$

where V_1 is simply the amount of labor used, with no distinction as to type. The data was from 1957, and the results were as follows:

Production function estimates by Hildebrand and Liu (United States, 1957).

industry	N	labour elasticities a_1	a_2	capital elasticities b	b'_1	b'_2	returns to scale
				estimates of equation (10.28)			
food products	35	.32 (.10)	.40 (.08)	.31 (.06)	53	1.29	2.00
apparel	18	.59 (.13)	.26 (.12)	.11 (.07)	.20	.44	1.28
paper products	28	.55 (.12)	.27 (.11)	16 (03)	28	.65	1 47
chemicals	31	.35 (.21)	.57 (.20)	.16 (.05)	.27	.75	1.66
petroleum and coal prod.	18	.27 (.23)	.50 (.27)	.14 (.16)	.23	.74	1.51
stone, clay, glass	25	.67 (.18)	.30 (.18)	.08 (.04)	.13	.32	1.28
fabricated metal produce	32	.53 (.14)	.34 (.12)	09 (.04)	.15	.34	1.21
machinery, not electrical	25	.47 (.13)	.27 (.14)	.19 (.04)	.33	.78	1.52
electrical machinery	22	.41 (.13)	.24 (.08)	.17 (.04)	.30	.69	1 34
transport equipment	26	.41 (.24)	.28 (.17)	.19 (.04)	32	.84	1 53
				estimates of equation (10.29)			
lumber & wood products	14	.79 (.34)		.18 (.07)	.31	.63	1.42
rubber and plastics	16	.85 (.10)		.14 (.05)	.23	.72	1.57
leather	15	.85 (.12)		.04 (.04)	.07	.20	1.05
primary metals	28	.96 (.11)		.10 (.05)	.16	.58	1.54
instruments	12	.67 (.12)		.25 (.07)	44	1.00	1.67

For further examples and discussion see:

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Intriligator, Michael D., (1978), Econometric Models, Techniques, and Applications, Prentice-Hall Inc., Englewood Cliffs, N. J., (pages 262-280).

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Input Demand Estimation

Input demand functions can be estimated in a variety of ways. The simplest approach is to use a partial equilibrium model of the form:

$$X = a + b\,P + \mu$$

or

$$\ln X = a + b \ln P + \mu$$

where X is the factor in question, P is its price, and μ is a disturbance term. Alternatively, one may wish to include the prices of other factors in the equation, so as to obtain:

$$X = a + b\,P_x + c\,P_y + \ldots + n\,P_z + \mu$$

or

$$\ln X = a + b \ln P_x + c \ln P_y + \ldots + n \ln P_z + \mu$$

where P_y, P_z, etc. are the prices of related inputs.

Cromarty (see below) employed a technique similar to this in estimating the farm sector's demand for tractors. Using U.S. data for the period 1926-1956 (omitting 1943), the following demand equations were obtained:

Least squares estimates, $\bar{R}^2 = .78$

$$Y_1 = 2210.69 - 1.689Y_{2/x_1} + .092X_2 + 1.434X_3 - .990X_9$$

$$(.846) \qquad (0.58) \qquad (.389) \qquad (.195)$$

Maximum likelihood, limited information estimates,

$$Y_1 = 3.229.98 - 2.726_{2/x_1} + 0.36X_2 + 1.817X_3 - 1.130X_9$$
$$\qquad\qquad (.960) \qquad (.061) \qquad (.391) \qquad (.184)$$

where

Y_1 = manufacturers' shipments of wheel type tractors (excluding garden) for domestic farm use

Y_{2/x_1} = the ratio of the index of retail prices for farm tractors to the prices received by farmers

X_2 = net cash receipts received by farmers in the previous year

X_3 = an eight year weighted average of the number of tractors on farms

X_9 = average tractor sales for the previous five and six years.

Input demand functions can also be derived from production functions. Consider the Cobb-Douglas production function:

$$Q = AL^{\alpha} K^{\beta}$$

Taking partial derivatives gives:

$$\frac{\partial Q}{\partial L} = \alpha AL^{\alpha-1} K^{\beta} = \frac{\alpha Q}{L}$$

$$\frac{\partial Q}{\partial K} = \beta AL^{\alpha} K^{\beta-1} = \frac{\beta Q}{K}$$

Setting these marginal products equal to the real wage rate and real rental rate, respectively, produces the first order conditions for profit maximization:

$$\frac{\alpha Q}{L} = \frac{W}{P} \quad \text{and} \quad \frac{\beta Q}{K} = \frac{r}{P}$$

or

$$\frac{\frac{\alpha Q}{L}}{\frac{\beta Q}{K}} = \frac{\frac{W}{P}}{\frac{r}{P}}$$

which implies

$$\frac{K}{L} = \frac{\beta}{\alpha}\frac{W}{r}$$

where

W = wage rate, and

r = rental rate of capital.

Solving this equation for K gives:

$$K = \frac{\beta}{\alpha}\frac{W}{r} \cdot L$$

Plugging this back into the production function produces:

$$Q = AL^{\alpha} \left(\frac{\beta}{\alpha}\frac{W}{r} L\right)^{\beta}$$

Solving this for L generates the demand function for labor, which may be estimated directly:

$$\ln L = A' - \frac{\beta}{\alpha + \beta} \ln \frac{W}{r} + \frac{1}{\alpha + \beta} \ln Q$$

The demand for capital may be obtained analogously.

An alternative formulation may be obtained by solving the Cobb-Douglas production function directly for L. This gives:

$$L = A^{-1/\alpha} K^{-\beta/\alpha} Q^{1/\alpha}$$

which is typically estimated in log form:

$$\ln L = A' - \frac{\beta}{\alpha} \ln K + \frac{1}{\alpha} \ln Q$$

Still another approach is to use a so-called "labor-adjustment model" where capital and desired output are considered fixed in the short run. In this case, labor demand is assumed to adjust itself each period in accordance to how close the actual amount of labor used is to the desired amount of labor. The adjustment mechanism is:

$$\frac{L_t}{L_{t-1}} = \left(\frac{L_t^*}{L_{t-1}}\right)^{\lambda}$$

where

L_t = actual labor use in period t

L_{t-1} = actual labor use in period t-1

L_t^* = desired labor use in period t, and

λ = adjustment paramter: $0 \leq \lambda < 1$

Putting this formula into the Cobb-Douglas production function and solving for $\ln L_t$ gives the demand for labor function:

$$\ln L_t = (1 - \lambda) \ln L_{t-1} - \frac{\lambda}{\alpha} \ln A - \frac{\beta\lambda}{\alpha} \ln K_t + \frac{\lambda}{\alpha} \ln Y_t$$

Waud's study (see below) used a labor demand function derived from a Cobb-Douglas production function under the assumption of perfect competition. By assuming a log linear demand for output function he estimated the elasticity of production worker manhours with respect to wages, capital costs, and GNP. Using data from U.S. manufacturing industries from 1954-1964, Waud obtained the following results:

Production Worker Manhour Behavior in U.S. Manufacturing Industry, 1954-1964

	Elasticity with Respect to			
Industry	*Wage*	*Cost of Capital*	*GNP*	R^2/d
Food	−0.506	0.157	−0.036	0.920
	(0.145)	(0.066)	(0.101)	2.137
Apparel	−0.287	0.136	0.796	0.726
	(0.442)	(0.154)	(0.173)	1.596
Paper	−0.613	0.364	0.583	0.846
	(0.345)	(0.095)	(0.152)	2.109
Chemicals	−0.654	0.339	0.690	0.674
	(0.270)	(0.115)	(0.136)	1.789
Rubber and plastics	−1.334	0.675	1.400	0.861
	(0.748)	(0.228)	(0.211)	1.737
Stone, clay, and glass	−1.967	0.445	1.466	0.574
	(0.776)	(0.182)	(0.334)	1.505
Fabricated metals	−2.366	0.317	1.683	0.771
	(0.708)	(0.124)	(0.244)	1.938
Machinery, except electrical	−2.103	0.995	2.340	0.791
	(0.922)	(0.206)	(0.462)	1.399
Electrical machinery	−2.142	0.943	1.256	0.771
	(0.838)	(0.217)	(0.259)	0.910

For further examples and discussion see:

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Projections

The ability to project present trends and tendencies is frequently useful, and indeed even necessary, for the policy maker. Therefore it is useful to consider some basic methods for making such projections.

One approach to making projections is the univariate method which focuses on the movements of a single variable. No attempt is made to explain the movement of this variable. Instead, the approach is to try and construct a model of the way it moves over time.

There are usually four components to a univariate time series, namely the trend (T), cyclical fluctuations (C) seasonal variation (S), and irregular movement (I). The actual value of the variable in question (Y) is hypothesized as being some combination of these components, e.g.:

$$Y = T + C + S + I$$

or

$$Y = TCSI$$

In broad terms, the trend component may be thought of as that part of the time series which displays a smooth regular movement over a fairly long period of time. The seasonal component of a time series can be thought of as that component which displays a regularly recurring pattern during subperiods of any specified period of time. Rice production, for example, may display a fairly regular monthly pattern from year to year.

The cyclical component of a time series can be thought of as that part of the time series that displays a fairly long-term, but not necessarily regular, movement around the trend. It usually is difficult to justify assumptions about the length and form of the cyclical movement of a time series. As a result, it generally is necessary to treat the cyclical component of a time series as a residual which is estimated after the trend and seasonal components have been identified and irregular movements averaged out. An alternative approach is to treat the cyclical and trend component as a single component and not attempt to estimate them separately. This approach is especially common when the investigator is interested primarily in adjusting for seasonal variations.

The irregular component of a time series can be thought of as that part of the time series that varies sporadically from period to period. Irregular movements may be due to chance events such as floods, strikes, or diseases. Irregular movements usually are smoothed out and "hidden" by averaging techniques.

It is assumed that the "components" of a time series can be regarded as independent of one another and therefore can be estimated successively rather than simultaneously. Projections based on univariate analysis are therefore based on the assumption that time series movements follow fairly regular patterns. While this assumption is not always justified, it does allow projections to be obtained quickly from relatively little information.

There are a variety of ways of projecting the trend component of a time series. One technique is to assume that the system has a certain momentum, and that it will continue along in the future the way it has in the past. For example, one might hypothesize that a variable might change by the same absolute amount each period. That is,

$$Y_{t-1} - Y_{t-2} = Y_{t-2} - Y_{t-3}, \text{ etc.}$$

which implies that

$$\hat{Y}_t = 2Y_{t-1} - Y_{t-2}$$

where $\hat{Y}_t$ is the value of the variable to be estimated for period t.

Another version of the same idea is to postulate that the variable changes by the same proportion each period. Hence,

$$\hat{Y}_t = Y_{t-1} + \frac{Y_{t-1}}{Y_{t-2}} (Y_{t-1} - Y_{t-2})$$

Still another variation of this same theme is to hypothesize that the variable is a weighted combination of past values. In that case,

$$Y_t = \sum_{i=1}^{\infty} b_i Y_{t-i}$$

The values for b_i may be estimated from information on past periods. The reader might note the similarity of this approach to the one used in Nerlove's distributed lag supply model discussed above.

Another method is to project a linear trend line using semi-averages. To do this, one first divides a time series into two parts. The mean value of each part is computed, and centered at the midpoint of the time intervals. By joining the two points with a straight line, a trend line is obtained.

This technique can be illustrated using the rice production data in the table on the following page.

Year	X	Rice Production, Y (Thousands of MT)	Estimated Trend value Y*
1970	-2	22.8	21.36
1971	-1	20.6	20.44
1972	0	19.5	19.52
1973	1	17.8	18.60
1974	2	16.9	17.68
1975	3	16.0	16.76
1976	4	15.6	15.84
1977	5	15.4	14.92
1978	6	13.8	14.00
1979	7	13.2	13.08
1980	8	12.0	12.16

Since the period 1970 to 1980 covers an odd number of years, the middle year, 1975, is omitted. The means of the two parts can then be based on the same number of years and are easily centered. For the first period the average is

$$\bar{Y}_1 = \frac{22.8 + 20.6 + 19.5 + 17.8 + 16.9}{5} = 19.52$$

For the second period the average is $\bar{Y}_2 = 14.00$.

The equation for the linear trend line is $Y^* = a + bX$ where Y^* is the estimated trend value and X is a time variable. Since 1972 is the midpoint of the first half of the data, X=0 in 1972, and increases (decreases) by one for each year that one moves forward (backward) in time. Hence, the equation for 1972 is

$$Y^* = a + b\ (0) \quad \text{or} \quad Y^* = a$$

We will assign to a the value of the mean for the first part of the data. Hence, Y* for 1972 equals 19.52. For other years, however, we must calculate the slope coefficient, b, which represents the average annual change in rice production. Solving $Y^* = a + bX$ for b we have

$$b = \frac{Y^* - a}{X}$$

Using the mean value for part two of the data as another measure of Y^*, we have

$$b = \frac{14.00 - 19.52}{6} = -.92$$

Note that X=6 here because the midpoint of section two of the data is 1978. We now have the whole trend line:

$$Y^* = 19.52 - .92\ (X)$$

Since this line is negatively sloped, it is clear that rice production is declining. If it continues to decline at the present rate, then by 1985, rice production will fall to

$$Y^* = 19.52 - .92(13) = 7.56 \text{ units.}$$

A more common method of obtaining a linear trend line is by using least squares estimates of the equation $Y^* = a + bX$. If the time scale is selected so that $\Sigma X = 0$ the trend line coefficients are obtained by solving the equations:

$$a = \frac{\Sigma Y}{n} = \overline{Y} \quad \text{and} \quad b = \frac{\Sigma XY}{\Sigma X^2}$$

The data on cattle in the table on the following page can be used to illustrate the procedure.

Year	X	Cattle, Y (In 1000s)	Estimated Trend Value Y*
1972	-4	4.2	4.035
1973	-3	4.6	4.590
1974	-2	5.2	5.145
1975	-1	5.7	5.700
1976	0	6.2	6.255
1977	1	6.6	6.810
1978	2	7.1	7.365
1979	3	7.6	7.920
1980	4	9.1	8.475

The least squares coefficients are:

$$a = \frac{\Sigma Y}{n} = \frac{56.3}{9} = 6.255$$

and $$b = \frac{\Sigma XY}{\Sigma X^2} = \frac{33.3}{60} = 0.555$$

The trend line is therefore equal to

$$Y^* = 6.255 + 0.555X$$

where X is in units of 1 year with its origin at 1976. The linear trend forecast for 1982 is therefore equal to

$$Y^* = 6.255 + 0.555(6) = 9.585 \text{ head}$$

Similar procedures are available for estimating parabolic ($Y^* = a + bX + cX^2$) and exponential ($Y^* = ab^X$) trend curves.

Yet another technique is known as the method of moving averages. The computations required to obtain a moving average are very easy, and yet the method is extremely flexible in the sense that the trend is not forced to conform to any particular mathematical function.

Given a set of numbers $Y_1, Y_2, \ldots, Y_n$; a k-period moving average is defined by a sequence of mathematical means:

$$\frac{Y_1 + Y_2 + \ldots + Y_k}{k}, \quad \frac{Y_2 + Y_3 + \ldots + Y_{K+1}}{k}, \ldots,$$

$$\frac{Y_{n+1-k} + Y_{n+2-k} + \ldots + Y_n}{k}$$

The data listed below on farm employment can be used to compute a three year moving average:

Year	Number of Employees (1000's)	3-Year Moving Total	3-Year Moving Average
1970	73.2	--	--
1971	81.9	223.6	74.53
1972	68.5	233.2	77.73
1973	82.8	239.6	79.86
1974	88.3	256.7	85.56
1975	85.6	261.3	87.09
1976	87.4	253.8	84.60
1977	80.8	251.6	83.86
1978	83.4	245.7	81.90
1979	81.5	--	--

Beginning with 1970 we have

$$\frac{73.2 + 81.9 + 68.5}{3} = \frac{223.6}{3} = 74.53$$

This average is located to correspond to the middle year 1971. To compute future values of a moving average requires knowledge (or assumptions) about the future value of the time series. As a result, moving averages are seldom used directly for making forecasts but as a first step in studying deviations from the trend and the analysis of seasonal variations.

The ability to accurately assess the seasonal component of a time series is frequently important. An agency that finds potato prices up by 30 percent in June may want to know if such an increase is consistent with an annually-recurring pattern before making decisions about price controls or importation of potatoes.

There are many ways to measure seasonal variation. The basic goal of most approaches is to obtain a seasonal index that can then be used to adjust the original data for seasonal variations. For quarterly data, a seasonal index consists of 4 numbers, one for each quarter. The methods discussed in this section are useful for measuring constant seasonal patterns, that is, seasonal patterns that do not change over time. Seasonal indexes computed on the assumption of constant seasonal patterns must be used with considerable care if there is evidence that the seasonal pattern of data may have changed over time. The seasonal pattern of rice production in the Philippines, for example, changed with the introduction of high yielding rice varieties.

The ratio-to-moving average or percent of moving average method is probably the most widely used for measuring seasonal variation. The first step of the method is to compute a moving average. This average is then centered if necessary. Next we compute the ratio-to-moving average percentages by dividing the original data by the centered moving average figures for corresponding periods and multiplying by 100. The ratio-to-moving average percentages for corresponding periods are next averaged using either the mean or median to obtain the seasonal index.

The wheat import data in the table below can be used to illustrate this idea:

Wheat Imports (Thousands of MT)

Year and Quarter	Wheat Imports	4-Quarter Moving Total	2-Quarter Moving Total	4-Quarter Centered Moving Average	Ratio-to-Moving Average
1970					
I	117	-	-	-	-
II	126	487	-	-	-
III	132	460	947	118.4	111.5
IV	112	438	898	112.3	99.7
1971					
I	90	419	857	107.1	84.0
II	104	407	826	103.3	100.7
III	113	400	807	100.9	112.0
IV	100	395	795	99.4	100.6
1972					
I	83	408	803	100.4	82.7
II	99	435	843	105.4	93.9
III	126	477	912	114.0	110.5
IV	127	548	1025	128.1	99.1
1973					
I	125	587	1135	141.9	88.1
II	170	604	1191	148.9	114.2
III	165	612	-	-	-
IV	144	593	-	-	-

We begin by calculating moving averages. The first and second numbers of the 4-quarter uncentered moving average are

$$\frac{(117 + 126 + 132 + 112)}{4} = \frac{487}{4} = 121.75$$

and

$$\frac{(126 + 132 + 112 + 90)}{4} = \frac{460}{4} = 115.00$$

The first number of the centered 4-quarter moving average is therefore equal to

$$\frac{(121.75 + 115.00)}{2} = 118.4$$

The first ratio-to-moving average percentage is for the third-quarter of 1970 and equal to

$$\frac{132.0\ (100)}{118.4} = 111.5$$

The next step is to arrange the ratio-to-moving averages by Quarters, as in the table below:

Ratio-to-Moving Average for Wheat Imports

Year	Quarter I	Quarter II	Quarter III	Quarter IV
1970	-	-	111.5	99.7
1971	84.0	100.7	112.0	100.6
1972	82.7	93.9	110.5	99.1
1973	88.1	114.2	-	-
Totals	254.8	308.8	334.0	299.4
Seasonal Index	84.9	102.9	111.3	99.8

The seasonal index is then calculated by obtaining the mean value for each Quarter. Therefore we have:

Quarter	Seasonal Index
1st	84.9
2nd	102.9
3rd	111.3
4th	99.8

Quarterly values of Y can then be divided by the seasonal index to remove the cyclical variations.

Besides the univariate approach, there are other projection methods. One such technique involves regressing a variable against explanatory variables, and then plugging in the expected values of those variables for the period in question. For example, estimate the equation

$$Y = a + bX + cZ$$

Then, use the following equation to predict $\hat{Y}_t$:

$$\hat{Y}_t = \hat{a} + \hat{b}\, X_t + \hat{c}\, Z_t$$

If X and Z are policy variables whose future values can be known with reasonable certainty, this can be a fairly effective technique. If X and/or Z are not policy variables, this method may be useful if the practioner feels more comfortable in projecting X and Z with the previously mentioned techniques than in projecting Y directly.

(Note that seasonal indices may be employed with this method as well.)

One other method involves the use of variables that are related in a cause and effect manner. If it is the case that variable Y can be expected to change following a change in variable X, then a knowledge of X may be used to predict movements in Y. This is called the "leading indicators" method. Mathematically, we may write

$$\Delta\hat{Y}_t = f\ (\Delta X_{t-b})$$

Where b is the length of time needed for the change in X to affect Y. The exact functional form obviously depends upon the relationship between X and Y.

This approach is appropriate for a variety of things. It has been used, for example, to predict changes in the price level based upon changes in the money supply, as well as to predict changes in GNP based upon construction contracts, business failures, hours worked per week, and other indicators.

For more examples and further discussion see:

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Short-run Vs. Long-run Elasticities and the Choice of Data

The reader should be aware of the fact that the choice of data is going to significantly affect the estimates obtained with econometric techniques. Economic data typically come in two forms, namely time series data and cross section data. Time series data measure the value of a variable for a particular entity over time. Annual values for the GNP of the U. K., or expenditures of a particular family over time, would be examples of time series data. Cross section data measure the value of a variable for different entities at a given time. Examples of cross section data would be values of GNP for all countries in 1970, or expenditures of a sample of families for a particular year.

Suprisingly, cross-section data are often the appropriate choice for estimating long-run elasticities, while short-run elasticities are best estimated by time series data (see Intrilligator or Kuh and Meyer below). For example, experience indicates that income elasticities estimated with cross section data are much larger than those estimated with time series data.

Sometimes, both types of data are employed together. A common practice is to estimate income elasticities using cross-section data (since prices are relatively stable for any one period). These estimates are than multiplied by a time series on aggregate income, and the product is then subtracted from a time series of the quantity demanded of a particular commodity. This new variable is then regressed against a time series on prices to estimate price elasticities.

This technique typically results in much larger estimates of price elasticities. Kuh and Meyer report the results of two studies, one by

Stone which uses the method of combining cross-section and time series data described above, and one by Wold using only time series data. A comparison of the two is quite interesting:

COMPARISON OF OWN PRICE ELASTICITIES FOR SELECTED FOOD PRODUCTS

	Stone estimates using extraneous income estimators,[a] England 1920–38	Wold estimates using time series only, Sweden	
		1921–39	1926–39
Beef (pork prices not in regression)	.55[b]	.00	..
Beef (pork prices in regression)	..	.50	..
Pork	.67	.45	..
Butter	.38	.94	.88
Margarine	.06	2.18	.79
Fresh milk	.05 }		..
Condensed milk	.60 }	.28	..
Cream	1.26 }		..
Flour	.79	.15	..
Sugar and syrup	.42	.11	..

[a] Where Stone has reported results from more than one regression for a given product, the regression that includes variables most similar to Wold's has been used. The butter and margarine regressions are for the years 1921–38.

[b] For both imported beef and veal.

SOURCE: Herman Wold and Lars Juréen, *Demand Analysis* (New York, 1953), 277–94; and Richard Stone, *The Measurement of Consumers' Expenditure and Behavior in the United Kingdom 1920–1938* (Cambridge, England, 1954), 322–27.

Finally, it should be noted that cross-section and time series data are often "pooled" to obtain a time series of cross sections. For example, time series data on GNP for country X might be combined with time series GNP data for country Y, allowing one to compare the two over time as well as at any given point in time.

For discussions and examples on the proper use of data see:

Barten, A. P., (1968), "Estimating Demand Equations," Econometrica, Vol. 36, #2, (pages 213-251, especially pages 239-240 and Appendix B).

Deaton, Angus, (1975), Models and Projections of Demand in Post-War Britain, Chapman and Hall, London (pages 50-51).

Houthakker, H. S., (1957), "An Introduction Comparison of Household Expenditure Patterns, Commemorating the Centenary of Engel's Law," Econometrica, Vol. 25, #4, (pages 532-551).

Houthakker, H. S. & L. D. Taylor, (1970), Consumer Demand in the United States: Analyses and Projections, Harvard University Press, Cambridge, Mass. (Chapter 6).

Intriligator, Michael D., (1978), Econometric Models, Techniques, and Applications, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, (pages 62-65).

Kuh, Edward & J. R. Meyer, (1957), "How Extraneous are Extraneous Estimates?", Review of Economics and Statistics, Vol. XXXIX, #4, (pages 380-393).

Maddala, G. S., (1977), Econometrics, McGraw-Hill, New York (Chapter 14).

Prais, S. J. and H. S. Houthakker, (1971), The Analysis of Family Budgets, Cambridge University Press, Cambridge (Chapters 3 and 4).

Stone, Richard, (1954), The Measurement of Consumers' Expenditure and Behavior in the United Kingdom, 1920-1938, Cambridge University Press, Cambridge (pages 322-327).

Estimation Methods

Basic Linear Regression

Simple Regression: Ordinary Least Squares (OLS). Linear regressions involving only a single independent variable are referred to as simple regressions. The object of such regressions is to fit a line to a set of data using the equation

$$Y = a + bX$$

It is convenient to transform X into deviations from its mean. In other words, define $x = X - \bar{X}$. This has the effect of shifting the Y axis in so that it begins at $\bar{X}$. The equation for the line to be fitted becomes

$$Y = a + bx$$

Where

$$\sum_{i=1}^{n} x_i = 0$$

The regression model itself is generally written

$$Y_i = a + b\,x_i + e_i \qquad i = 1, 2 \ldots n^*$$

Where the e_i represents a stochastic disturbance term. The assumptions for this model are as follows:

---

*n is the number of observations.

$E(e_i) = 0$ for all i

$Var\ (e_i) = \sigma^2$ for all i

$Cov\ (e_i) = 0$ for all i, and the x_i are fixed for all i.

The idea of OLS is to select values for a and b that minimize the squared deviations of the predicted Y_i (hereafter called $\hat{Y}_i$) from the actual Y_i. In other words, choose a and b so as to minimize

$$\sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2$$

Where

$$\hat{Y}_i = \hat{a} + \hat{b}\ X_i$$

Hence, we must minimize the function S(a,b) where

$$S(a,b) = \sum_{i=1}^{n} (Y_i - \hat{Y}_i)^2 = \sum_{i=1}^{n} (Y_i - \hat{a} - \hat{b}\ x_i)^2$$

Taking derivatives and setting them equal to zero gives us:

$$\frac{\partial S}{\partial a} = \sum_{i=1}^{n} (-2)\ (Y_i - \hat{a} - \hat{b}\ x_i) = 0 \qquad (1)$$

and

$$\frac{\partial S}{\partial b} = \sum_{i=1}^{n} (-2x_i)(Y_i - \hat{a} - \hat{b}x_i) = 0 \qquad (2)$$

Solving the first equation for a:

$$\Sigma\ -2\ (Y_i - \hat{a} - \hat{b}\ x_i) = 0$$

$$\Sigma\ (Y_i - \hat{a} - \hat{b}\ x_i) = 0$$

$$\Sigma Y_i - n\hat{a} - \hat{b}\Sigma x_i = 0$$

Recall that

$$\Sigma x_i = 0$$

so

$$\Sigma Y_i = n\,\hat{a}$$

or

$$\hat{a} = \frac{\Sigma Y_i}{n} = \overline{Y}$$

Solving equation 2 for b:

$$\Sigma(-2x_i)(Y_i - \hat{a} - \hat{b}x_i) = 0$$

$$\Sigma(x_i)(Y_i - \hat{a} - \hat{b}x_i) = 0$$

$$\Sigma x_i Y_i - a\Sigma x_i - \hat{b}\,\Sigma x_i^2 = 0$$

Recall once again that

$$\Sigma x_i = 0$$

So

$$\Sigma x_i Y_i = \hat{b}\,\Sigma x_i^2$$

Therefore

$$\hat{b} = \frac{\Sigma x_i Y_i}{\Sigma x_i^2}$$

These estimates are said to be unbiased because $E(\hat{a}) = a$ and $E(\hat{b}) = b$. The variance of $\hat{\alpha}=\sigma^2/n$ and the variance of $\hat{b} = \sigma^2/\Sigma x_i^2$. Furthermore, the Gauss-Markov theorem states that these least squares estimators of a and b have smaller variances than any other linear unbiased estimators.

(See Wonnacott and Wonnacott, page 21, below). This characteristic makes the OLS method the most popular technique when the assumptions which underlie it seem to be appropriate.

An example of the use of OLS in simple regression is presented below. The example is taken from Wonnacott and Wonnacott.

(1) X_i	(2) Y_i	(3) $x_i = X_i - \bar{X}$ $= X_i - 400$	(4) $Y_i x_i$	(5) x_i^2	(6) $\hat{Y}_i = a + bx_i$ $= 60 + .068x_i$	(7) $Y_i - \hat{Y}_i$	(8) $(Y_i - \hat{Y}_i)^2$
100	40	−300	−12,000	90,000	39.60	.40	.16
200	45	−200	−9,000	40,000	46.40	−1.40	1.96
300	50	−100	−5,000	10,000	53.20	−3.20	10.24
400	65	0	0	0	60.00	5.00	25.00
500	70	100	7,000	10,000	66.80	3.20	10.24
600	70	200	14,000	40,000	73.60	−3.60	12.96
700	80	300	24,000	90,000	80.40	−.40	.16
$\Sigma X_i = 2,800$	$\Sigma Y_i = 420$	$\Sigma x_i = 0$ ✓	$\Sigma Y_i x_i = 19,000$	$\Sigma x_i^2 = 280,000$			$\Sigma (Y_i - \hat{Y}_i)^2 = 60.72$
$\bar{X} = \frac{\Sigma X_i}{n}$	$\bar{Y} = \frac{\Sigma Y_i}{n}$			$b = \frac{\Sigma Y_i x_i}{\Sigma x_i^2}$			$s^2 = \frac{1}{n-2} \Sigma (Y_i - \hat{Y}_i)^2$
$= \frac{2,800}{7}$	$= \frac{420}{7}$			$= \frac{19,000}{280,000}$			$= 12.144$
$= 400$	$= 60$						and $s = 3.48$
	$a = 60$			$b = .068$			

<u>Simple Regression: Maximum Likelihood Estimators (MLE)</u>. Another approach to estimating the coefficients of our simple regression equation is to choose $\hat{a}$ and $\hat{b}$ so that they are the most probable values of the true parameters a and b, given the sample data. This idea is known as the maximum likelihood method. The same assumptions are made in this case as in the OLS method, but there is, in addition, the strong assumption that the error term is distributed normally, i.e.,

$$e_i \sim N(0, \sigma) \text{ for all } i.$$

The simple regression equation is, as before,

$$Y_i = a + bx_i + e_i \qquad i = 1, 2 \ldots n$$

so

$$e_i = Y_i - a - bx_i \qquad i = 1, 2 \ldots n$$

Each e_i, if it is distributed normally, is described by the density function

$$f(e_i) = \frac{1}{\sigma\sqrt{2\pi}} \quad \exp\left(\frac{-e_i^2}{2\sigma^2}\right)$$

or

$$f(e_i) = \frac{1}{\sigma\sqrt{2\pi}} \quad \exp\left(\frac{-(y_i - a - bx_i)^2}{2\sigma^2}\right)$$

Since the e_i are assumed to be independent, the joint probability density function is simply the product of each e_i's density function. This gives us the likelihood function, L:

$$L = \prod_{i=1}^{n} f(\hat{e}_i) = \prod_{i=1}^{n} \left[\frac{1}{\sigma\sqrt{2\Pi}} \quad \exp\left(\frac{-(Y_i - a - bx_i)^2}{2\sigma^2}\right)\right]$$

To obtain the maximum likelihood estimators, we must choose $\hat{a}$ and $\hat{b}$ so as to maximize L. Note that a and b only appear in the exponent, and that the exponent is negative. Hence, to maximize L we must minimize the exponent. In other words, minimize

$$\frac{(y_i - a - bx_i)^2}{2\sigma^2}$$

which is equivalent to minimizing

$$(Y_i - a - bx_i)^2$$

The reader should recognize this expression as the one that is minimized by OLS estimators of a and b. Thus, MLE of a and b are the same as OLS estimators. However, the maximum likelihood approach allows us to estimate σ^2 as well. Differentiating L with respect to σ and setting this equal to zero gives us

$$\hat{\sigma}^2 = \frac{1}{n} \Sigma(Y_i - \hat{a} - \hat{b}x_i)^2$$

However, this estimator of σ^2 is biased. This bias can be eliminated by a simple adjustment, and we are left with

$$\hat{\sigma}^2 = \frac{1}{n-2} \Sigma(Y_i - \hat{a} - \hat{b}x_i)^2$$

Multiple Regression: Ordinary Least Squares. While simple regression employs only one independent variable, multiple regression uses two or more independent variables. Algebraically, the multiple regression model is typically written as

$$Y_i = \beta_o + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots\ldots \beta_k x_{ik} + e_i \qquad i = 1,2,\ldots n$$

Using matrix notation, the model is written

$$Y = X\beta + e$$

Where

$$Y = \underset{n \times 1}{\begin{bmatrix} Y_1 \\ Y_2 \\ \cdot \\ \cdot \\ \cdot \\ Y_n \end{bmatrix}} \qquad X = \underset{n \times (k+1)}{\begin{bmatrix} 1 & X_{11} & X_{12} & \ldots & X_{1k} \\ 1 & X_{21} & X_{22} & \ldots & X_{2k} \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ 1 & X_{n1} & X_{n2} & \ldots & X_{nk} \end{bmatrix}}$$

$$\beta = \begin{bmatrix} \beta_o \\ \beta_1 \\ \beta_2 \\ \cdot \\ \cdot \\ \cdot \\ \beta_k \end{bmatrix} \qquad e = \begin{bmatrix} e_1 \\ e_2 \\ \cdot \\ \cdot \\ \cdot \\ e_n \end{bmatrix}$$

$(k + 1) \times 1$ $\qquad$ $n \times 1$

The assumptions of the model are as follows:

$E(e) = 0$

$Cov(e) = \sigma^2 I$

X is a fixed matrix, and $k < n$

The capital I in the expression $Cov(e) = \sigma^2 I$ refers to the identity matrix. Thus, the variance- covariance matrix is

$$\sigma^2 I = \begin{bmatrix} \sigma^2 & o & o & \cdot\cdot\cdot\cdot & o \\ o & \sigma^2 & \cdot & \cdot\cdot\cdot\cdot & o \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ o & o & o & \cdot\cdot\cdot\cdot & \sigma^2 \end{bmatrix}$$

This condition is analogous to the simple regression model in that all e_i have the same variance (σ^2), and all covariances are equal to zero.

As with the simple regression model, OLS estimators are found by choosing the regression coefficients (β) which minimize the squared difference between the actual and predicted Y_i. The procedure is as follows:

$$Y = X\hat{\beta} + \hat{e}$$
$$Y - X\hat{\beta} = \hat{e}$$
$$(Y - x\hat{\beta})' \ (Y - X\hat{\beta}) = \hat{e}'\hat{e} = S$$

Where S is the sum of squared residuals, thus,

$$S = Y'Y - 2\,\hat{\beta}'X'Y + \hat{\beta}'X'X\hat{\beta}$$

To minimize this expression we take the derivative of S with respect to $\hat{\beta}$, and set it equal to zero:

$$\frac{\partial S}{\partial \hat{\beta}'} = -2\,X'Y + 2X'X\hat{\beta} = 0$$

Solving for $\hat{\beta}$ gives us

$$\hat{\beta} = (X'X)^{-1}\,X'Y$$

Once again, the OLS estimators of the true regression parameters are said to be unbiased because $E(\hat{\beta}) = \beta$. The variance - covariance matrix of $\hat{\beta}$ is

$$Cov(\hat{\beta}) = \sigma^2\,(X'X)^{-1}$$

Like the simple regression estimators, the OLS estimators in the multiple regression model are the best linear unbiased estimators available.

To illustrate the method, consider the following set of data where

S = pounds of steam used monthly

A = pounds of acid in storage per month

D = operating days per month, and

T = average temperature (°F):

Month	S	A	D	T
1	10.98	5.20	20	35.3
2	11.13	5.12	20	29.7
3	12.51	6.19	23	30.8
4	8.40	3.89	20	58.8
5	9.27	6.28	21	61.4
6	8.73	5.76	22	71.3
7	6.36	3.45	11	74.4
8	8.50	6.57	23	76.7
9	7.82	5.69	21	70.7
10	9.14	6.14	20	57.5
11	8.24	4.84	20	46.4
12	12.19	4.88	21	28.9
13	11.88	6.03	21	28.1
14	9.57	4.55	19	39.1
15	10.94	5.71	23	46.8
16	9.58	5.67	20	48.5
17	10.09	6.72	22	59.3
18	8.11	4.95	22	70.0
19	6.83	4.62	11	70.0
20	8.88	6.60	23	74.5
21	7.68	5.01	20	72.1
22	8.47	5.68	21	58.1
23	8.86	5.28	20	44.6
24	10.36	5.36	20	33.4
25	11.08	5.87	22	28.6

Suppose that we want to fit the model

$$S_i = \beta_o + \beta_1 A_i + \beta_2 D_i + \beta_3 T_i + e_i$$

In matrix form, this model is

$$Y = X\beta + e$$

Where

$$Y = \begin{bmatrix} S_1 \\ S_2 \\ S_3 \\ \cdot \\ \cdot \\ \cdot \\ S_{25} \end{bmatrix} \qquad X = \begin{bmatrix} 1 & A_1 & D_1 & T_1 \\ 1 & A_2 & D_2 & T_2 \\ 1 & A_3 & D_3 & T_3 \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ 1 & A_{25} & D_{25} & T_{25} \end{bmatrix}$$

25 x 1   25 x 4

$$\beta = \begin{bmatrix} \beta_o \\ \beta_1 \\ \beta_3 \\ \beta_4 \end{bmatrix} \qquad e = \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ \cdot \\ \cdot \\ \cdot \\ e_{25} \end{bmatrix}$$

4 x 1   25 x 1

Recall that

$$\hat{\beta} = (X'X)^{-1} (X'Y)$$

In this case,

$$(X'X)^{-1} = \begin{bmatrix} 2.940 & -.140 & -.079 & -.010 \\ -.140 & .123 & -.024 & -.001 \\ -.079 & -.024 & .009 & .0003 \\ -.010 & -.001 & .0003 & .0002 \end{bmatrix}$$

$$X'Y = \begin{bmatrix} 235.6 \\ 1294.48 \\ 4831.86 \\ 11821.4 \end{bmatrix}$$

So

$$\hat{\beta} = \begin{bmatrix} 8.5664 \\ .487 \\ .1082 \\ -.0758 \end{bmatrix}$$

The estimated regression equation is therefore

$$\hat{S} = 8.5664 + .487\, A + .1082D - .0758T$$

We can also calculate "R^2" which is a measure of how well the regression equation explains the variation in S. An $R^2 = 1$ implies that the regression equation explains <u>all</u> of the variation in S, while $R^2 = 0$ means that none of the variation in S is explained. The formula for R^2 is

$$R^2 = \frac{\hat{\beta}'X'Y - n\overline{Y}_2}{Y'Y - n\overline{Y}_2}$$

Where n is equal to twenty five in this case. The calculated R^2 for this example is .8796, indicating that our regression equation explains most of the variation in S.

<u>Multiple Regression: Maximum Likelihood Estimators</u>. As in the simple regression case, the maximum likelihood approach has the same assumptions

as the OLS method, with the additional assumption that e is distributed multivariate normal.

As before, the MLE of β turns out to be the same as the OLS estimators. The maximum likelihood estimator of σ^2 is

$$\hat{\sigma}^2 = \frac{1}{n}(Y - \hat{Y})'(Y - \hat{Y})$$

Where

$$\hat{Y} = X\hat{\beta}$$

However, this estimator is biased. The unbiased estimator of σ^2 is

$$\hat{\sigma}^2 = \frac{1}{n-k}(Y - \hat{Y})'(Y - \hat{Y})$$

Generalized Least Squares (GLS)

The OLS model is based on the assumption that Cov(e) = $\sigma^2 I$. In other words, the error terms all have the same variance (i.e. they are homoskedastic), and they are not serially correlated. The general least squares model, on the other hand, does not place these restrictions on the error term (though the other assumptions of the OLS model are retained). The variance - covariance matrix (U) of the error terms in the GLS model is

$$U = \begin{bmatrix} \sigma_{11} & \sigma_{12} \cdots\cdots & \sigma_{1n} \\ \sigma_{21} & \sigma_{22} \cdots\cdots & \sigma_{2n} \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \sigma_{n1} & \sigma_{n2} \cdots\cdots & \sigma_{nn} \end{bmatrix}$$

Thus, the GLS model is called "generalized" because it can allow for a variety of assumptions about the error terms. The GLS model includes the OLS model as a special case when

$$\sigma_{11} = \sigma_{22} = . . . = \sigma_{nn}$$

and

$$\sigma_{ij} = o, i \neq j$$

Once again, the formal regression model is, in matrix notation,

$$Y = X\beta + e$$

where

$$Cov(e) = U$$

The vector of $\hat{\beta}$'s can be obtained through the maximum likelihood technique if we assume that the error terms are normally (but not necessarily identically) distributed. The loss function then becomes

$$L = \frac{1}{(2\pi)^{n/2} \; |U|^{1/2}} \; \exp \left[-1/2(Y - X\beta)' \; U^{-1} \; (Y - X\beta) \right]$$

This function is maximized when the exponent is minimized. (This is because the exponent is negative). Hence we must minimize

$$(Y - X\beta)' \; U^{-1} \; (Y-X\beta)$$

Taking the derivative of this expression with respect to β, setting it equal to zero and solving for $\hat{\beta}$ gives us

$$\hat{\beta} = (X' \; U^{-1} \; X)^{-1} \; X' \; U^{-1} \; Y$$

which is the GLS estimators of the regression coefficients. These estimators are unbiased because $E(\hat{\beta}) = \beta$, and $Cov(\hat{\beta}) = (X'U^{-1}X)^{-1}$. Furthermore, GLS estimators are the best linear unbiased estimators.

Note again that when the OLS assumptions are met,

$$U = \begin{bmatrix} \sigma^2 & o \; . \; . \; . \; . \; . & o \\ o & \sigma^2 . \; . \; . \; . \; . & o \\ . & . & . \\ . & . & . \\ . & . & . \\ o & o \; . \; . \; . \; . \; . & \sigma^2 \end{bmatrix}$$

and

$$\hat{\beta} = (X'X)^{-1} X'Y$$

Which is the same as the OLS estimators.

However, the GLS model allows to account for, among other things, <u>heteroskedasticity</u>. With heteroskedasticity, the variances of the error term differ, so

$$U = \begin{bmatrix} \sigma_1^2 & o \; . \; . \; . \; . \; . & o \\ o & \sigma_2^2 \; . \; . \; . \; . & o \\ . & . & . \\ . & . & . \\ . & . & . \\ o & o \; . \; . \; . \; . & \sigma_n^2 \end{bmatrix}$$

where

$$\sigma_1^2 \neq \sigma^2{}_2 \; . \; . \; . \neq \sigma^2{}_n$$

The GLS model also lets us account for <u>Serial Correlation</u>. This situation arises when the error term at any one point in time is correlated with one or more of its previous values. In this situation,

$$U = \sigma^2 \begin{bmatrix} 1 & \rho & \rho^2 \ldots & \rho^{n-1} \\ \rho & 1 & \rho \ldots & \rho^{n-2} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \rho^{n-1} & \rho^{n-2} & \rho^{n-3} & 1 \end{bmatrix}$$

Where ρ is the correlation coefficient.

The question arises as to the relative merits of GLS and OLS estimators. In all cases, both types of estimators will be unbiased, but GLS estimators will have smaller variances. When heteroskedasticity is present, the GLS estimators are far superior to OLS estimators, but with serial correlation the difference is not quite as great. Frequently, ρ itself is not known, and must be estimated. The difficulty of estimating ρ might justify the use of OLS, since the improvement in estimation might not be significant.

Two-Stage Least Squares (2LS)

A previous section of this paper discussed the identification problem and the use of simultaneous equations to solve it. An alternative way of solving the identification problem is to use two-stage least squares.

Consider, for example, the demand and supply model:

$$Q_d = a_o + a_1 P + a_2 Y + a_3 Z + u$$

$$Q_s = b_o + b_1 P + b_2 R + V$$

$$Q_d = Q_s$$

Where

Q = quantity

P = price

Y = income

Z = family size

R = rainfall, and

u and V are error terms.

If one tried to estimate the supply equation using OLS, one would get inconsistent estimates of b_o, b_1, and b_2. This is because P is endogenous to the system, and therefore correlated with V. However, we can still use OLS if we proceed in two stages as follows:

First, we must find a modified version of P (call it $\hat{P}$) that is independent of V. To find $\hat{P}$, we can regress P against all of the exogenous variables (Y, Z and R). i.e., use OLS to estimate

$$P = C_o + C_1 Y + C_2 Z + C_3 R + e$$

Where e is an error term. Coefficients estimated from this equation can then be multiplied times the exogenous variables to obtain $\hat{P}$ as follows:

$$\hat{P} = \hat{C}_o + \hat{C}_1 Y + \hat{C}_2 Z + \hat{C}_3 R$$

The second stage of the process is to estimate the supply equation using $\hat{P}$ instead of P. In other words, use OLS to estimate

$$Q_s = b_o + b_1 \hat{P} + b_2 R + V^*$$

Where V* is a new error term that is no longer correlated with $\hat{P}$. The estimates of the coefficients will now be valid.

By way of example, consider the following demand and supply model for beef:

Demand: $Q_b = a_o + a_1 P_b + a_2 P_p + a_3 P_c + a_4 R_c + a_y D_{rc} + U$

Supply: $Q_b = b_o + b_1 P_b + b_2 P_{sbm} + b_3 P_{corn} + b_y B_{cl_2} + b_5 D_{sbm} + V$

Where

Q_b = Quantity of beef

P_b = Price of beef

P_p = Price of pork

P_c = Price of chicken

R_c = Real consumption expenditures

D_{rc} = A dummy variable for consumption expenditure

P_{sbm} = Price of soybean meal

P_{corn} = Price of corn

B_{cl_2} = Per capita stock of beef cows, lagged two years, and

D_{sbm} = a dummy variable for the protein in the soybean meal

The data to be used are listed in the table on the following page:

QBS	YEAR	QB	PB	PC	RC	PP	DRC	PCORN	PSBM	BCL2	DSAM
1	1948	63.1	82.9	75.4	1438	67.6	0	1.64678	91.169	112.004	1
2	1949	63.9	76.3	71.8	1451	61.5	0	1.55422	89.880	111.127	1
3	1950	63.4	88.3	68.0	1520	60.4	0	2.06444	91.766	106.167	1
4	1951	56.1	90.0	66.0	1509	60.6	0	2.02434	106.471	105.007	1
5	1952	62.2	85.4	65.0	1525	57.3	0	1.72078	86.580	108.791	1
6	1953	77.6	66.2	62.8	1572	62.9	0	1.64339	84.479	118.301	0
7	1954	80.1	64.1	56.4	1575	63.7	0	1.58120	64.850	130.639	0
8	1955	82.0	63.2	58.7	1659	54.6	0	1.33047	56.384	142.890	0
9	1956	85.4	60.9	50.4	1673	51.4	0	1.38478	50.159	150.813	0
10	1957	84.6	63.1	47.6	1683	57.6	0	1.23469	54.490	151.739	0
11	1958	80.5	72.0	45.8	1666	60.5	0	1.20159	55.412	147.334	0
12	1959	81.4	73.3	41.4	1735	52.8	0	1.15271	54.729	139.954	0
13	1960	85.2	70.4	41.4	1749	51.6	0	1.06693	58.778	135.682	0
14	1961	88.0	68.3	37.0	1755	53.3	0	1.06628	61.095	138.664	0
15	1962	89.1	69.8	38.6	1813	52.9	0	1.13010	67.664	143.408	0
16	1963	94.5	76.0	37.6	1865	53.8	0	2.00750	66.604	145.319	0
17	1964	99.9	72.0	35.0	1945	52.2	0	1.16667	66.852	149.683	0
18	1965	99.5	74.1	35.5	2044	58.4	0	1.15665	74.226	156.420	0
19	1966	104.2	74.6	36.6	2123	65.0	0	1.20354	69.735	164.483	0
20	1967	106.5	72.4	32.8	2160	57.8	0	0.96386	66.179	171.019	0
21	1968	109.7	71.5	32.9	2248	55.7	0	0.96614	61.189	169.964	0
22	1969	110.8	75.4	33.1	2301	58.2	0	0.97962	61.442	169.613	0
23	1970	113.7	72.9	30.2	3265	57.7	1	1.06509	58.062	171.393	0
24	1971	113.0	74.5	29.3	3342	50.2	1	0.84226	64.383	173.715	0
25	1972	116.1	78.2	28.4	3510	57.1	1	1.25000	157.280	177.671	0
26	1973	109.6	87.6	38.5	3648	71.0	1	1.84874	94.570	182.018	0
27	1974	116.8	80.8	32.6	3589	63.0	1	1.88119	76.704	185.074	0
28	1975	120.1	77.9	33.8	3629	72.0	1	1.43543	78.869	193.623	0
29	1976	129.3	67.8	30.1	3817	70.1	1	1.23613	100.807	202.732	0

If one were to use OLS, the estimates of the demand and supply equations would be as follows (t statistics are in parentheses):

Demand: $(R^2 = .983)$

$$Q_b = \underset{(6.95)}{68.58} - \underset{(-5.95)}{.49P_b} + \underset{(.11)}{.17P_p} - \underset{(-2.9)}{.34P_c} + \underset{(7.35)}{.038R_c} - \underset{(-5.58)}{39.34\ D_{rc}}$$

Supply: $(R^2 = .954)$

$$Q_b = \underset{(-1.22)}{-14.187} + \underset{(1.17)}{.23P_b} + \underset{(1.35)}{.0698\ P_{sbm}} - \underset{(-1.35)}{4.62\ P_{corn}} + \underset{(10.4)}{.615\ B_{cl_2}} - \underset{(-1.69)}{8.527\ D_{sbm}}$$

The two-stage least squares equations, however, are:

Demand:

$$Q_b = \underset{(6.83)}{68.07} - \underset{(-5.07)}{.48P_b} + \underset{(.12)}{.18P_p} - \underset{(-2.9)}{.35\ P_c} + \underset{(7.24)}{.0347\ R_c} - \underset{(-5.52)}{39.11\ D_{rc}}$$

Supply:

$$Q_b = \underset{(-2.38)}{-38.66} + \underset{(2.71)}{.86P_b} + \underset{(.63)}{.039\ P_{sbm}} - \underset{(-1.96)}{8.54\ P_{corn}} + \underset{(6.84)}{.52\ B_{cl_2}} - \underset{(-2.64)}{18.23\ D_{sbm}}$$

The reader should note that the demand equations are very similar, but that the supply equations are not.

For further discussion, the reader should use a good econometrics book. A partial list of such books is presented below.

Beals, R. (1972), Statistics for Economists, Rand McNally & Co., Chicago.

Intriligator, M. (1978), Econometric Models, Techniques, and Applications, Prentic-Hall, Inc., Englewood Cliffs, New Jersey.

Kmenta, Jan (1971), Elements of Econometrics, Macmillan Publishing Co., Inc., New York.

Leser, C.E.V. (1974), Econometric Techniques and Problems, Charles Griffin & Co., Ltd., London.

Maddala, G.S. (1977), Econometrics, McGraw-Hill, Inc., New York.

Walters, A.A. (1970), An Introduction to Econometrics, W.W. Norton & & Co., Inc., New York.

Wonnacott, R.J. and T.H. Wonnacott (1970), Econometrics, John Wiley & Sons, Inc., New York.

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