Volume Title: Commodity Markets and Latin American Development: A Modeling Approach

Volume Author/Editor: Walter C. Labys, M. Ishaq Nadiri, and Jose Nunez Del Arco, eds.

Volume Publisher: Ballinger

Volume ISBN: 0-88410-481-0

Volume URL: http://www.nber.org/books/laby80-1

Publication Date: 1980

Chapter Title: Commodity Models and Their Potential for Latin American Planning

Chapter Author: Walter C. Labys

Chapter URL: http://www.nber.org/chapters/c1746

Chapter pages in book: (p. 9 - 40)

2

WALTER C. LABYS

Commodity Models and Their Potential for Latin American Planning

This chapter examines the role commodity models can play in analyzing commodity markets and policies in Latin America. To show the importance of such models for planning, the strategic nature of primary commodities in Latin American development is first discussed. A perspective for planning featuring commodity models is presented next. The modeling methodologies employed in this context are discussed according to: (1) models of commodity markets, (2) models linking commodity markets and the dependent national economies, and (3) models designed specifically to analyze commodity stabilization. So that this chapter will help introduce the modeling methodologies of the other chapters, examples of commodity modeling studies related directly to Latin America's planning needs and policies are also presented. A full model's list appears in the bibliography.

IMPORTANCE OF PRIMARY COMMODITIES

Recent fluctuations in international commodity markets and their impacts on dependent national economies have been dramatic. From the fourth quarter of 1972 to the end of 1974, the prices of commodities important to Latin America such as maize, sugar, and copper doubled and quadrupled before they reached their peak as shown below.

	Price Increases	*Price Decreases*
Maize	1972–IV to 74–IV = 111%	74–IV to 76–II = 20%
Sugar	1972–IV to 74–IV = 490%	74–IV to 76–II = 71%
Copper	1972–IV to 74–II = 175%	74–II to 76–II = 45%

From 1974 through 1976 they have tumbled almost as sharply. The price swings were also reflected in foreign exchange earnings. From a prospect for debt repayment capability in 1974, Latin American countries now find themselves again with balance of payments problems.

Among causes of price fluctuations during this period, Labys and Thomas (1975) cite real and anticipated scarcities of food, fuel, and other strategic commodities; responses of producers to years of declining income and prices; a shift in the technological-ecological availability of commodities; deviations in world weather patterns; shifts in speculative activity toward and away from commodity futures markets; use of the latter to hedge against exchange rate instability, rising inflation, and general monetary instability; and closer cooperation among nations leading to the formation of producers' cartels.

In addition, there are causes related to basic market forces. To begin with, the price adjustments needed to equate supply and demand in commodity markets are normally large. World supply of these commodities is limited by production conditions in exporting countries such as capacity or credit constraints, while many commodities are harvested only annually. World demand can also be relatively constant, because commodities normally represent only a small proportion of the value of the products for which they serve as inputs. Taken together, one finds that both supply and demand are relatively price inelastic, and, therefore, a given change in available or desired supplies causes a substantial price movement. In addition, a large share of this output derives from relatively few countries; excess supplies in only one of these countries can thus affect the market substantially.

Latin America suffers appreciably from fluctuations in commodity prices and earnings because of its position as a major commodity exporter.[1] Selecting a few examples from Table 2–1, Argentina provides 13.8 percent of the world's beef and 10.6 percent of the hides and skins; Brazil exports 30.1 percent of the coffee, 24.9 percent of the sisal, and 8.0 percent of the sugar; Ecuador supplies 18.0 percent of the bananas; and Peru 54.2 percent of the fish meal. These various commodities are also shown to exhibit substantial price instability. Of the eighteen commodities listed in Table 2–1, the ratio of the price variation to mean is above 40 percent for twelve of them. While the above commodity shares are substantial, their national impact is even greater, given the fact that these exports represent such a large proportion of each country's total earnings. Table 2-1 also indicates that copper accounts for 71.6 percent of Chile's total exports, coffee 59.5 percent of Colombia's exports, bananas 53.9 percent of Panama's exports, and tin 50.1 percent of Bolivia's exports.

With such a high degree of primary commodity dependence, we are justified in seeking planning approaches that invoke the latest advances in commodity modeling methodologies.

THE PLANNING PERSPECTIVE

The planning perspective developed concentrates initially on the role of economic analysis in the planning procedure and secondly on the contribution made by modeling to that analysis. Planning is widespread in both developed and developing countries. Not only are there ministries of planning and central planning boards, but there also are economic forecasting units and planning research departments. At one extreme, planning may consist of the normal tasks of government budgeting, the management of public enterprises, and the national time-phasing of certain public services.[2] At the other extreme, planning consists of preparing a detailed framework for the future economic structure and of implementing it through direct or indirect manipulation of government instruments. While in the former case market prices play a large role, in the latter case they are subordinate to overall plan goals.

The types of planning associated with commodity markets lie in between these extremes. Most typically they consist of forecasts of the prices, production, or exports of commodities; alternatively, they focus on the importance of nonprice factors in allocating scarce resources among competing commodities. Although planning varies considerably among countries, its character depends on considerations such as the degree to which the market mechanism pervades economic decisions or the extent of market imperfections and price distortions and their causes. Another complicating factor is the disequilibrium nature of commodity markets. Related market fluctuations cause development to slow down between periods of export revenue declines. Such "stop and go" phenomena require that commodity planning be pursued as intensely as planning in other sectors.

Although it is difficult to generalize about the nature of national, institutional, or even corporate planning processes, the example given in Figure 2-1 provides a starting point. Beginning at the top of the figure and following downward, the recognition stage views the planner as being confronted with certain policy problems. These problems

Table 2–1. Latin America: Characteristics of Primary Commodity Exports

Commodity	*Average Export Value, 1970–1972*	*Major Exporting Countries*	*Country Share of World Exports 1970–1972*	*Commodity Share of Country Exports 1970–1972*	*Ratio of Price Variation to Mean 1960–1973*
Beef	668.1	Argentina	13.8%	17.4%	43%
		Brazil	4.9%	3.5%	
Maize	335.2	Argentina	13.0%	14.5%	46%
Bananas	425.1	Costa Rica	13.0%	29.3%	26%
		Ecuador	18.0%	0.3%	
		Panama	11.3%	53.9%	
Sugar	1452.5	Brazil	8.0%	71.0%	129%
Coffee	1912.7	Brazil	30.1%	28.0%	31%
		Colombia	14.4%	59.5%	
Cocoa	126.6	Brazil	8.5%	2.1%	47%
Fishmeal	295.5	Peru	54.2%	28.0%	38%

Groundnuts	46.0	Brazil	5.3%	0.4%	54%
Cotton	488.1	Brazil Mexico	5.7% 4.6%	5.0% 8.3%	36%
Sisal	29.2	Brazil Mexico	24.9% 13.7%	0.6% 0.6%	76%
Hides	145.9	Argentina	10.6%	5.1%	29%
Copper	963.3	Chile	16.1%	71.6%	40%
Iron Ore	498.0	Brazil	8.5%	7.0%	22%
Lead	64.6	Peru	6.5%	3.3%	41%
Manganese Ore	35.8	Brazil	16.4%	1.0%	23%
Silver	109.8	Peru	10.0%	6.0%	42%
Tin	122.2	Bolivia	14.4%	50.1%	41%
Zinc	120.7	Peru Mexico	7.1% 6.4%	5.7% 3.2%	81%
Petroleum	4245	Venezuela	9.9%	86.8%	—

Source: World Bank (1975).

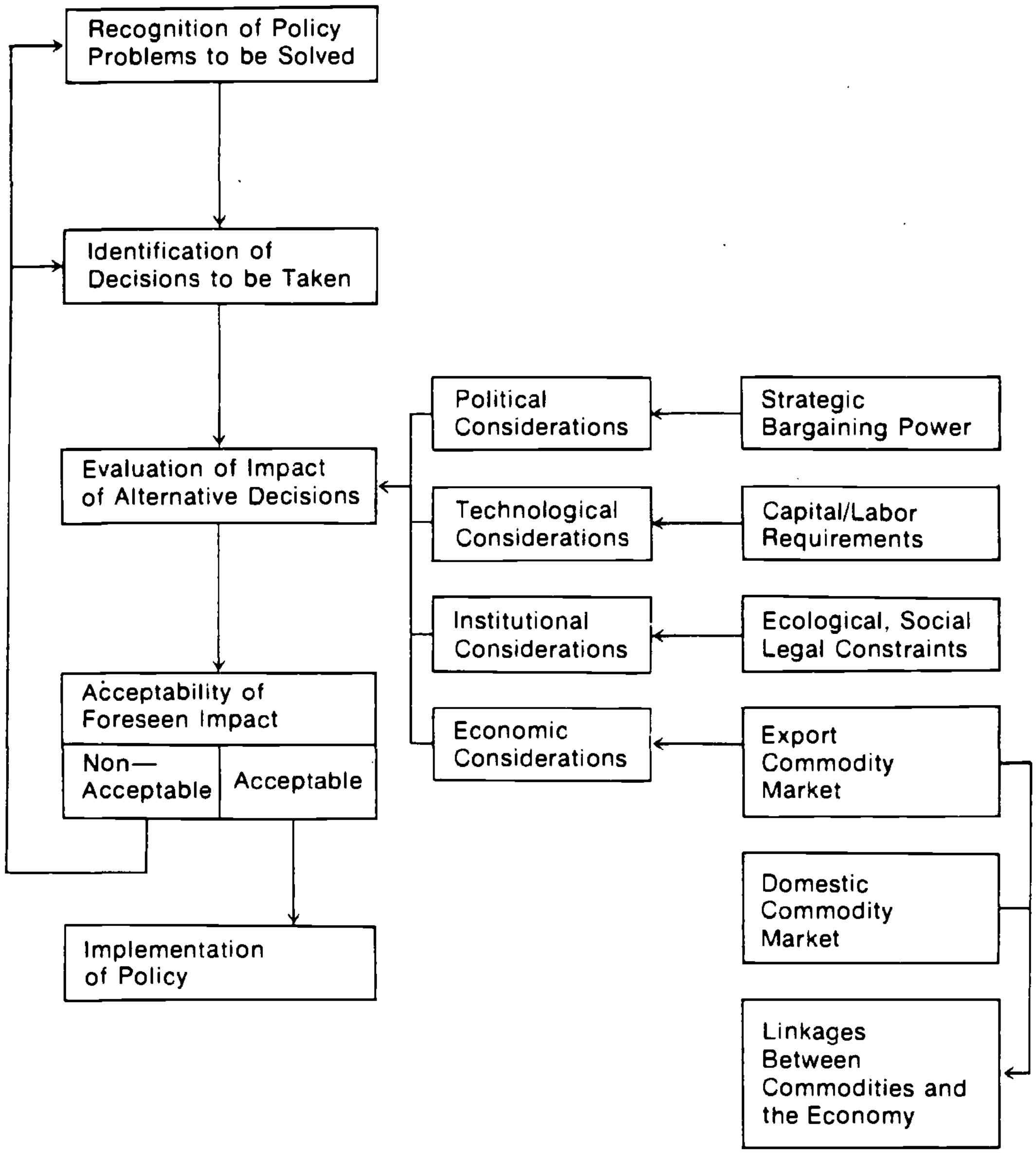

FIGURE 2-1. Commodity Policy Analysts and Planning

normally are concerned with relating commodity activity to specific planning targets or national objectives. At the identification stage, a number of alternative decisions or policies are proposed that could help solve the problems.

The most complex stage is the next one, that of evaluating the alternatives. Although most planners have a verbal or mental model of their evaluation process, they seldom are able to quantify it. We do know that it consists of assessing the relative welfare outcomes of alternative policies, each of which is influenced by economic, political, technological, and institutional considerations. Economic considerations, for example, might pertain to economic gains resulting from investment in the domestic or export commodity sector. Political considerations might refer to a commodity's importance in terms of bargaining strategies in contracting or trading. Technological considerations might relate to the level of capital intensiveness to be adopted in the production or extraction of the commodity. And institutional considerations might reflect ecological, sociological, or legal factors such as land distribution schemes.

Once the alternatives are examined, planners make decisions hoping the outcome will be politically acceptable. In some cases as shown, the decision may not be acceptable, and previously stated problems and alternatives will have to be reconsidered. The entire planning process can thus be described as requiring feedback to previous stages until an acceptable decision is reached. Once a decision or policy is deemed acceptable, it moves to the implementation stage.

A major concern in this book is the appropriate quantitative framework that will help planners analyze economic considerations in their evaluation of the impact of alternative commodity policies. The framework proposed is a modeling one.[3] Strictly speaking, a model embodies a hypothesis that involves a relationship between variables and that intends to explain and predict past, present, and future events or to describe policies and predict their outcome. For policy purposes, a model distinguishes between target variables that constitute the objectives of economic policy and controlled variables that are instruments affected by policies. Variations occurring in the levels of the controlled variables affect the levels of the target variables. In addition to specifying the economic relationship between variables, a model also attempts to incorporate technological, institutional and political relationships.

Figure 2–1 also shows commodity policies to be directed to either domestic markets or export markets. Domestic commodity policies normally are analyzed using a commodity model that interrelates factors inherent to domestic supply, demand, inventories, and prices. One can then demonstrate through simulations of the model how changing policies, for example, regarding employment or capacity adjustment, can influence quantities and prices. This dependence can be described according to how the market might have reacted historically or how it might react in the future. Essential to employing the model is that it be properly validated so that planners will have confidence in its explanation of market behavior or in its predictions.

Export commodity policies are analyzed with a similar modeling approach; only now the variables included relate to world commodity markets. As we shall see later, such models have been used to determine the impact of commodity stabilization schemes such as those proposed within the UNCTAD Integrated Program. One weakness of this approach is its limitations for explaining the impact of commodity exports on various sectors of the dependent national economy. Instead, the type of modeling exercise required involves linking one or more commodity models with a macroeconometric model or an equivalent computational model of the national economy. Let us now examine each of these modeling approaches more closely.

COMMODITY MODELS

Generally speaking, a commodity model is a quantitative representation of a commodity market or industry; the behavioral relationships included reflect demand and supply aspects of price determination as well as other related phenomena. Commodity models deal with foods and raw materials in an unprocessed and partially processed state. These commodities can be extracted from the land (fuel and nonfuel minerals), grown on the land (annual and perennial crops, including timber), raised on the land (cattle and poultry), or harvested from the water (fish, plants, and water itself). Recyclable and scrap materials are also included.

The most basic type of model from which other commodity methodologies have developed is the *market* model.[4] Focusing on the price mechanism that serves to clear the market, the rudiments of a market model can be summarized in four equations, although much more complex structures are used in practice.

$$
\begin{aligned}
D &= d(D_{-1}, P, P^c, A, T) \\
Q &= q(Q_{-1}, P_{-\theta}, N, Z) \\
P &= p(P_{-1}, D, \Delta I) \\
I &= I_{-1} + Q - D
\end{aligned}
$$

Demand (D) is explained as being dependent on prices (P), economic activity (A), prices of one or more substitute commodities (P^c), and possible technical influences (T) such as the growth of synthetic substitutes. Other possible influencing factors and the customary stochastic disturbance term are omitted here and elsewhere to simplify presentation. Accordingly supply (Q) would depend on prices ($P_{-\theta}$) as well as natural factors (N) such as weather, yields, and a possible policy variable (Z). A lagged price variable ($P_{-\theta}$) is included since the supply process is normally described using some form of the general class of distributed lag functions.

Prices (P) are explained by demand (D) and inventories (I), although this equation is sometimes inverted to explain inventory demand. The model is closed using an identity that equates inventories (I) with lagged inventories (I_{-1}) plus supply (Q) minus demand (D). Where the price equation is inverted to represent inventory demand, the identity can be recognized as the equivalent supply of inventories equation.

Market models have received considerable development in analyzing commodity policies in Latin America. Cocoa, coffee, cotton, rice, and wheat models have been constructed by Adams and Behrman (1976). Segura (1973) has studied the economics of anchovy exploitation and its relation to fish meal consumption patterns, including implications for Peru. Epps (1970) has evaluated the impact of alternative Brazilian coffee export policies on the world coffee market. And Fisher, Cootner, and Bailey (1972) have studied fluctuations in the world copper market in relation to Chilean export income.

In addition to the market model, there are a number of different modeling methodologies. Table 2–2 provides a summary of their basic characteristics: purpose of the methodology, quantitative method used, economic behavior specified, and examples of applications. Reviewing each of these briefly, models of the *process* type are also econometric in nature, but they deal with supply and demand within an industry rather than across a market. They thus focus on the transformation of commodity inputs into finished products. Whereas market models balance supply and demand to explain commodity prices, prices in a process model are normally a function of production and material costs, that is, markup. They are well suited for describing process industries dealing with petroleum, steel, or chemicals because they concentrate on the industrial production process, requirements for raw materials and labor, and plant capacity.

A recent extension of this approach has been to expand the description of the production process to include *linear programming* or *input-output* models that transform the raw materials inputs into intermediate and final products. Input-output models of commodity processes have also been developed independently of process models. Kruegar (1976) has shown how they can be used to explain intermediate and final demands for mineral commodities. Another use has been the disaggregation of the tables to analyze individual agricultural products. In relation to Latin America, Simpson in Chapter 7 employs disaggregated input-output models to determine output and income multipliers for agricultural product lines. The commodity principally studied is beef with implications for Argentina, Brazil, Paraguay, and Uruguay.

Optimization and programming methodologies have also proven

Table 2–2. Commodity Modeling Methodologies and the Modeling Process

Modeling Process / *Methodologies*	*What is the purpose of the methodology?*	*What quantitative method is used?*	*What economic behavior is specified?*	*Examples of Commodity applications*
Market Model	Demand, supply, inventories interact to produce an equilibrium price in competitive or noncompetitive markets	Dynamic microeconometric system composed of difference or differential equations	Interaction between decision-makers in reaching market equilibrium based on demand, supply inventories, prices, trade, etc.	Beef Wheat Cocoa Coffee Sugar Copper Tin
Process Model	Demand and production determined within an industry, focusing on transformation from product demand to input requirements	Dynamic microeconomic difference equation system suitable for integrating linear programming on production side	Interaction between decisionmakers in industries, markets, national economies based on demand, production, investment, capacity, commodity inputs, etc.	Petroleum Steel
Input-Output Model	System regarded as process that converts raw materials into intermediate and final products via intermediate processes	Input-output model operated separately or combined with macroeconomic framework or disaggregated raw materials balance framework	Interactions between inputs and outputs based on technical coefficients and demand permit computation of output and income multipliers for commodity sectors.	Energy Minerals Beef
Optimization and Programming Models: 1. Linear and Quadratic Programming Spatial Equilibrium	Spatial flows of demand and supply and equilibrium conditions assigned optimally in equilibrium depending on configuration of transportation network	Activity analysis of a spatial and/or temporal form. Degree of complexity depends on endogeneity and method of incorporation of demand and supply functions	Interaction between decision makers in allocating shipments (exports) and consumption (imports) optimized through maximizing sectoral revenues or minimizing sectoral costs	Wheat Sugar Livestock Petroleum Beef Cocoa

2. Recursive Programming	Production conditions and input revenue determined through primal/dual of linear program. Recursivity introduced through feedback component which includes profit, capital and demand	Activity analysis involving a sequence of constrained maximization problems in which objective function, limitation coefficients depend on optimal primal/dual solutions attained earlier in the sequence	Interaction between decision makers in reaching market equilibrium involves adaptive intertemporal processes related to production, investment and technological change	Coal Iron and Steel Wheat Corn and Soybeans
3. Mixed Integer Programming	Size of firm, location, time phasing, technology and product-mix determined optimally	Activity analysis involving a maximization problem that combines a process component with a spatial or transportation component	Capital costs and transport costs minimized with respect to material balance in final products, intermediate products, capacity, investment and market requirements.	Fertilizers Copper Steel
Trade Flow Model	Trade flows reflect not only resistance and potential but also policies relating to geography, contract arrangements and trade blocs	Structure of trade model which estimates trade flow matrix directly. Imports and exports follow from summation of trade flows.	Interaction between potential to import and to export limited by resistance to trade between countries.	Copper Iron Ore Tin Bauxite Lead Zinc
Industrial Dynamics: Dynamic Commodity Cycle Model	Demand, supply, Inventories interact to produce an equilibrium price, emphasizing role of amplifications and feedback delays	Dynamic microeconometric differential equation system that features lagged feedback relations and variables in rates of change	Interaction between decision makers in adjusting rate of production to maintain a desired level of inventory in relationship to rate of consumption	Aluminum Broilers Cattle Copper Hogs Oranges
Systems Model	Demand, supply and other major variables and objectives considered as a complete system rather than a single market	Dynamic microeconometric equation system which when formed into a simulation framework is coupled with activity analysis and/or decision rules	Interaction between decision makers belonging to the system environment based on performance variables such as revenues and costs as well as market variables such as demand, supply, prices, etc.	Beef Energy Fish Livestock Multicommodity Rice

Source: Labys (1975a).

useful. The linear and quadratic forms of *spatial equilibrium* models are popular in modeling international commodity markets. In particular, they can analyze spatial or interregional efficiency in the production, distribution, and utilization of commodities. Optimal patterns of commodity supply and demand can be determined subject to changes in trade policies such as tariffs and quotas as well as in domestic price support and acreage allotments. A recent application of spatial equilibrium with implications for Latin America given in Chapter 6 is Gemmill's model of the world sugar market. Among other studies are Brandt's (1967) analysis of Brazilian coffee policies, Kennedy's (1974) analysis of the world petroleum market with implications for Venezuela, and the Schmitz and Bawden (1976) analysis of the world wheat economy including Argentina.

The *recursive programming* variant of these models concentrates on the production side of the market, emphasizing the role of investment and technological change in allocating commodity production and omitting spatial allocation. These models relate more to investment behavior in a single nation because they are disaggregated below the market level, reflecting the behavior of individual decision makers. Within this context, they have been useful in analyzing diversification among agricultural crops as well as the impact of changing technologies on production in the steel and coal industries. The most noted application in Latin America has been that of Singh and Ahn (1973) analyzing agricultural development and crop investment patterns in the Rio Grande do Sol, Brazil.

A more recent development among optimization models is that of multiperiod *mixed integer programming*. Like recursive programming, which achieves optimization over time, this form of model emphasizes the impact of technological change on production processes. But it also combines a process component with a spatial or transportation component. Using an objective function that minimizes the total of capital costs, recurrent costs, and transport costs, the constraints reflect material balance for final products, intermediate products, capacity, investment, and market requirements. The resulting model permits size, location, time-phasing, technology, and product mix decisions to be made within its framework. An application of this type of model is described in Chapter 4 where Dammert analyzes investment planning in the Latin American copper industry.

Models of any methodology considered thus far can analyze trade patterns and trade policies for the commodity exporting and importing countries involved. However, trade patterns can also be considered in the context of traditional *trade* models such as that of Linneman (1966) and Taplin (1973). The actual tailoring of this approach to commodity markets has been performed by Tilton (1966). He explains variations in the trade flow matrix for a mineral commodity based on three factors: (1) the potential of country *i* to export a commodity; (2) the potential of country *j* to import the commodity; and (3) the resistance to trade between country *i* and country *j*. Policy applications of this approach relate to potential access to the mineral or potential access to foreign markets, as affected by geographic location, ownership ties, contracts, and preferential trade blocs. Examples of econometric studies related to Latin America include that of Whitney (1976) on copper, Dorr (1975) on aluminum, and Santos (1976) on iron ore. Chapter 5 by Demler and Tilton concentrates on a policy application to tin and zinc.

Both the *industrial dynamics* and *systems forms* of models deviate somewhat from the traditional market approaches; they describe commodity markets and industries as a complete system in which the impacts of objectives and decisions are viewed through adaptive and feedback processes. While the industrial dynamics model is preferable for dynamic analysis emphasizing feedback delays and cyclical processes, systems models typically incorporate biological or agronomic models with market models to emphasize the technical character of commodity production. Among commodities to which systems models have been applied in Latin America, the cattle industry in Argentina has received most attention. In particular Jarvis (1969), Yver (1971), and Nores (1972) have studied the cattle industry from the point of view of the optimal inventory of beef cattle.

MODELS LINKING COMMODITIES AND THE ECONOMY

The role of primary commodities in economic development has been emphasized mainly through linkages between the commodity export sector and the dependent economy.[5] Among the more important works in which this relationship has been studied are those of Singer (1950), Baldwin (1963), Reynolds (1965), and Maizels (1968). Statistical confirmation can be found in Baldwin (1966), Emery (1967), and Thoburn (1977). More recent investigations have centered upon the concept of domestic resource costs. Primary commodity studies of this nature include those of Pearson (1970) and Pearson and Cownie (1975).

Among reasons normally offered to support the argument of a linkage between exports and economic growth, Emery (1967;471) suggests the following: (1) an increasing level of exports generally implies that the country has the capabilities to step up its level of imports; (2) export development tends to concentrate investment in the most efficient sectors of the economy, those in which the country enjoys a comparative advantage; (3) the country also gains from economies of scale because the international market added to the domestic market increases the scale of operation possible; (4) the necessity of remaining competitive in international markets tends to maintain pressure on the export industries to improve efficiency; (5) for primary commodities, the country exports those goods most suitable to its natural resource, agricultural, and cultural base; and (6) secondary benefits are generated that result in increased investment, consumption, and flow of technology.

Underlying these reasons are several theories of trade and growth as recently summarized by Thoburn (1977). Export sector effects, particularly of primary commodities, are viewed as working through the impacts of export income flows and through externalities. This process has been viewed as following the theory of capital formation, based on a disaggregated multiplier-accelerator mechanism. Commodity export growth thus impinges on the economy through investment opportunities: (1) in the industry itself; (2) in industries supplying inputs to the export sector; (3) in industries employing the export as an input; (4) and in industries producing consumer goods for factors of production employed in the export sector. Hirschman (1958) has termed these additional investment opportunities as *linkages*. Where they are reasonably continuous and of sufficient duration, we should be able to detect and to study them.

The present relevance of the linkage concept depends on the particular growth of investment in the primary commodity subsector. Where foreign investment has been important in the launching of an industry, the focus on linkages is highly appropriate. The greater the proportion of intermediate to final purchases and of intermediate to final sales, the more can the local population participate as investors. Such opportunities would be over and above those resulting from direct participation in the industry. Where an investment in a commodity industry has been primarily domestic, linkage effects are not as notable, but linkage analysis still provides insight into the impact of the investment on the economy.

Linkage effects considered can generally be allocated into two groups. The first group relates principally to industry operations within the commodity subsector: *backward* linkages, *forward* linkages, and *technological* linkages. Backward linkages can be viewed to the extent that locally produced intermediate inputs and capital goods are used by the commodity industry. Forward linkages are found when the outputs of the export industry are used as inputs by other local industries. To these can be added technological linkages, which relate to different external effects imparted by the commodity industry on other industries in the economy, including the diffusion of new technologies, methods of organization, and so on. Depending on the magnitude of these linkages, the commodity subsector contributes to economic development by providing additional income and employment possibilities in the linked industries.

The second group of linkages results from expenditures of factor incomes and taxes paid by the commodity industry. The multiplier effects normally associated with macromodels embodying the accelerator operate through final demand payments by factors of production employed and by government expenditure of taxes gained from the industry. Such multipliers reflect the impact of a change in export income or commodity investment on domestic factor income. Of principal interest are the *final demand* linkages, in which purchases are made with incomes obtained from the employment opportunities. The proportion of such incomes spent on local products represents a second round of multiplier effects; investment in these products can thus be generated through the accelerator. Depending on the extent to which these incomes are saved, spent locally, or spent on imports, different income generation effects will result.

The tax expenditure component has been termed *fiscal* linkage, and these effects reflect the extent to which the government spends domestically the payments it receives from the commodity industry. In certain cases, these tax payments are substantial and thus highly important. Finally, the *external effects* or unpriced externalities are important. They can consist of social effects such as increased domestic savings and improved labor skills or environmental effects such as degradation of the land surface and water pollution.

Among analytical methods used to evaluate the impact of commodity linkages on the economy, one can cite works on returned value by Reynolds (1965), Mamalakis (1971), and Pearson and Cownie (1975) as well as studies on input-output linkages by Lydell (1975) and Panchamukhi (1975). Formal modeling systems derive from the early work on the use of macroeconomic models of trade and development.[6] In its simplest form, such a model system normally entails an elaboration of investment, effective demand, and income determination. This permits the tracing of the impact of policies on attaining full employment and can be implemented with existing forms of social accounting systems. The structure of such a system can be represented as follows:

$$
\begin{aligned}
C &= F(Y) \\
V &= f(Y, R) \\
Y &= C + V + E - M \\
F &= M - E \\
S &= Y - C
\end{aligned}
$$

Consumption expenditure (C) depends on the level of national income (Y). The investment (V) that would stimulate the correct level of income is influenced by the income level itself as well as the rate of interest (R). Where savings equals investment, national income is identical to consumption plus investment. However, such an identity fails to reflect the dependence of the economy on the rest of the world, particularly on the industrialized economies. Similar to the two-gap models suggested by Chenery and Strout (1966), the income identity contains in addition the balance of payments, exports (E) minus imports (M). This can also be interpreted as the net inflow of foreign capital (F), where E and M involve invisible payments and receipts including those on transportation, travel, banking, insurance, factor income payments and receipts, and other miscellaneous transactions. To insure that the savings and investment gap is identical with the foreign inflows gap, the savings identity (S) is included.

The impact of commodity exports on the macroeconomy is seen principally through E, which can be disaggregated into noncommodity E_{nc} and commodity E_c components:

$$E = E_{nc} + E_c$$

The value of commodity exports is determined from the previous commodity model considered at the county level:

$$E_c = PX \text{ where } X = Q - D \pm \Delta I$$

Exports are determined as a residual from the market equilibrium identity in the commodity model, although they also can be estimated from a behavioral relationship.

Of course such a model is weak in its inclusion of the various linkage effects mentioned. More complex models are used in practice that concentrate on the demand, investment, employment, wage and price, and fiscal and monetary aspects of the macroeconomy rather than on its two-gap character. *Econometric linkage* models of this type are just beginning to be developed. As explained by Adams and Roldan in Chapter 7, linkage models can assume either that the world commodity market impacts on the dependent economy without intervention or that domestic policy can be used to offset fluctuations on the world commodity markets. An important aspect of the Adams and Roldan model is that it contains both a coffee model and a model of the Brazilian economy. Thus, the possibility exists of analyzing feedback effects from country commodity policy to the world commodity market. A linkage analysis of a less elaborate nature appears in Chapter 8, where Lira measures impacts of fluctuations in the copper market on the Chilean economy.

One inadequacy of the above models is that they deal largely with final demand. To learn more about linkages between the export sector and the economy, one must also be concerned with intermediate demand. This can be analyzed by formulating a more general system encompassing a macrostructure plus an *input-output* structure. The latter is normally defined by

$$(I - A)\, Q' = D$$

Gross output of a sector (Q') when multiplied by the adjusted matrix of technical coefficients ($I - A$) gives the final demands of a sector (D). Technology that is embodied in the fixed input-output coefficients (A) determines what can be used in further production, while I is an identity matrix. At market price valuation, the elements of D satisfy

$$\sum_{i=1}^{n} D_i = \text{GNP} \approx \text{Y}$$

except possibly for the allocation of competitive imports to domestic producing sectors.

Input-output models that have been combined with macromodels for planning purposes fall in the class of *general equilibrium consistency framework* models. Such models, for example, as developed by Thorbecke and Sengupta (1972) for Colombia focus on the linkages between resource endowment, the structure of production, and the distribution of income. Recently, input-output models have been linked to macroeconomic structures that provide national and international product demands; they are also included in energy balance frameworks that feature supply-demand determination as well as ecological aspects of resource utilization, depletion, and waste. Possibilities for studying individual commodity impacts within the context of an input-output model are featured in Chapter 3 by Simpson

An alternative approach for combining commodity and country models is *commodity-link* models of the type originally suggested by Klein (1968) for improving the explanation of world trade patterns in the project LINK model. In his approach, the economic relationships between the developed and the developing countries depend largely on the quantities and price of commodities in world trade. Exports of commodities from developing countries depend on the income and activity variables represented in the models of the importing countries. At the same time, the income and activity variables represented by the models of the developing countries depend on the production and export of these commodities. The economies of the developed countries also depend on the supply of these commodities. Interaction between economic activity and world commodity supply and demand, which are balanced through an iterative process, results in the determination of commodity prices and other target variables.

While the LINK system features primarily country models, the SIMLINK system developed by Hicks (1975) explains trade and growth for developing regions principally using commodity models. In identifying certain commodities as a source of trade and growth for specific national economies, it utilizes economic activity in four developed economy regions to generate the demand for commodities and other exportable goods and services from eight developing economy regions. Volumes of commodity exports together with prices determine the export earnings of the developing regions, in which prices depend on world supply and demand conditions. Prices for all other sectors are introduced to derive import values. The supply of imports to each region is then compared with exports, and from the resulting terms of trade, the growth of domestic product is computed for each region. Both LINK and SIMLINK obviously are well suited for analyzing multicommodity interactions and policies.

Analysis of the interaction of commodity markets with the economies of Latin America is possible with either model. Also of importance is the Latin American World Model that has been developed to aid integrated planning at a national and regional level in developing countries. As described by Chichilnisky (1977), the model emphasizes the role of food and energy commodities in analyzing basic needs strategies.

One final approach worth considering, which includes commodity-economy interaction, is that of a *multilevel, multisector* model; such a model consists of a system of optimizing models corresponding to different levels of aggregation. The principal application of this approach as described by Goreux and Manne (1973) has been in relation to the Mexican economy. The model features three levels of aggregation: (1) a multisector model of the Mexican economy; (2) two sectoral models—agriculture and energy; and (3) two regional models—agricultural district and electric power plants (including transmission lines). The type of planning intended relates to each of the three levels. At the central level, decisions may refer to the rate of domestic savings and the levels of borrowings from abroad. At the sectoral level, policies may relate to subsidies in fertilizer use or to pricing policies for industrial fuels. In this context, some thirty-two commodities are included in the agricultural submodel. At the regional level, policies can be analyzed related to specific investment projects, such as those dealing with irrigation or electric power.

MODELS FOR COMMODITY STABILIZATION

Recent studies of the impact of commodity stabilization on the economies of Latin America have dealt mainly with the issue of buffer stock stabilization policies as featured within the UNCTAD (1975) Integrated Program. Although that program includes possibilities for stabilization through compensatory finance, multilateral contracts, and processing and diversification as well as buffer stocks, the latter has received the most attention in policy modeling.

At this point there is no need to review the extensive works that have recently emerged regarding the likely impacts of buffer stock stabilization schemes. This has been well documented by Behrman (1977), by Adams (1978), and by Labys (1979a). In addition, Lord in Chapter 9 provides a further review with special reference to Latin America. Thus we turn directly to the particular role played by commodity stabilization models. Although the models analyzed are strictly commodity models, Klein (1971) has mentioned the possibility of analyzing stabilization with linkage models of the type described above. Adams (1977) has further shown how this could take place on an international level though including commodity models into the LINK framework.

The use of commodity models for stabilization analysis has most typically involved incorporating the model into a simulation framework that also includes buffer stocks as well as a buffer stock triggering mechanism. Economic analysis of buffer stock operation involves the computation of the value of buffer stock operations and of the revenue changes falling upon consumers and producers. An example of such a modeling exercise can be based on the previously given market model. Only now the level of inventories is adjusted to accommodate purchases or sales of stocks (S) by a buffer stock agency.

$$\begin{aligned} D &= d(D_{-1}, P, P^c, A, T) \\ Q &= a(Q_{-1}, P_{-\theta}, N, Z) \\ P &= p(P_{-1}, \Delta I) \\ \Delta I &= Q - D + S - S_{-1} \end{aligned}$$

Stochastic disturbances that are among the destabilizing influences in commodity markets are omitted to help simplify the discussion.

The decision as to whether to make purchases or sales from the buffer stock depends on whether the market price falls to the floor price

(P^f) or rises to the ceiling price (P^c). The evaluation of economic benefits of the stocking operations begins with the computation of financial costs (B) for the stocking agency[7]

$$B = cS + (1 - ab)\,(S - S_{-1})P$$

where c is the cost of storage, a is the cost of moving the commodity in and out of the buffer stock, and $b = 1$ for $S > S_{-1}$ or $b = -1$ for $S \leqslant S_{-1}$. Since the benefits from buffer stock operation are usually considered over some period, it is necessary to discount the net worth of the agency at rate r and to value initial (S^i) stocks at some given value (P^i).

$$PVB = (1 + r)^{-T}\, S_T P_T - \sum_{1}^{T} (1 + r)^{-t}\, B_t - S^i P^i$$

To these financial costs must be added the "surplus" or "gains and losses" accuring to producers and consumers. The gains and losses of producers depend on whether the commodity is purchased for or released from the buffer stock. When purchases are made, producers sell the same amount as they would but at a higher price

$$PG = (P^* - P)Q$$

where P^* is the stabilized price and Q the quantity produced. When sales are made out of stock, producers receive a lower price and hence experience a loss

$$PL = (P - P^*)Q$$

Similar to the financial costs, it is necessary to state producers surplus in terms of net present value.

$$PPS = \sum_{1}^{T}(1 + r)^{-t}(PG_t - PL_t)$$

Consumer gains and losses similarly differ depending on whether purchases or sales are made. When sales occur, consumers gain by the reduction in price of the commodity demanded[8]

$$CG = (P - P^*)Q + \{(P^* - P)\,(S - S_{-1})/2\}$$

where Q is the quantity produced adjusted by buffer stock transactions. When purchases are made, the reduction in consumer surplus because of the higher prices becomes a loss.

$$CL = (P^* - P)Q^* + \{(P^* - P)\,(S - S_{-1})/2\}$$

The present value of consumers surplus is given by

$$PCS = \sum_{1}^{T}(1 + r)^{-t}(CG_t - CL_t)$$

The total economic benefits to be derived from the buffer stock operation are the sum of the present value of the financial costs and the producers and consumers surplus.

$$TEB = PVB + PPS + PCS$$

In the actual simulation of such a model a number of other factors enter that affect the outcome of the gains and losses, as explained by Goreux (1978). For commodity stabilization analyses conducted in relation to Latin America, Behrman and Tinakorn in Chapter 10 report on country earnings and financial costs of buffer stock operations for Latin American commodities considered within the UNCTAD integrated program: coffee, cotton, cocoa, copper, tin, and sugar. Other modeling efforts have dealt with individual commodities. Among studies of importance to Latin America are those of Ford (1977) on coffee, Kim et al. (1975) and Kofi (1972) on cocoa, Smith and Schink (1976) on tin, Chaipravat (1977) on rice, and Smith (1975) on copper.

Mentioned earlier was the fact that policy stabilization approaches other than buffer stocks exist. One approach where commodity modeling has been effective examines the likely impacts of the formation of commodity cartels in addition to OPEC. Pindyck (1976) uses a market model that includes commodity production by the cartel and by the fringe as well as net demand facing the cartel. The operation of the model involves feedback control that selects the price levels over time that will maximize the sum of discounted profits. Producer cartels studied include petroleum, copper, and bauxite.

Among other quantitative stabilization studies of interest, the use of commodity modeling has been minimal. Information derived from commodity models such as price elasticities of supply and demand has been employed, but the simulation methodology developed relates more to the direct computation of certain stabilization gains. For example, de Vries (1975) has analyzed the effects of different compensatory financing schemes, including those designed to stabilize earnings for individual commodities as well as total export earnings. In this regard, Goreux (1977) has recently analyzed the pattern of export shortfalls. Reutlinger (1976) has computed the impact of alternative buffer stock levels and storage policies in stabilizing world wheat supplies. This includes the valuation of economic benefits to the storage operation, producers, and consumers. Finally, Konandreas (1978) has analyzed the implications of a proposed world food reserve system on Latin America.

CONCLUSIONS

The extent of the primary commodity dependence in Latin America warrants more extensive commodity planning. Both coping with the commodity instability problem and developing the primary commodity subsector require that decisionmaking have a sound footing. The use of commodity models is not only indispensable, but it will also provide objective information to help reduce conflicts among policymakers as well as to help them shape the future more effectively.

To understand how commodity models can assist in planning, it has been necessary to define and explain a number of modeling methodologies and modeling approaches. An important element in using these models is the interaction between the modeler and the decisionmaker. Both sides have a responsibility toward each other. The modeler has the responsibility of clarifying the limits of the model and the degree of certitude to attach to the forecasts. The decisionmaker must select competent specialists who can help translate the technical information into useful policy inputs.

To improve decision making related to investment in minerals or other commodities, adequate knowledge of both the investment decision process and the market environment is necessary. Of particular importance is an understanding of the policy variables entering the decision makers' framework that come under government control, for example, taxation, export and import controls, mining laws, and exchange rates and controls.

For the market environment, a number of studies are available that provide information on commodities of relevance to Latin America. Also available are forecasts of government and private agencies as well as of other modelers. It is thus feasible for any government to expand its analysis of commodity markets with only a minimum of resources. This would furnish a background against which commodity planning and the formulation of commodity models could begin. It is hoped that this book will stimulate efforts in this direction.

NOTES

1. This problem is described more extensively in Chapter 9.

2. This view of planning is further developed in Yotopoulos and Nugent (1976) as well as in Pyatt and Thorbecke (1976).

3. The possibility of using models for planning has been discussed extensively. The modeling definition provided here appears from Islam (1970).

4. This introductory description appears from Labys (1978). The summary of modeling methodologies that follows appears from Labys (1976b): 36–45. A more complete description of the nature and use of commodity models can be found in Labys (1973a; 1975a).

5. The present modeling perspective has been developed by the author in several papers. See Labys (1978; 1976a); and Labys and Weaver (1973).

6. A review of this class of models appears in Dayal (1975).

7. This simplification is essentially that prescribed by Labys (1979b) and Goreux (1978).

8. The following expressions involve an adjustment factor of 1/2, which reflects surplus derived under a condition of an elastic demand curve but an inelastic (fixed) supply.

BIBLIOGRAPHY

Adams, F.G., ed. 1978. *Stabilizing World Commodity Markets: Analysis, Practice and Policy*. Lexington, Mass.: Heath Lexington Books.

——. 1977. "Commodity Prices in the LINK system: An Empirical Appraisal of Commodity Price Impacts." Conference on Stabilizing World Commodity Markets: Analysis Practice and Policy, Airlie, Virginia.

——. 1975. "Applied Econometric Modeling of Non-Ferrous Metal Markets: The Case of Ocean Floor Nodules." In W. Vogely, ed., *Mineral Materials Modeling*. Washington, D.C.: R.F.F. Working Paper EN-5.

Adams, F.G., and J.R. Behrman. 1976. *Econometric Models of World Agriculture Commodity Markets*. Cambridge, Mass.: Ballinger Publishing Co.

Adams, F.G., and A. Roldan. 1978. "Econometric Studies of the Impact of Primary Commodity Markets on Economic Development in Latin America." Conference of Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Alejandro, F.; P. Clark; and A. Jul. 1973. "Projecting the Optimal Level of Copper Production in Chile." In R.S. Eckaus and P.N. Rodensteinrodan, ed., *Analysis of Development Problems: Studies of the Chilean Economy*. Amsterdam: North-Holland Publishing Co.

Assis, C. 1977. "A mixed integer programming model for the Brazilian cement industry." Ph.D. thesis, John Hopkins University.

Baanante, Carlos Arturo. 1975. "Andean Group Economic Integration: The Case of the Nitrogenous Fertilizer Industry." Ph.D. thesis, North Carolina State University at Raleigh.

Baby, V.J. 1973. "An Analysis of Economic Fertility and Recommendations for Increased Sorghum Production and Utilization in Colombia." Ph.D. thesis, University of Nebraska.

Bacha, E.L. 1968. "An Econometric Model for the World Coffee Market: The Impact of Brazilian Price Policy." Ph.D. thesis, Yale University.

Baldwin R.E. 1966. *Economic Development and Export Growth.* Berkeley: California University Press.

——. 1963. "Export Technology and Development from a Subsistence Level." *Economic Journal* 73, no. 289: 54–79.

Barreyro, H. 1971. "An Analysis of the Supply of Grains in the Pergamino Region of Argentina: A Dynamic Approach." Ph.D. thesis, Texas A & M University.

Bateman, M. 1978. "Analyzing and Forecasting World Sugar Prices." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Bates, L.W. 1975. "The Petroleum Industry in Brazil." Ph.D. thesis, University of Texas at Austin.

Bates, T., and A. Schmitz. 1969. "A Spatial Equilibrium Analysis of the World Sugar Economy." Berkeley, Calif.: Giannini Monograph No. 23.

Behrman, J.R. 1977. "International Commodity Stabilization." Working Paper. Washington, D.C.: Overseas Development Council.

Behrman, J.R., and P. Tinakorn. 1978. "The Impact of the UNCTAD Integrated Program on Latin American Export Earnings." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Bell, F.W., and others. 1975. "A World Model of Living Marine Resources." In W.C. Labys, ed., *Quantitative Models of Commodity Markets.* Cambridge, Mass.: Ballinger Publishing Co.

Bierber, J.L. 1970. "Diversification Opportunities and Effects of Alternative Policies on Costa Rican Coffee Farms." Ph.D. thesis, University of Florida.

Biondolillo, A.L. 1972. "Social Cost of Production Instability in the Grape Wine Industry: Argentina." Ph.D. thesis, University of Minnesota.

Brandt, S.A. 1967. "Spatial Analysis of the World Coffee Market: The Brazilian Position." Ph.D. thesis, Ohio State.

Brien, R.H. 1967. "Petroleum Refining in Costa Rica: A Study in Industrial Development." Ph.D. thesis, University of Texas.

Brown, C.P. 1975. *Primary Commodity Control.* Kuala Lumpur and London: Oxford University Press.

Brown, L.C. 1974. "An Economic Analysis of the Bolivian Poultry Industry." Ph.D. thesis, University of Maryland.

Burga, G.S. 1971. "Considerations on Development and the Poultry Industry in Peru." Ph.D. thesis, Michigan State.

Burrows, J.; W. Hughes; and J. Vallette. 1972. "An Econometric Analysis of the Silver Industry." Cambridge, Mass.: Charles Rivers Associates.

——. 1978. "Modeling Long Run Adjustments in World Metal Markets." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Casperson, Paul Richard. 1974. "Responsive Pricing of Hydroelectricity in a Developing Region: The Case of Minas Gerais, Brazil." Ph.D. thesis, Vanderbilt University.

Cavendar, D. 1976. "The U.S. and the World Zinc Industry: An Econometric Study of Consumption." Working Paper, Iowa State University. Annual Meetings of the American Economic Association, Atlantic City, New Jersey.

Chaipravat, O. 1977. "International Rice Buffer Stock Operations: A Simulation Study." Conference on Stabilizing World Commodity Markets: Analysis, Practice and Policy, Airlie, Virginia.

Chen, J. 1975. "World Cotton Market, 1953–1965: An Econometric Model with Applications to Economic Policy." Rheda, Germany: Institut fur Mathematische Wirtschaft, University of Bielefeld.

Chenery, H.B., and A.M. Strout. 1966. "Foreign Assistance and Economic Development." *American Economic Review* 56, no. 4: 679–733.

Chichilnisky, G. 1977. "Development Patterns and the International Order." *International Affairs* 31, no. 2: 275–304.

Cole, S. 1977. "A Case Study of a Normative Model: The Latin American World Model as a Tool of Analysis in Integrated Planning at a National and Regional Level in Developing Countries." Working Paper, Department of Social Statistics, UNESCO and Science Policy Research Unit, University of Sussex (England).

Cole, W.E. 1965. "The Mexican Steel Industry and its Impact on the Mexican Economy." Ph.D. thesis, University of Texas.

Cutie, T., and A. Jaris. 1975. "Diffusion of Hybrid Corn Technology: The Case of El Salvador." Ph.D. thesis, University of Wisconsin–Madison.

Dammert, A. 1978. "Planning Investments in the Copper Sector in Latin America." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Dammert, A., and D. Kendrick. 1976. "A Model of the World Copper Market." Working Paper, University of Texas at Austin. Annual Meetings of the American Economic Association, Atlantic City, September.

Dayal, R. 1975. *Models of Trade and Development: A Theoretical Review.* Monograph No. 13, Center for Economic Research, Zurich: Swiss Federal Institute of Technology.

Deare, S.M. 1973. "Spatial Agricultural Economy: A Theoretical Study with Special Reference to Brazil." Ph.D. thesis, Yale University.

de Vries, J. 1975. "Compensatory Financing: A Quantitative Analysis." Staff Working Paper No. 228. Washington, D.C.: World Bank.

de Vries, J. 1975. "Structure and Prospects of the World Coffee Economy." Bank Staff Working Paper No. 208. Washington, D.C.: World Bank.

Dorr, A. 1975. "International Trade in the Primary Aluminum Industry." Ph.D. thesis, Pennsylvania State University.

Doyle, J. 1976. "World Wheat Economy: Development of Dynamic Analysis of an Imperfect Market." Ph.D. thesis, Kansas State University.

Emery, R. 1967. "The Relation of Exports to Economic Growth," *Kyklos* 20, no. 2: 470–84.

Epps, M.L. 1970. "A Computer Simulation Model of the World Coffee Market." Ph.D. thesis, Duke University.

Ertek, Tumay. 1967. "World Demand for Copper, 1948–63: An Econometric Study." Ph.D. thesis, University of Wisconsin.

Fisher, B.F. 1966. "The Influence of Agrarian Reform on the Mexican Sugar Industry." Ph.D. thesis, Colombia University.

Fisher, F.M.; P.H. Cootner; and M. Baily. 1972. "An Econometric Model of the World Copper Industry." *Bell Journal of Economics and Management Science* 3: 568–609.

Ford, D.J. 1977. "Commodity Market Modeling and the Simulation of Market Intervention: The Case of Coffee." Conference on Stabilizing World Commodity Markets: Analysis, Practice and Policy. Airlie, Virginia.

Gemmill, H.G. 1976. "An Equilibrium Analysis of U.S. Sugar Policy." Working Paper, Wye College, London University.

Goreux, L.M. 1978. "Optimal Rule of Buffer Stock Intervention." Working Paper, Research Department, Washington, D.C.: International Monetary Fund.

——. 1977. "Compensatory Financing: The Cyclical Pattern of Export Shortfalls." *IMF Staff Papers* 24: 613–41.

Goreaux, L., and A. Manne, eds. 1973. *Multilevel Planning: Case Studies in Mexico.* Amsterdam: North-Holland Publishers.

Hakim, O.A. 1972. "The Effects of the U.S. Cotton Policy on the World Market for Extra-Long Staple Cotton." Ph.D. thesis, University of Arizona.

Harris, W.G. 1967. "The Impact of the Petroleum Industry on the Pattern of Venezuelan Economic Development." Ph.D. thesis, University of Oregon.

Hatch, John Keith. 1974. "The Corn Farms of Motupe: A Study of Traditional Farming Practices in Northern Coastal Peru." Ph.D. thesis, University of Wisconsin–Madison.

Hicks, N., et al. 1975. "The Simlink Model of Trade and Growth of the Developing World." Staff Working Paper No. 220. Washington, D.C.: World Bank.

Hirschman, A.O. 1958. *The Strategy of Economic Development.* New Haven: Yale University Press.

Homem de Melo, F.B. 1973. An Analysis of the World Cocoa Economy in 1980." Ph.D. thesis, North Carolina State University at Raleigh.

——. 1974. "An International Cocoa Agreement: Potential Gains to Producing Countries." Instituto de Economia Agricola, Sao Paulo. Mimeographed.

Houck, J.P.; M.E. Ryan; and A. Subotnik. 1972. *Soybeans and their Products: Markets, Models and Policy.* Minneapolis: University of Minnesota Press.

Hughes, H.G. 1971. "Economic Analysis of Sugarcane Production in Brazil." Ph.D. thesis, University of Missouri at Colombia.

Islam, N. 1970. "The Relevance of Development Models to Economic Planning in Developing Countries." *Economic Bulletin for Asia and the Far East.*

Jarvis, L. 1969. "Supply Response in the Cattle Industry: The Argentine Case." Ph.D. thesis, Massachusetts Institute of Technology.

——. 1974. "Cattle as Capital Goods and Ranchers as Portfolio Managers: An Application to the Argentine Cattle Sector." Berkeley: Institute of Business and Economic Research. No. 118, University of California at Berkeley.

Jul, Ana Maria. 1977. "A Macroeconomic Model for Brazil." Ph.D. thesis, University of Pennsylvania.

Kennedy, M. 1974. "An Economic Model of the World Oil Market." *Bell Journal of Economics and Management Science* 5: 540–77.

Kim, H.K.; L.M. Goreux; and D. Kendrick. 1975. "Feedback Control Rule for Cocoa Market Stabilization." In W.C. Labys, ed., *Quantitative Models of Commodity Markets.* Cambridge, Mass.: Ballinger Publishing Co.

Klein, L.R. 1968. "What Kind of Macro-econometric Model for Developing Economies." In A. Zellner, ed., *Readings in Economic Statistics and Econometrics*. Boston: Little, Brown and Co.

——. 1971. "Some Notes on the Introduction of Commodity Models in Project LINK." Link Working Paper. Philadelphia: University of Pennsylvania.

——. 1977. "Potentials of Econometrics for Commodity Stabilization Analysis." Conference for Stabilizing World Commodity Markets: Analysis, Practice and Policy. Airlie, Virginia.

Kofi, T.A. 1972. "International Commodity Agreements and Export Earnings: Simulation of the 1968 Draft International Cocoa Agreement." *Food Research Institute Studies* II.

Kohout, J.C. 1968. "A Price and Allocation Model for the Beef Economy in Argentina." Ph.D. thesis, University of Illinois.

Konandreas, P. 1978. "The World Food Reserve System and Its Implications for Latin America." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Kovisars, L. 1975. "World Trade Flows in Copper, an LP-Model." Palo Alto, Calif.: Stanford Research Institute. Unpublished.

——. 1976. "World Production, Consumption and Trade in Zinc-an LP-Model." U. S. Bureau of Mines Contract J-0166003. Palo Alto, Calif.: Stanford Research Institute.

Kruegar, P.K. 1976. "Modeling Future Requirements for Metals and Minerals." In *Proceedings of the XIV Symposium of the Council for the Application of Computers and Mathematics in the Minerals Industries*. University Park, Pa.

Labys, W.C. 1973a. *Dynamic Commodity Models: Specification, Estimation Simulation*. Lexington, Mass.: Heath Lexington Books.

——. 1973b. "Preliminary Results of an Econometric Model of the International Wine Market." Geneva: Graduate Institute of International Studies. Mimeographed.

——. 1975a. *Quantitative Models of Commodity Markets*. Cambridge, Mass.: Ballinger Publishing Co.

——. 1975b. "Commodity Planning Models for East Asia." In *Studies and Documents*. Geneva: Graduate Institute of International Studies.

——. 1976a. "Integrating Primary Commodity Exports in the Macroeconomic Planning Process: Theory and Practice in Southeast Asia." Summary of a research study carried out for the ASEAN Secretariat under the Auspices of the F.A.O. Rome: F.A.O. of the United Nations.

——. 1976b. "International Commodity Markets, Models and Forecasts." *Columbia Journal of World Business* 4: 36–45.

——. 1978. "Commodity Markets and Models: The Range of Experience." In F. G. Adams, ed., *Stabilizing World Commodity Markets: Analysis, Practice and Policy*. Lexington, Mass.: Heath Lexington Books.

——. 1979a. "Analyzing Commodity Price Stabilization Schemes." *Journal of Policy Modeling* (in press).

——. 1979b. "Simulation Analysis of an International Buffer Stock for Jute." *Journal of Development Studies* 15: 154–166.

Labys, W.C., and H. Thomas. 1975. "Speculation, Hedging and Commodity

Price Behavior: An International Comparison." *Applied Economics* 7: 287–301.

Labys, W.C., and T.E. Weaver. 1973. "Towards a Commodity Oriented Development Model." SEADAG Paper 73-11. New York: Southeast Asia Development Advisory Group.

——. 1978. "Interactions Between the Resource Commodity Sector, the Developing Economy and the Environment." Geneva: UNCTAD/UNEP Project 005.

Lattimore, R.G. 1974. "Econometric Study of the Brazilian Beef Sector." Ph.D. thesis, Purdue University.

Lattimore, R., and G.E. Schuh. 1976. "Un Modelo de Politica Para La Industria Brasilena de Ganado Vacuno" ("A Policy Model of the Brazilian Beef Cattle Economy"). *Cuadernos de Economia* 39: 51–75.

Law, A.D. 1975. *International Commodity Agreements*. Lexington, Mass.: Heath Lexington Books.

Ley, R. 1977. "Bolivian Tin and Bolivian Development." Ph.D. thesis, Washington State University.

Lira, Ricardo. 1974. "The Impact of an Export Commodity in a Developing Economy: The Case of Chilean Copper, 1955–1968." Ph.D. thesis, University of Pennsylvania.

Linneman, H. 1966. *An Econometric Study of International Trade Flows*. Amsterdam: North-Holland Publishing Co.

Lord, M. 1978. "Commodity Export Instability and Growth in Latin America." Paper presented at Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Lydell, H.F. 1975. *Trade and Employment*. Geneva: International Labor Office.

MacBean, A.I. 1966. *Export Instability and Economic Development*. Cambridge, Mass.: Harvard University Press.

Mack, F.G. 1973. "The Impact of Transfer Cost and Trade Policies on International Trade in Beef, 1967–1980." Ph.D. thesis, Texas A & M University.

Mafucci, E. 1974. "Export Earnings Instability—the Argentine Case." Ph.D. thesis, University of Minnesota.

Magueron, G. 1972. "A Quantitative Analysis of the Supply-Demand Patterns in Iron Ore: The Future Possibilities of Brazil." Ph.D. thesis, Columbia University.

Maizels, A., assisted by L.G. Cambell-Boross and P.B.W. Rayment. 1968. *Exports and Economic Growth of Developing Countries*. London: NIESR.

Mamalakis, M. 1971. "Contribution of Copper to Chilean Economic Development." In R.G. Mikesell, ed., *Foreign Investment in the Petroleum and Mineral Industries*. Baltimore: John Hopkins University Press.

Marcus, P.M. 1972. "An Economic Analysis of the World Corn Trade." Ph.D. thesis, Purdue University.

Matetic, J.R. 1971. "An Economic Analysis of the Chilean Fresh Fruit and Vegetable Export Sector." Ph.D. thesis, University of Minnesota.

Mathis, K. 1969. *An Economic Simulation Model of the Cocoa Industry of the*

Dominican Republic. International Programs Info. Rep. 69-2, Department of Agricultural Economics and Sociology, Texas A & M University.

McGarry, J.J. 1968. "The World Beef Industry." Ph.D. thesis, University of Wisconsin.

McGuann, J.M. 1973. "Microeconomic Analysis of Opportunities for Increasing Beef Production: The Pampean Area, Argentina." Ph.D. thesis, Texas A & M University.

Melo, F.H. 1973. "An Analysis of the World Cocoa Economy in 1980." Ph.D. thesis, North Carolina State University at Raleigh.

Mertz, W.N. 1969. "The Feasibility of Nicaraguan Caustic Soda Industry, 1977–80." Ph.D. thesis, University of Houston.

Mueller, C. 1975. "Factors Affecting the Development of the Cattle Industry in Central Brazil." Ph.D. thesis, Vanderbilt University.

Naggar, T.R. 1976. "The role of the iron, copper, lead and zinc petroleum export sectors in the economic development of Brazil, Chile, Mexico and Venezuela: an empirical macroeconomic analysis." Ph.D. thesis, University of Oklahoma.

Nelson, W.E. 1971. "An Economic Analysis of Fertilizer Utilization in Brazil." Ph.D. thesis, Ohio State University.

Nores, G.A. 1972. "Structure of the Argentine Beef Cattle Economy: A Short Run Model, 1960–70." Ph.D. thesis, Purdue University.

Norton, R.D., and L. Bassoco. 1974. "A Quantitative Agricultural Planning Methodology." Bank Staff Working Paper No. 180. Washington, D.C.: World Bank.

Otrera, W.R. 1966. "An Econometric Model for Analyzing Argentine Beef Export Potentials." Ph.D. thesis, Texas A & M University.

Palma-Carillo, P.A. 1976. "A macroeconometric model of Venezuela with oil price impact applications." Ph.D. thesis, University of Pennsylvania.

Panchamukhi, V.R. 1975. "Linkages in Industrialization: A Study of Selected Developing Countries in Asia." *Journal of Development Planning* 9: 121–66.

Paniago, E. 1968. "An Evaluation of Agricultural Price Policies for Selected Food Products: Brazil." Ph.D. thesis, Purdue University.

Parikh, A. 1974. "A Model of World Coffee Economy: 1950–68." *Applied Economics* 6: 23–43.

Parks, L. 1976. "Estimation of Water Production Functions and Farm Demand for Irrigation Water, with Analysis of Alternatives for Increasing the Economic Returns of Water on Chilean Farms." Ph.D. thesis, University of California at Davis.

Pearson, S.R. 1970. *Petroleum and Nigerian Economy*. Palo Alto, Calif.: Stanford University Press.

Pearson, S.R., and J. Cownie. 1975. *Commodity Exports and African Economic Development*. Lexington, Mass.: Heath Lexington Books.

Penna, J.A. 1974. "Optimal Storage and Export Levels of a Tradeable Product and Their Relationship with Annual Price Variability: The Case of Corn in Brazil." Ph.D. thesis, Purdue University.

Pindyck, R. 1976. "Gains to Producers from the Cartelization of Exhaustible Resources." Cambridge, Mass.: Massachusetts Institute of Technology, MITEL76-012WP.

Posada, A. 1974. "A Simulation Analysis of Policies for the Northern Columbia Beef Cattle Industry." Ph.D. thesis, Michigan State University.

Pringle, G.E. 1969. "A Temporal Spatial Analysis of Sugar Production and Marketing in Puerto Rico." Ph.D. thesis, University of Wisconsin.

Pyatt, G., and E. Thorbecke. 1976. *Planning Techniques for a Better Future.* Geneva: International Labor Office.

Quintana, C., and G. Bueno. 1968. "Processes and Location in the Mexican Steel Industry." Vienna: UNIDO, Evaluation of Industrial Projects, No. E. 6711.B23.

Quiros, J.L. 1966. "Engineering and Economic Aspects of the Aluminum Industry with Applications in Panama." Ph.D. thesis, University of Illinois.

Reutlinger, S. 1976. "A Simulation Model for Evaluating Worldwide Buffer Stocks for Wheat." *American Journal of Agricultural Economics* 58: 1–12.

Reynolds, C.W. 1963. "Domestic Consequences of Export Instability," *American Economic Review*, Papers and Proceedings 53: 93–102.

——. 1965. "Development Problems of an Export Economy, the Case of Chile and Copper." In M. Mamalakis and C. W. Reynolds, eds., *Essays on the Chilean Economy.* Homewood, Ill.: R.D. Irwin.

Reynolds, C.W., and L. Spellman. 1975. "Financial Intermediation and Economic Development as Seen Through the Flow of Finds Accounts." Working Paper, Food Research Institute, Stanford University.

Robertson, T. 1968. "Structure, Performance, and Conduct of the Peruvian Fertilizer Industry and a Linear Programming Analysis for Future Plan Sizes and Location." Ph.D. thesis, Iowa State University.

Santos, A. 1976. "International Trade in Iron Ore: An Econometric Analysis of the Determinants of Trade Patterns." Ph.D. thesis, Pennsylvania State University.

Saylor, R.G., and C.F. Trench de Freitas. 1975. "Price, Quality and the Demand for Coffee." Sao Paulo: Instituto de Economia Agricola. Mimeographed.

Schmitz, A. and D. Bawden. 1973. "World Wheat Economy: An Empirical Analysis." Giannini Foundation Monograph No. 32, University of California at Berkeley.

Segura, E.L. 1973. "An Econometric Study of the Fish Meal Industry." Ph.D. dissertation, Columbia University. Published as FAO Fisheries Technical Paper No. 119, FIEF/T119 (En), Rome.

Shaw, J. 1973. "Manganese Model, Parts I and II." Geneva: Miscellaneous Paper, Commodities Division, U.N. Conference on Trade and Development.

Simpson, J.R. 1974. "International Trade in Beef and Economic Development of Selected Latin American Countries." Ph.D. thesis, Texas A & M University.

——. 1978. "Input-Output Modeling and Its Implications for Commodity Planning in Latin America." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Simpson, J.R., and J.W. Adams. 1975. "Disaggregation of Input-Output

Models into Product Lines as an Economic Development Policy Tool." *American Journal of Agricultural Economics* 57, no. 4: 584–90.

Singer, H. 1950. "The Distribution of Gains Between Investing and Borrowing Countries." *American Economic Review*, Papers and Preceedings 40: 473–85.

Singh, B. 1971. "An Econometric Study of Raw Materials in International Trade: A Case Study of Hides and Skins." Ph.D. thesis, University of Pennsylvania.

Singh, I.J. 1978. "A Dynamic Multicommodity Model of the Agricultural Sector: A Regional Application in Brazil." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Singh, I.J., and C.Y. Ahn. 1973. "The Future of Agriculture in Southern Brazil: Some Policy Projections with a Dynamic Model of the Wheat Region, Rio Grande do Sol (1970–85). Columbus: Ohio State University. Mimeographed.

Smith, G.W. 1975. "An Economic Evaluation of International Buffer Stocks for Copper." Working Paper. Washington, D.C.: U.S. Treasury.

Smith, G.W., and G.R. Schink. 1976. "The International Tin Agreement: A Reassessment." *Economic Journal* 86, no. 344: 715–28.

Smith, J.N. 1968. "A Dynamic Model of the Cattle Industry of Argentina." Ph.D. thesis, University of Maryland.

Smith, R. 1974. "Diversification Alternatives and Inducements in the Columbian Coffee Industry." Ph.D. thesis, University of Texas at Austin.

Spreen, T.A. 1977. "An application of capital theory in a recursive linear programming model of the cattle subsector of Guyana." Ph.D. thesis, Purdue University.

Staloff, S. 1977. "A stock-flow analysis for copper markets." Ph.D. thesis, University of Oregon.

Sugai, Yoshimido. 1974. "A Quota System Policy and Its Impact on the Labor Market in the Sugarcane Industry Analysis Through Dynamic Linear Programming Procedure, Sao Paulo, Brazil." Ph.D. thesis, Iowa State University.

Taplin, G.B. 1973. "A Model of World Trade" in R.J. Ball, ed. *The International Linkage of National Economic Models*. Amsterdam: North Holland Publishing Co.

Tewes, T. 1972. "Sugar: A Short-Term Forecasting Model of the World Market, with a Forecast of the World Market Price for Sugar in 1972–1973." *The Business Economist* 4 (Summer): 89–97.

Thoburn, J.T. 1977. *Primary Commodity Exports and Economic Development*. New York: John Wiley & Sons.

Thompson, R.L., and J.L. Garcia. 1978. "The Export Demand for Maize from Brazil." *Revista de Economia Rural* 16.

Thompson, R.L., and G.E. Schuh. 1978. "Trade Policy and Exports: The Case of Maize in Brazil." Working Paper, Department of Agricultural Economics, Purdue University.

Thorbecke, E., and J.K. Sengupta. 1972. "A Consistency Framework for Employment, Output and Income Projections Applied to Colombia." Washington, D.C.: World Bank.

Thorbecke, E., and A. Stoutjeskijk. 1970. "Employment and Output: A Methodology Applied to Peru and Guatemala." Paris: OECD Working Paper.

Tilton, J. 1966. "The Choice of Trading Partners: An Analysis of International Trade in Aluminum, Bauxite, Copper, Lead, Manganese, Tin, and Zinc." *Yale Economic Essays* 6, no. 2: 416–74.

——. 1978. "Modeling International Trade Flows in Mineral Markets, with Applications to Latin America's Trade Policies." Conference on Commodity Markets, Models and Policies in Latin America, Lima, Peru.

Truett, D.B. 1967. "Sulfur and the Development of a Chemical Fertilizer Industry in Mexico." Ph.D. dissertation, University of Texas.

UNCTAD. 1974 and 1975. "An Integrated Program for Commodities." Paper Series UNCTAD TD/B/C 1/166 to UNCTAD TD/B/C.1/194. Geneva: UNCTAD.

——. 1967. *Trade Expansion and Economic Integration Among Developing Countries*. Geneva: United Nations.

Valdez, M.A. 1972. "The Petroleum Policies of the Venezuelan Government." Ph.D. thesis, New York University Graduate School of Business.

Vernon, R. 1966. "Comprehensive Model Building in the Planning Process: The Case of the Less Developed Economies." *Economic Journal* 76, no. 301: 57–69.

Vilas, A.T. 1975. "A Spatial Equilibrium Analysis of the Rice Economy in Brazil." Ph.D. thesis, Purdue University.

Weymar, F. Helmut. 1968. *The Dynamics of the World Cocoa Market*. Cambridge, Mass.: The MIT Press.

Whitney, J. 1976. "Analysis of Copper Production, Processing and Trade Patterns, 1950–1972." Ph.D. thesis, Pennsylvania State Universitv.

Wickens, M.; J. Greenfield; and G. Marshall. 1971. *A World Coffee Model*. CCP: 71/W.P. 4. Rome: Food and Agricultural Organization of the United Nations.

Williams, R.L. 1973. "Growth, Structure and Performance of the Coffee Industry in Jamaica." Ph.D. thesis, Columbia University.

World Bank. 1975. *Commodity Trade and Price Trends*. Washington, D.C.: World Bank.

Wymer, C.R. 1975. "Estimation of Continuous Time Models with an Application to the World Sugar Market." In W.C. Labys, ed., *Quantitative Models of Commodity Markets*. Cambridge, Mass.: Ballinger Publishing Co.

Yepez, L.F. 1970. "An Evaluation of Venezuelan Sugar Policy." Ph.D. thesis, University of Wisconsin.

Yotopoulos, P., and J. Nugent. 1976. *Economics of Development*. New York: Harper and Row.

Yver, R.E. 1971. "The Investment Behavior and the Supply Response of the Cattle Industry in Argentina." Ph.D. thesis, University of Chicago.

Zinser, J.S. 1967. "Alternative Means of Satisfying Argentine Petroleum Demand." Ph.D. thesis, University of Oregon.

Zulberti, Carlos Alberto. 1974. "The Feasibility of Beef Cattle Feed Lots in Argentina: Methodology of Economic Evaluation." Ph.D. thesis, Cornell University.