INTER-AMERICAN DEVELOPMENT BANK

MARKET PRICE MODELS FOR LATIN AMERICA'S MAJOR COMMODITY EXPORTS

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PREFACE

The present report describes the specification, estimation, and validation of a set of market price models for Latin America's major non-fuel commodity exports. The models offer a means by which to generate forecasts that are conditioned on assumptions made about key variables such as foreign income growth, inflation, and interest rates. As such, they also provide a mechanism by which to examine the effect of changes in those key assumptions on commodity market prices.

The report was prepared with research assistance by Greta Boye and Stephane Conte. Greta Boye wrote the sections that describe the market structure of individual commodities. She also prepared the regression results and derived the reduced form of the market price equations presented in Appendix A, and she compiled and processed the data used in the models presented in Appendix B. Stephane Conte estimated and validated the preliminary set of commodity market models.

This report also benefitted from the assistance of a number of individuals. The staff of the World Bank's Commodity Studies and Projections Division provided useful information for modeling individual markets. James Fry, Director of Landell Mills Commodities (LMC) Studies, furnished much of the argument set forth in this study for modeling sugar and high fructose corn syrup (HFCS) as one market. Bronwyn Curtis, also of LMC Studies, and Blair Rourke, of the International Monetary Fund's Commodities Division, supplied valuable information about the cocoa market. Finally, up-to-date data for modeling the agricultural markets were obtained from economists of the Foreign Agricultural Service of the United States Department of Agriculture.

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INTRODUCTION

Commodity market models have proliferated in the last decade. The first bibliography on commodity models by Labys (1973) lists 241 entries; in the ten years that followed that first survey, an additional 684 commodity models were constructed. The increased number of commodity models has been due, in part, to the concern generated by generally greater fluctuations in commodity market prices than in the post-World War II period. For example, price fluctuations of thirty-three commodities monitored by the World Bank (1985) have varied an average of 20 percent around their trend since 1972, in contrast to an average fluctuation of only 6 percent in the 1960's and early 1970's (measured by the mean average of absolute deviations from the fitted trend).

More recently, interest in commodity market price movements has grown as attention has focused on the earnings growth potential of commodity exports by developing countries. After the 1981-82 world recession, exports of manufactured goods by developing countries, which had been primarily traded among the developing countries themselves, were sharply curtailed. The precipitous decline in trade among developing countries occurred as a consequence of import cutbacks needed so that foreign exchange earnings could be redirected to service the foreign debt. Confronted with foreign market constraints for manufactured exports, as well as reduced capital flows, developing countries have directed their attention to the performance of commodity exports.

Concurrent with the proliferation of commodity market models has been the growth in diversity of methodologies used to analyze and forecast price movements (for a taxonomic classification of methodologies, see Labys and Pollak, 1984: 38-47). Methodologies have become so innovative and motivations to score accurate forecasts so great that even astrology is being used to forecast the apparently unpredictable movement, or "random walk", of commodity prices (see, for example, Rotton's (1985) article "Astrological Forecasts and the Commodity Market: Random Walks As a Source of Illusory Correlation"). The random walk nature of commodity prices has led to the use of time series models such as the autoregressive integrated moving average (ARIMA) model developed by Box and Jenkins (1970), in which an attempt is made to identify regularities in movements of time series of prices that might be obscured by noise (for an example of its application, see Chu, 1978).

However, these methods of analysis and forecasting avoid the fundamentals of supply and demand in the determination of price. Furthermore, they cannot be used to examine policies in which interventions in a market occurs either through supply, be it in the form of production, export, or stocks policies, or through demand, for example, in the form of non-tariff barriers (NTBs) to trade by the imposition of import quotas, discretionary licensing, or minimum import price restrictions. For this reason, the approach adopted in the present study is one in which the supply and demand components in the market are estimated and price determined by their equilibrium condition. This approach is certainly not new. Multi-commodity models based on parsimonious specifications of the underlying data-generating processes in markets include those of Adams and Berhman (1976) and Hwa (1985).

The present study incorporates recent advances in modeling techniques to the empirical econometric analysis of commodity market models. The spuriousness of results that can be obtained from empirical econometric analysis is well documented (see for example Granger and Newbold, 1974). However, as Hendry (1980) points out in his article "Econometrics - Alchemy or Science?" the spurious results obtained from econometric analysis that shows inflation in England to be well explained by cumulative rainfall in that country can be remedied by the application of proper modeling techniques. Recently, those correct modeling techniques have been enumerated in McAleer, Pagan, and Volker's (1985) article "What will take the Con Out of Econometrics?". The guidelines for an appropriately constructed model are laid out as follows: (a) theory consistency, (b) dynamic specifications that encompass others, (c) statistical significance, and (d) sensitivity of the estimates to new data.

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These guidelines motivate the approach of this study of price formation in commodity markets. Part I specifies the theory of commodity markets and the dynamics underlying the data-generating process. The theory that is postulated provides a parsimonious interpretation of the process of price formation in commodity markets, and the dynamics specification both encompasses previous specification and reproduces the postulated theory of market price formation.

In Part II the general specification of the model is applied to the ten commodity markets for Latin America's major non-fuel exports. The commodities are those that during the 1970's contributed, on average, more than 1 percent of the total regional value of merchandise exports. Together the ten commodities accounted for nearly one-half of total non-fuel export revenue in the last decade. The contribution to total regional export earnings in 1980-84 was as follows:

	Percent		Percent
Coffee	9.5	Beef	1.6
Soybeans	5.7	Bananas	1.5
Copper	3.7	Cocoa	1.4
Iron Ore	3.4	Maize	1.4
Sugar	2.9	Cotton	1.3

Appropriate modifications to the general model are introduced when they are warranted by the characteristics of the market. Part II describes the market structures of these commodities and introduces appropriate modifications to the general model. Estimates of the equations are based on data for the period 1960 to 1982, and the results of the estimates are presented in Part III. The study concludes with the validation of the models for the 1983-84 period and the performance of multiplier analysis.

The models are parsimonious since they are designed to simulate and forecast market prices over the medium and long term. Though they generally do not provide country-detailed information about the market, they do offer ease of use to the analyst. By containing a small number of parameters, the models permit the analyst to focus attention on the key variables that are the dominating influences on market prices.

PART I

GENERAL SPECIFICATION OF THE MODEL

In this part, we develop a theory-based econometric model which seeks to characterize the data-generating process in commodity markets. The theory that is formulated describes demand and supply, as well as equilibrium conditions, in these markets, and it makes explicit the constraints that need to be imposed in order to formulate and estimate a complete market system. The dynamic specification of the system adopts recent work on dynamic time-series models that explains observed disequilibria in the context of long-term, or steady-state, solutions which are theory consistent.

Chapter 1

THEORY OF MARKET PRICE FORMATION

The theory formulated in this chapter seeks to represent the essential features underlying the process of market price formation, as distinct from an attempt to represent a complete market system. Our purpose is to derive causal relationships with which to quantitatively characterize the interrelationships that exist among the principal agents in commodity markets.

These relationships are framed in terms of equilibrium solutions, so their immediate use is limited to comparative statics. In the following chapter, representations of lags that exist in the behavior of agents as they adjust towards equilibrium growth paths are introduced. The resulting dynamic system provides a characterization of the underlying process whereby data are generated in commodity markets.

1.1 CONSUMPTION

The market demand schedule for a commodity is obtained from identical and homothetic preferences for all consumers. A market demand schedule that lends itself to empirical estimation can be derived by assuming that substitution between a commodity, denoted C, and the numeraire, N_o, takes place in the constant elasticity form. As such, the indifference curve is:

$$U(C,N_o) = [\pi C^{\alpha} + (1-\pi)N_o^{\alpha}]^{1/\alpha} \qquad \ldots(1)$$

where $\alpha < 1$ and $0 < \pi < 0.5$.

Given the preference ordering by consumers, the market demand schedule is derived by maximizing the overall utility function subject to the budget constraint. The utility maximization problem, given a commodity price P and a level of nominal dollar income Y^n, is:

$$\max[\pi C^{\alpha} + (1-\pi)N_o^{\alpha}]^{1/\alpha}$$
$$\text{subject to } PC + N_o = Y^n \qquad \ldots(2)$$

where $\alpha < 1$ and $0 < \pi < 0.5$. The solution to the above problem yields the <u>demand schedules</u> for the commodity C and the numeraire N_o:

$$C = k_1 \left[\frac{P}{D}\right]^{\varphi-1} Y \qquad \ldots(3a)$$

and

$$N_o = (1-k_1)\left[\frac{P}{D}\right]^{\varphi} Y^n \qquad \ldots(3b)$$

where $\varphi = \alpha/(\alpha-1)$ and $k_1 = [\pi/(1-\pi)]^{1/(1-\alpha)}$; where $D = [1 + k_1 P^{\alpha/(\alpha-1)}]^{(\alpha-1)/\alpha}$ is the deflator; and where $Y = Y^n/D$ is constant dollar income of the consumer. In both demand schedules the income elasticities are equal to unity, a hypothesis that will be tested in Chapter 14 for demand functions of particular commodities. The price elasticity of demand for a commodity can take on any value between 0 and $-\infty$ because the elasticity is equal to $\varphi-1$, where the parameter $\varphi = \alpha/(\alpha-1)$ and $\alpha < 1$.

The above system of demand schedules lends itself to empirical application since the exponential form of the equations can be converted to double-logarithmic equations whose estimated coefficients are directly interpreted to be elasticities. Moreover, the use of CES preference functions does not impose undue restrictions on the own-price and cross-price elasticities. Their values are consistent with those that would be expected for normal goods 1/.

1/ The generalized constant elasticity of substitution (CES) preference function was introduced by Brown and Heien (1972) to overcome two restrictions of the linear expenditure system used by Klein and Rubin (1948). The restrictions in the linear expenditure system are, first, that the own-price elasticities of demand cannot exceed (minus) unity and, second, that cross-price elasticities are zero. In equation (1), both complementary and substitution effects are represented. The exponent α has the interpretation that when the goods are perfect substitutes, its value approaches unity; (and $\varphi \to \infty$) when the goods are non-substitutable, its value approaches $-\infty$. The own-price elasticity lies in the range between 0 and $-\infty$.

1.2 PRODUCTION

The market supply schedule is derived from the maximization of earnings objective by producers with the cost-minimizing combination of factor inputs used to produce the commodity. The slope of the curve depends on returns to scale which, in general, are expected to be decreasing in most commodity markets because, once the industry has become established, producers in general will have exhausted their opportunity to obtain cost reductions from increases in the size of the industry.

Total revenue depends on the quantity that is produced, denoted Q, and the commodity market price, denoted P, which is related to the quantity produced. As such, total revenue equals $Q*P(Q)$. Total cost also depends on the quantity produced. The cost schedule of the producer is derived from the least-cost combination of inputs required to generate a given level of output. Hence, the producer seeks to minimize the outlay for inputs that is required to produce a given level of output, subject to the production schedule. In order to derive the market supply schedule, all producers are assumed to have identical production schedules.

The production schedule needs to take on a specific functional form, in particular, the constant elasticity of substitution (CES) function, in order that the derived cost schedule can be used to obtain a supply schedule that lends itself to empirical estimation. Then the production schedule relating the amount of labor A and capital B needed to generate a given level of output Q is:

$$Q = k_2[A^\Theta + B^\Theta]^{\tau/\Theta} \qquad \ldots(4)$$

where $\Theta < 1$ and $\tau > 0$, and where $k_2 = e^{\sigma_o + \sigma_1 T + \sigma_2 W}$. The first effect explicitly incorporated into the constant term k_2 is an efficiency parameter $e^{\sigma_1 T}$, which measures the state of technology in production of the commodity; the second is a shift parameter $e^{\sigma_2 W}$, which measures major disturbances --such as natural disasters and labor disruptions-- in production of the commodity. The value of τ in equation (4) determines returns to scale. When $\tau = 1$, there are constant returns to scale and the production function is of the Cobb-Douglas type; when $\tau > 1$ there are increasing returns to scale; when $0 < \tau < 1$ there are decreasing returns to scale.

The cost of production, denoted E, from constant unit costs of capital V_1 and labor V_2 equals:

$$E = V_1 A + V_2 B \qquad \ldots(5)$$

The producer seeking the cheapest way to obtain a given level of output faces the problem of minimizing production cost in equation (5) subject to the production schedule in equation (4). The solution to this problem yields the <u>cost schedule</u>:

$$E = k_2^{1/\tau} Q^{1/\tau} \left[V_1^{\frac{\Theta}{\Theta-1}} + V_2^{\frac{\Theta}{\Theta-1}} \right]^{\frac{\Theta-1}{\Theta}} \qquad \ldots(6)$$

where $\Theta < 1$ and $\tau > 0$. The cost schedule is an explicit function of the commodity output level and input prices of capital and labor.

The supply schedule is derived from the producer's objective to maximize earnings $P(Q)*Q - E(Q)$. The first-order condition yields as a solution the supply schedule:

$$Q = k_3 \left[\frac{P}{D}\right]^{\gamma_1} t^{\gamma_2} w^{\gamma_3} \qquad \ldots(7)$$

Equation (7) says that supply is related to (a) the constant dollar price of the product (P/D), where $D = \left[V_1^{\frac{\Theta}{\Theta-1}} + V_2^{\frac{\Theta}{\Theta-1}} \right]^{\frac{\Theta-1}{\Theta}}$ is the deflator; (b) an efficiency variable $t = e^T$; and (c) a disturbance variable $w = e^W$. The parameters in the supply equation have the following definitions:

$\gamma_1 = \frac{\tau}{1-\tau}$, $\gamma_2 = \frac{\sigma_1}{\tau-1}$, $\gamma_3 = \frac{\sigma_2}{\tau-1}$, and $k_3 = e^{\frac{\sigma_0}{\tau-1}} \tau^{\frac{\tau}{1-\tau}} \left[\frac{\beta}{1-\beta}\right]^{\frac{\tau}{1-\tau}}$, where $\beta-1$ is the price elasticity of demand. The constant term k_3 contains the terms $\left[\frac{\beta}{1-\beta}\right]^{\tau/(1-\tau)}$, which accounts for the difference between the supply curve and the marginal cost curve. Since $\tau > 0$ and $\beta < 1$, then the value of the constant terms is positive (unless $0 < \beta < 1$ and $0 < \tau < 0.5$, in which case the solution is indeterminate).

The variable w in equation (7) represents a shift variable that measures major random disturbances in supply. Major disturbances in supply are primarily related to natural disasters and labor disruptions. For example, in a study on major swings in commodity market prices, Chu and Morrison (1984) found that supply disruptions had an important influence in each phase of the 1975 and 1981 recessions. These disruptions intensified the demand-induced price volatility of commodity market prices. Hence the expected sign of the coefficient for the shift variable is generally negative.

The efficiency variable t measures technological changes in the production process. On the one hand, it includes innovations and techniques that are introduced in order to improve the level of production and, on the other, it incorporate expansion of infrastructures that support production. The effects of these technological changes are to bring about a long-term, or secular, shift in the supply schedule.

The price elasticity of supply is given by the exponent γ_1, which defines the percentage change in supply brought about by a one percent change in the constant dollar price of the commodity. Since $\gamma_1 = (1-\tau)/\tau$ and $\tau > 0$, then γ_1 can take on a positive, negative, or zero value.

Because the value of the price elasticity of supply is directly dependent on the value of τ, which measures returns to scale, the shape of the supply schedule is determined by returns to scale in the industry. When there are decreasing returns to scale, so that $0 < \tau < 1$ and hence $\gamma_1 > 0$, the supply schedule is strictly increasing; when there are constant returns to scale, so that $\tau = 1$ and hence $\gamma_1 = 0$, the supply schedule is constant; and when there are increasing returns to scale, so that $\tau > 1$ and hence $\gamma_1 < 0$, the supply schedule is strictly decreasing.

As already mentioned, producers are likely to exhibit diminishing returns to scale in the production of most of the principal commodities traded in world markets. Once the commodity has become established, producers in general will have exhausted their opportunity to obtain cost reductions from increases in the size of the industry. The use of variable inputs of capital and labor in the production of the commodity will ultimately lead to diseconomies of scale when combined with fixed inputs such as arable land or mine reserves. Diseconomies can also arise from large-scale management, particularly by producer associations and by government agencies, and from rising transportation costs per unit produced to more distant geographic markets. An expansion in the amount of variable inputs in the industry then generate a less-than-proportional increase in output. Average costs rise with output as unit costs begin to rise. At the minimum point of the average cost curve the marginal cost curve begins to rise. Then the supply curve is strictly increasing. However, economies of scale can arise from lower factor input prices, greater access to financial capital, and increased acceptance of commodity types. As a result, some commodities might have downward sloping supply curves. The slope of the supply curve of particular commodities is an empirical issue, one which will be addressed in Chapter 15.

1.3 EQUILIBRIUM

This section considers equilibria conditions for commodity producers and the market --for perishable and non-perishable commodities, and it describes the properties of equilibria.

<u>**The Producer**</u> - The equilibrium price and quantity of a commodity producer operating in monopolistic competition can be obtained by adopting the behavioral assumption underlying the Cournot-Nash equilibrium, which postulates that each producer takes the actions of its competitors as given. In this framework, producers vary their prices without concern about reactions in competitors because in monopolistic competition each country's market share is small. Consequently, a producer that seeks to maximize its foreign exchange earnings under conditions of monopolistic competition in a commodity market will do so by assuming that the price of its competitors is given.

For each producer i, $i = 1,\ldots,n$, net earnings (denoted F_i) equals the difference between total revenue $P_i(Q_i) * Q_i$ and total cost $E_i(Q_i)$:

$$F_i = P_i(Q_i)*Q_i - E_i(Q_i) \qquad \ldots(8)$$

so that maximization of earnings by each producer yields the first-order condition:

$P'(Q)\cdot Q + P(Q) = MR$

$P(Q)\left(\frac{1}{\eta} + 1\right) = MR$ ✓

$$\left[1 + \frac{1}{\varphi-1}\right] P_i = E_i'(Q_i) \qquad \ldots(9)$$

↑ MC

for all producers $i = 1,\ldots,n$, where $\varphi-1 < 0$ is the price elasticity of demand for the producers and $E_i'(Q_i) = \partial E_i(Q_i)/\partial Q_i$. Hence, following the Cournot-Nash behavioral assumption, producers operating in monopolistic competition equate their marginal revenue with their marginal cost, taking the actions of competitors as givens.

From the solution obtained in equation (9) above, the price of each producer can be expressed as:

$$P_i = \frac{E_i'(Q_i)}{\left[1 + \frac{1}{\varphi-1}\right]} \qquad \ldots(10)$$

Equilibrium price for a commodity producer in monopolistic competition is equal to a fractional markup over marginal cost, the amount of the markup being a function of its price elasticity of demand. The left-hand side of the above solution may be interpreted as the inverse of the producer's demand schedule, while the right-hand side is the inverse of the producer's supply schedule.

With free entry into the market, the number of producers will increase until there are no excess earnings. The long-run equilibrium solution will therefore be such as to drive all net earnings to zero:

$$F_i = P_i Q_i - E_i(Q_i) = 0$$

Then each producer's price will equal its average cost:

$$\frac{E(Q)}{\partial E/\partial Q}\cdot\frac{1}{Q} = \left(1+1/\psi_{-1}\right)^{-1}$$

$$\frac{Q}{E(Q)}\cdot\frac{\partial E}{\partial Q} = \left(1+1/\psi_{-1}\right) = \left(\psi/\psi_{1}\right)$$

$$P_i = \frac{E(Q_i)}{Q_i} = \frac{E_i'(Q_i)}{\left(1+1/\psi_{-1}\right)} \quad \text{in eqbm} \qquad \ldots(11)$$

Like the producer which operates under conditions of pure competition the monopolistic competitor's price equals average cost. But like the pure monopolist, its demand schedule will slope downward.

The equilibrium price of the producer can also be derived from its solution in the equality between the demand equation in (3a) and the supply equation in (7). This solution indicates that a producer's price in monopolistic competition is related, not only to market price P, but also to the general price level D, economic activity Y, a secular trend t, and major random disturbances w:

$$P_i = k_6 P^{\omega_1} D^{\omega_2} Y^{\omega_3} t^{\omega_4} w^{\omega_5} \qquad \ldots(12)$$

where $0 < \omega_1 < 1$, $\omega_2 > 0$, $0 < \omega_3 < 1$, $\omega_4 \gtrless 0$, and $\omega_5 < 0$.

The most interesting feature of the expression in equation (12) is the relationship between the producer's price and market price. A change in world market price P of the commodity induces a less-than-proportional response in the producer's price P_i since $0 < \omega_1 < 1$. The reason for the less-than-proportional response is that the price elasticity of producers is always greater than that of market demand. As a result, a change in the quantity demanded of a commodity will lead to a smaller change in a producer's price than in the market price. Hence, the elasticity of the producer's price with respect to market price is less than unity.

The price elasticity $\omega_1 = (\varphi-1)/[(\varphi-1)-\gamma_1]$, that is, the elasticity of the producer's price P_i with respect to the market price P equals the price elasticity of demand $\varphi-1$ divided by itself minus the price elasticity of supply γ_1. In general, the price elasticity of demand is considered to be larger than the price elasticity of supply for primary commodities, the expected value of the elasticity of a producer's price with respect to the market price is near, but less than, unity. Only if the price elasticity of supply were to be completely inelastic with respect to price would a change in market price induce a proportional change in the price of the producer.

The producer's price has the anticipated response to its other determinants in equation (12). It moves in the same direction as a change in either the general price level D or economic activity Y. The change in price of a commodity producer will be greater, the same, or smaller than a change in the general price level. On the other hand, there will always occur a less-than-proportional response in the producer's price as a result of a change in market demand. Major disturbance, usually associated with natural disasters, industrial strikes, and the like, have the expected effect of bringing about a price rise.

The equilibrium quantity produced is found by substitution of the equilibrium price in equation (12) into either the demand schedule in equation (3a) or its supply schedule in equation (7). The resulting equilibrium solution for the quantity produced is not shown here to avoid excessively complicated notation, but the derivation is straightforward.

<u>**Second-Order Condition**</u> - For the equilibrium output of a commodity producer to be a maximum the sufficient condition is that $F''_i(Q_i) < 0$. From equation (8), the second-order condition for a relative maximum is:

$$\frac{\partial P_i}{\partial Q_i} < \frac{\partial F''_i(Q_i)}{\left[1 + \frac{1}{\varphi - 1}\right]} \qquad \ldots(13)$$

that is, the slope of the inverse demand curve must be less than the slope of the inverse supply curve. The slope of the demand curve for a commodity producer is known to be always negative because, as may be recalled, the marginal revenue curve is always downward sloping under monopolistic competition. The slope of the supply curve was shown to depend on returns to scale and, as such, it can be positive, constant, or negative. Specifically, it will be recalled that the supply curve is downward sloping when there are increasing returns to scale. As a result, both the demand and supply curves can be downward sloping. Nonetheless, the second-order condition for a maximum will be satisfied as long as the slope of the demand curve is greater than that of the supply curve.

<u>The Commodity Market</u>

(a) <u>**Equilibrium in Perishable Commodities**</u> - In the case of commodities that are perishable, the system is closed by equilibrium between consumption C and production Q. From the consumption equation in (3a) and the production equation in (7), equilibrium price is:

$$P = k_9 D\, Y^{\xi_1}\, t^{\xi_2}\, w^{\xi_3} \qquad \ldots(14)$$

where ξ_1 and $\xi_3 > 0$, and $\xi_2 \gtrless 0$.

The commodity market price has a proportional response to a change in general price level D. This proportionality implies that the terms of trade for the commodity remains constant in equilibrium. Where the terms of trade not to remain constant then either consumption or production would be related to nominal, rather than constant, prices of the commodity, with the result that the market price would have a non-proportional response to a change in the general price level. The market price is positively related to changes in economic activity Y and major disturbances w such as natural disasters.

(b) <u>Equilibrium in Storable Commodities</u> - When a commodity can be stored for a long time period then equilibrium in the market occurs when the supply, or actual availability, of stocks is equal to the demand for stocks by agents in the market. Market prices may then be determined by the so-called "stock-adjustment processes" (see Labys, 1973: 91-103, for a general discussion and Hwa, 1979 and 1985, for an application). The stock-adjustment process determines an equilibrium price in the commodity market in which the supply of stocks equals the demand for stocks. Supply of stocks is simply defined to be actual stocks on hand; demand for stocks is primarily associated with transactions, precautionary and speculative motives for holding stocks, the transactions and precautionary demand being related to the level of consumption and the speculative demand being related to the expected price of the commodity. The remainder of this chapter will derive the stock-adjustment process determining the world market price of a commodity.

(i) **Supply of Stocks**. The change in the supply of stocks, or inventories, (denoted K^s) is equal to the difference between total world production (Q) and total world consumption (C):

$$\Delta K^s = Q - C \qquad \ldots(15a)$$

(ii) **Demand for Stocks**. The demand for stocks, or inventories, (denoted K^d) arises from transaction and speculative motives. The transactions demand for stocks originates from the desire to hold stocks to meet future consumption. It is therefore related to the level of consumption in the market as well as the cost of holding stocks, as measured by the real rate of interest, denoted R. The speculative demand for stocks is motivated by the desire of economic agents to profit from future price changes; as such, it is related to the commodity's expected price, denoted P^*. The demand for stocks therefore depends on consumption, C, and the real interest rate, R, for transaction purposes and on expected prices, P^*, for speculative purposes:

$$K^d = k_7 C\, R^{\lambda_1}\, P^{*\lambda_2} \qquad \ldots(15b)$$

where $\lambda_1 < 0$ and $\lambda_2 > 0$ since the desire to hold stocks is negatively related to the cost of holding them, and it is positively related to expectations about the price level. Stockholders usually maintain some ratio k_7 of stocks to output C for transactions purposes. Any change in output will bring about a proportional change in the transactions demand for stocks so that, ceteris paribus, the ratio of desired stocks to output will be constant (i.e., $K^d/C = k_7$).

The expected price P^* is assumed to be formed through a rational process. The rational expectations hypothesis of Muth (1961) uses conditional probability theory to argue that expectations about a variable such as the price of a commodity should be treated as a problem of optimal forecasting whereby the minimum mean squared error forecast of that variable is produced by all available information at the time of making the forecast. Thus, at time period t+1 the expected price P^*_{t+1} of a commodity is the expected value of the price, conditional on all information F available at period t to agents in the market:

$$P^*_{t+1} = E(P_{t+1} \mid F) \qquad \ldots(16)$$

Although the concept of the rational expectations hypothesis is simple, its application has proven to be difficult because it is general about what information rational economic agents have available in order to form their expectations (Chan-Lee, 1980: 58-59). Nevertheless, for applied work on a particular system such as a commodity market, it is clear that the expectations must be consistent with the relationships postulated for the system under study. So, in order to form their price expectations, those agents which are speculative buyers of stocks in commodity markets must postulate the same relationships representing the essential features underlying commodity markets as those which have been postulated in this part of the study.

One way to obtain such an approximation of the commodity market price from the relationships postulated in the system is to use the reduced form of the system of equations for the commodity market. The reduced form yields a solution for the market price of the commodity in terms of predetermined variables in the system. In this way, it is enough that the economic agents know what are the predetermined variables in the system and that they then apply a general functional form to the relationship.

In its reduced form, the commodity market price determined by the present system of equations depends on economic activity in the world economy Y, the general price level D, and a trend variable T representing the state of technology for production. Then the relationship describing the formation of expectations about the market price of the commodity can be expressed in the following general functional form:

$$P^{*} = k_8 Y^{\lambda_3} D^{\lambda_4} \qquad \ldots(17)$$

$\ln P^{*} = \ln k_8 + \lambda_3 \ln Y + \lambda_4 \ln D$

with expected signs $\lambda_3, \lambda_4 > 0$. Substitution of equation (17) into equation (15b) yields a stock demand schedule that is expressed in terms of observable variables.

(15b) $K^d = k_7 C R^{\lambda_1} P^{*\lambda_2}$

$\Rightarrow K^d = k_7 C R^{\lambda_1} (k_8 Y^{\lambda_3} D^{\lambda_4})^{\lambda_2}$

(iii) **Market Price**. Equilibrium in the world market of a commodity with stocks is attained when the demand for stocks equals the supply of stocks:

$$K^d = K^s \qquad \text{...(18)}$$

which yields a solution for market price. The solution is a polynomial in price which has powers that are real numbers. Its solution is described in Chapter 2.

Properties of Equilibrium - The equilibrium for commodity trade in monopolistic competition should satisfy three properties: existence, uniqueness, and stability. Although stability of equilibrium is quite easy to ensure and is the most important for purposes of empirical econometric application of the model, the literature on monopolistic competition has been unable to ensure existence or uniqueness without invoking stringent conditions. In particular, asymmetric utility and production schedules lead to equilibria with unequal prices (see Salop and Stiglitz, 1977, Miyao and Shapiro, 1981, and Perloff and Salop, 1982, for an analysis). Here, as in Sattinger (1984), we assume symmetric utility and production schedules, which yield equilibria in which prices are equal.

(i) **Existence and Uniqueness**. There exits an equilibrium solution for commodity trade in monopolistic competition when each producer achieves the first-order condition for maximization of foreign exchange earnings described by equation (9). Situations in which an equilibrium is non-existent in trade models often arise --particularly in their empirical application-- because of improper specification of the coefficient values of functions.

The equilibrium is unique when the first-order condition for maximization of foreign exchange earnings described by equation (11) is satisfied. In this case, the price of the producer is set at a level at which it equals average cost, so net foreign exchange earnings (total revenue less total cost) are zero. A unique equilibrium is ensured by free entry into the market because positive net foreign exchange earnings would induce new production to come onstream until net earnings were eventually reduced to zero. Without free entry, positive net foreign exchange earnings could prevail and it would be possible to have many different solutions.

The first-order condition is a necessary, but not sufficient, condition for a unique solution. The second-order sufficient condition for a maximum described by equation (13) requires that, when there are increasing returns to scale, the negatively sloped supply curve must be greater than the negatively slope of the demand curve. A unique solution will exist for the first-order condition for maximization of foreign exchange earnings once the sufficient condition for a maximum has been ensured.

(ii) **<u>Stability</u>**. Whether an equilibrium is stable for a producer i can be evaluated from its excess demand schedule:

$$ED_i = C_i - Q_i \qquad \text{...(18)}$$

The necessary Walrasian condition for stability is that $\partial ED_i/\partial P_i < 0$. The condition will be satisfied if the supply curve is positive. If it is negative then the slope must be less than that of the demand curve. For the demand and supply schedules in equations (3a) and (7):

$$\frac{\partial ED_i}{\partial P_i} = [(\varphi-1)P_i^{\varphi-1}*\{ROD\} - \gamma_1 P_i^{\gamma_1}*\{ROS\}] \;/\; P_i \qquad \ldots(19)$$

where {ROD} represents rest-of-demand terms and {ROS} represents rest-of-supply terms, whose respective values are both positive. The parameter φ-1 is the demand elasticity and the parameter γ_1 is the supply elasticity. Then Walrasian stable equilibrium occurs when:

$$(\varphi-1)P_i^{\varphi-1} < \gamma_1 P_i^{\gamma_1} \qquad \ldots(20)$$

When there are constant or decreasing returns to scale, the condition is automatically satisfied: the first term is negative since the slope of the demand curve is always negative and the second term is zero (since $\gamma_1 = 0$) or positive (since $\gamma_1 < 0$). On the other hand, if there are increasing returns to scale then $\gamma_1 > 0$ and it is necessary that $\varphi-1 < \gamma_1$ for stability to occur. Since the parameters in equation (20) refer to demand and supply elasticities, specifically $\varepsilon^d = \varphi-1$ and $\varepsilon^s = \gamma_1$, then the stability condition is $\varepsilon^d < \varepsilon^s$.

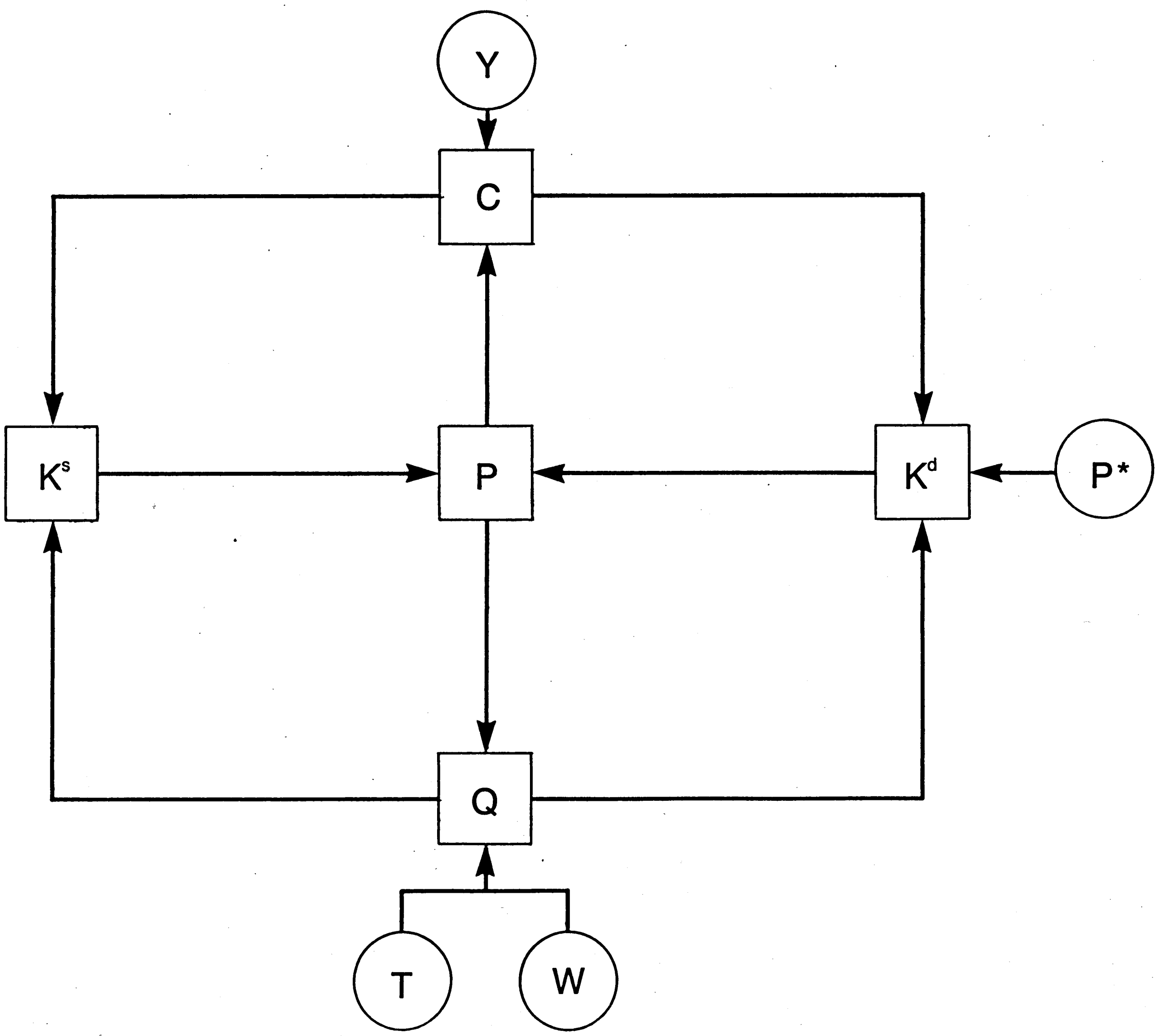
The symmetry assumption ensures that there will be stability of equilibrium in the market when there is stability of equilibrium for each agent. It will be recalled that all producers have identical production schedules. A stable equilibrium in one producer therefore implies overall stability in the commodity market.

1.4 SUMMARY

Figure 1 provides a visual representation of the equations of the system which has been derived in order to describe the underlying features of commodity markets. The variables are enclosed in a box if they are endogenous and in a circle if they are exogenous. The direction of dependence is shown by arrows. An arrow emanating from a box or circle indicates the influence of that variable on another; an arrow penetrating a box or circle shows what influences that variable.

Figure 1

SCHEMATIC DIAGRAM OF COMMODITY MARKET MODEL



VARIABLES

C Consumption

K^d Demand for stocks

K^s Supply of stocks

P Market price

P* Expected market price

Q Production

R Interest rate

T Secular trend

W Major disturbance

Y Income

Chapter 2

DYNAMIC SPECIFICATION

Commodity markets adjust with lagged responses by economic agents, even in time series data with annual periodicity. Suppliers of copper, coffee, and cocoa, for example, take at least six years to completely react to price changes. Only perishable product suppliers, like those of bananas, appear to conform to a static model by completely adjusting their production levels to price changes within the same year. On the demand-side, apart from normal delays the response of trade buyers and consumers, dynamic effects arise in the derived demand for raw materials and for basic, pre-processed foods from filtering the transmission of price changes to final demand for the commodity.

The absence of an instantaneous adjustment in either supply or demand gives rise to observations that can represent states of disequilibrium. If all changes in the explanatory variables were to cease, the dependent market variable of a given relationship in the system would converge to its equilibrium state after a sufficient number of years had elapsed. Actual observations of these variables can therefore be considered to be related to their equilibrium states in a predictable way. Accordingly, the aim of dynamic specification is to describe observed behavior of variables as an adjustment to long-run equilibrium states which are consistent with their postulated equilibrium relationships. The purpose of this chapter is to specify the dynamic relationships that characterize the underlying processes of these adjustments in commodity trade. Succinctly, it seeks to generalize the static, or timeless, relationships formulated in Chapter 1 to their dynamic characterization of adjustment processes toward long-run equilibrium.

2.1 INTRODUCTION

Consider the general form of a long-run equilibrium relationship for any of the behavioral functions postulated in Chapter 1. A simple representation of such a relationship is one between two variables X and Z described by a nonlinear function of the form:

$$X = kZ^{\gamma_o} \qquad \text{...(21a)}$$

where k is some constant. When the above relationship is expressed as a logarithmic function, then the function becomes linear-in-logarithms and is consistent with the form of the equation used to empirically estimate the relationship:

$$x = \alpha + \gamma_o z \qquad \text{...(21b)}$$

where lower-case letters denote the logarithms of upper-case letters, i.e., $x = \ln X$, $z = \ln Z$, and $\alpha = \ln k$. A useful property of equation (21b) is that the calculated coefficient γ_o directly yields the point elasticities of the dependent variable in the expression.

The dynamic specification of any postulated theoretical relationship is based on the introduction of appropriate lags in the explanatory variables. However, when the adjustment of the dependent variable to a change in the value of one of the explanatory variables is gradual, the high correlation between successive lagged values of the explanatory variable can lead to multicollinearity, and imprecise estimates of the coefficients make the lag structure difficult to determine. This problem can be avoided by the use of a stochastic difference equation, whereby the lag structure is approximated by the direct introduction of lagged values of the dependent variable into the equation. The rationale for this construct is that the dependent variable is regarded as a stochastic process in which observations evolve over time on the basis of some probabilistic law. Thus the process that generates the data of the dependent market variable in the current period t is one in which the variable is related to its own past behavior and to present and past behavior of explanatory variables. The first-order stochastic difference equation of the theoretical relationship in equation (21) is expressed as:

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \alpha_2 z_t + \alpha_3 z_{t-1} + v_t \qquad \text{...(22)}$$

where $0 < \alpha_1 < 1$ for the system to be stable; where $\alpha_2, \alpha_3 > 0$ for purpose of exposition; and where all variables are measured in logarithmic terms.

There are two important advantages to specification of the dynamic process in terms of this class of equations. First, as pointed out by Harvey (1981: Chapter 8), the stochastic difference equation lends itself to a specification procedure that moves from a general unrestricted dynamic model to a specific restricted model. At the outset there is a deliberate inclusion of all the explanatory variables postulated by economic theory and of lags of a relatively higher order than appear in equation (22). From the results obtained, decisions are made about whether or not a particular explanatory variable should be retained and which lags are important. The second advantage of the use of the stochastic difference equation relates to the estimation procedure. Mizon (1983) has noted that if there are sufficient lags in the dependent and explanatory variables, then the stochastic difference equation can be defined to have a white noise process in its disturbance term. As a result, the ordinary least squares estimator for the coefficients will be fully efficient.

Dynamic Equilibrium - The long-run dynamic solution of a single-equation system generates a steady-state response in which growth occurs at a constant rate, say π, and all transient responses have disappeared. For the dynamic specification of the relationship described by equation (21), if π_1 is defined to be the steady-state growth rate of the dependent variable, X, and π_2 corresponds to the steady-state growth rate of the explanatory variable, Z, then since lower case letters denote the logarithms of variables, $\pi_1 = \Delta x$ and $\pi_2 = \Delta z$ in dynamic equilibrium. For the more general dynamic specification of such a relationship, Currie (1981) and Patterson and Ryding (1984) have derived the long-run dynamic equilibrium solution. The approach used by Currie will be adopted here in order to derive the long-run dynamic equilibrium properties of our simple relationship between a commodity market variable and its explanatory variable.

The first step is to find the relationship between the rate of change of the relevant market variable, Δx, and that of its explanatory variable, Δz. Given the systematic dynamics of the general stochastic difference equation (22), add $(-x_{t-1})$ both sides:

$$\Delta x_t = \alpha_0 + (\alpha_1-1)x_{t-1} + \alpha_2 z_t + \alpha_3 z_{t-1} + v_t$$

Then subtract $(\alpha_2 y_{t-1})$ from the third term and add it to the fourth term:

$$\Delta x_t = \alpha_0 + (\alpha_1-1)x_{t-1} + \alpha_2\Delta z_t + (\alpha_2+\alpha_3)z_{t-1} + v_t$$

or

$$\Delta x_t = \alpha_0 + \beta_1 x_{t-1} + \alpha_2\Delta z_t + \beta_3 z_{t-1} + v_t \qquad \text{...(23)}$$

where $\beta_1 = \alpha_1-1$ and $\beta_3 = \alpha_3+\alpha_3$, and where the expected signs are $-1 < \beta_1 < 0$ and $\alpha_2, \beta_3 > 0$.

Next, take the first difference of equation (22):

$$\Delta x_t = \alpha_1\Delta x_{t-1} + \alpha_2\Delta z_t + \alpha_3\Delta z_{t-1}.$$

Since in dynamic equilibrium $\Delta x = \pi_1$ and $\Delta z = \pi_2$, it follows that

$$(1-\alpha_1)\pi_1 = (\alpha_2 + \alpha_3)\pi_2.$$

Hence

$$\pi_1 = \frac{\alpha_2-\alpha_3}{1-\alpha_1}\pi_2 \qquad \text{...(23')}$$

Then for the systematic dynamics of the transformed stochastic difference equation (23'):

$$\pi_1 = \alpha_0 + \beta_1 x_{t-1} + \alpha_2\pi_2 + \beta_3 z_{t-1}$$

Substitution of this expression for π_1 in equation (23') and rearrangement of terms yields the long-run dynamic relationship:

$$x = -\frac{\alpha_0}{\beta_1} - \frac{\alpha_1\alpha_2 + \alpha_3}{\beta_1}\pi_2 - \frac{\alpha_2 + \alpha_3}{\beta_1} z$$

or in terms of the original values of the variables:

$$X = k_o^* Z^{\gamma_o} \qquad \ldots(24)$$

where $k_o^* = \exp\text{-}\{\alpha_0/\beta_1 + [(\alpha_1\alpha_2 + \alpha_3)/\beta_1^2\ ]\pi_2\}$ and $\gamma_o = -\beta_3/\beta_1$, whose expected value is positive. Equation (24) encompasses the static equilibrium solution when $\pi_2 = 0$.

The steady-state solutions, unlike the static equilibrium solution, shows X to be influenced by changes in the rate of growth of Z --despite the same long-run elasticity of X with respect to Z in both the static and dynamic solutions. In particular, the dynamic solution in equation (24) indicates that were the rate of growth of the explanatory variable to accelerate, say from π_2 to π_2', the value of the variable X would increase 1/.

Although in our simple example X depends solely on Z and the response is one which generates steady-state growth, in practice more than one explanatory variable often characterizes the underlying process of the market variable. Moreover, the response to each explanatory variable can be either transient or steady-state. Where theoretical considerations suggest that an explanatory variable generates a transient, rather than a steady-state, response it is

1/ Because of the dependence of the long-run dynamic solution on both the growth rates and levels of the explanatory variables that determine the steady-state response, Currie (1981) has warned against policy stimulations and forecasts that rely on unstable growth rates for those explanatory variables.

appropriate to constrain its long-run effect to zero 1/.

2.2 PRODUCTION

Supply of a commodity is primarily related to the price received by producers. The relationship between production and market price is often characterized by long lags since the effects of price changes usually take a long time to work themselves through to supply. Moreover, transmission of the price effects can be complex. For example, a price rise could induce a short-term response from new plantings, higher yields, or stock depletion; it could induce a medium-term response from an expansion in installed capacity; and it could induce a long-term response from new capacity initiation. For these reasons, the nature of the response to price changes is central to the dynamic specification of supply.

The nature of the response can be roughly estimated in a general unrestricted equation relating supply to a sequence of lagged prices. However, since unrestricted estimation is inefficient when slow lag responses exist, it is appropriate to introduce lag structures which suitably represent the underlying nature of the response once the response has been approximated in the unrestricted equation estimate. Consistent with the general approach outlined in the previous section to represent the data generating process, the lag structure in the supply equation is represented by a stochastic difference equation.

1/ Patterson and Ryding (1984) have demonstrated that the imposition of such a constraint on one explanatory variable can induce substantial changes in the lag distribution of not only that variable but all others. Consequently, they warn against routine applications of such constraints.

Accordingly, the expression for production, Q, in terms of own market price, P, relative to the general price deflator, D, and other price P_o for competing or complementary goods, as well as major disturbances, W, and a secular trend, T, is given by:

$$q_t = \alpha_{10} + \alpha_{11} q_{t-1} + \alpha_{12} q_{t-2} + \sum_{n=0}^{s} \alpha_{13+n} (p-d)_{t-n}$$

$$+ \beta_{15} (p_o - d)_{t-m} + \gamma_{16} T + \gamma_{17} W_t + v_{1t} \qquad \ldots(25)$$

where lower-case letters denote logarithms of corresponding capital letters, eg., $(p-d) = \ln(P/D)$, and where the expected signs of the explanatory variables are $\alpha_{13+n} > 0$ and $\gamma_{16}, \gamma_{17} \lessgtr 0$. The expected signs of the coefficients α_{11} and α_{12} of the lagged dependent variable, Q, must satisfy the following constrains in order that the equation imply a non-negative and convergent lag distribution for Q (see Griliches, 1967: 27): (a) $0 < \alpha_{11} < 2$, (b) $-1 < \alpha_{12} < 1$, (c) $[1 - \alpha_{11} - \alpha_{12}] > 0$, (d) $\alpha_{11}^2 \geq -4\alpha_{12}$. (Note that restrictions (a) and (c) imply (b)). If there were only a one-period lag in the dependent variable then it would be necessary that the restriction $0 < \alpha_{11} < 1$ be met. The maximum lag of the dependent variable in the above expression is two periods, since for annual time-series data longer lags are seldom used in practice. A one-period lag produces a dampened smooth approach to the new equilibrium solution, whereas a two-period lag can produce a dampened cyclical movement to the new equilibrium solution.

The advantage of the above stochastic equation, which by construction has white noise disturbances, diminishes when serial correlation appears in relationships formulated with levels variables. As mentioned earlier, dynamics of relatively high order often characterize supply relationships because of complex structures of the lag response to price variations. Even if the correct estimation procedure is adopted, the coefficient estimates of the stochastic difference equation can be imprecise when the dynamics are of a relatively high order, the reason being multicollinearity between lagged values of a market variable. Yet correction of residual autocorrelation by an autoregressive process is invalid in the absence of a common factor assumption test for dynamic misspecification (Sargan, 1980; see also Hendry and Mizon, 1978). On the other hand, reformulations with only differences variables meant to avoid serial correlation when the true relationship is in terms of levels will introduce an additional moving average term into the disturbance (Plosser and Schwert, 1977).

The problem can be remedied by transformation of the equation in such a way that "differences" formulations of the variables are nested in the levels form of the equation:

$$\Delta q_t = \alpha_{10} + \beta_{11} q_{t-1} + \alpha_{12} q_{t-2} + \sum_{k=0}^{n-1} \alpha_{13+k} \Delta(p-d)_{t-k} + \beta_{14}(p-d)_{t-k-1} + \beta_{15}(p_o-d)_{t-m} + \gamma_{16} T + \gamma_{17} W_t + v_t \quad \ldots(26)$$

where $\beta_{11} = \alpha_{11} - 1$, $\beta_{14} = \sum_{k=0}^{n} \alpha_{13+k}$. The expected sign of the own price variable coefficients are $\alpha_{13+k} \lessgtr 0$, and $\beta_{14} > 0$. Hence, $\Delta \ln(P/D)$ may have a negative coefficient, which does not preclude the derived coefficients for the levels formulation of the price variables from being all positive. For the transformed equation to imply a non-negative and convergent lag distribution for Q, the restrictions on the coefficients of the lagged dependent variable becomes: (a) $-1 < \beta_{11} < 1$, (b) $-1 < \alpha_{12} < 1$, (c) $\beta_{11}+\alpha_{12} < 0$, (d) $(1+\beta_{11})^2 \geq \alpha_{12}$.

The formulation of the relationship in equation (26) avoids the problem of indeterminate long-run dynamic equilibrium solutions in equations with only first-differenced variables whose relationship would then be considered to be jointly stationary. At the same time it remedies the problem of spurious correlations associated with regressions of trending variables in levels (see for example Granger and Newbold, 1974, or in a lighter vein, Hendry, 1980).

Steady-State Solution - Production of a commodity has a transient response to the rate of change of it constant dollar price. As such, the long-run dynamic solution to the dynamic specification is the same as that for the static solution. Following the procedure outlined in the introduction to this chapter, since $\Delta \ln(P/D) = 0$ implies $\Delta q = 0$, the long-run relationship in equation (26) is:

$$Q = k_1(P/D)^{\gamma_5} e^{\gamma_6 T + \gamma_7 W} \qquad ...(27)$$

where $k_1 = \exp[-(\alpha_{10}/\beta_{12})]$, $\gamma_5 = -\beta_{14+s}/(\beta_{11}+\alpha_{12})$, $\gamma_6 = -\beta_{15}/(\beta_{11}+\alpha_{12})$, and $\gamma_7 = -\beta_{16}/(\beta_{11}+\alpha_{12})$, the expected signs being $\gamma_5 > 0$, γ_6 and $\gamma_7 \gtrless 0$. Hence the long-run equilibrium solution of production depends solely on the level of its explanatory variables and is independent of the rate of growth of any one of them.

2.3 CONSUMPTION

The demand for a commodity by trade buyers and consumers is postulated to have a steady-state response to income and a transient response to the constant dollar price of the product. The life-cycle approach to consumption (see Deaton and Muellbauer, 1980, Ch. 12) emphasizes income as a determinant of intertemporal consumption planning and provides theoretical justification for the existence of the dynamic effect on demand from changes in the rate of growth of income. On the other hand, the steady-state response to price is likely to be transient.

An important characteristic of demand for commodities is that its steady-state response to the growth in domestic national income is not necessarily proportional. As Nurkse (1959:57) noted, "The main point we must recognize is that this focal center [the industrialized countries], in terms of real income per head, is advancing vigorously, but is not transmitting its own rate of growth to the rest of the world through a proportional increase in its demand for primary products." Whether or not this characterization is correct, the point it suggests is that the dynamic specification of the demand equation should not introduce any restrictions that would impose long-run unitary elasticity with respect to income, as in the theoretical specification of the consumption schedule in equation (1.3a).

Another feature is that in annual time-series data the dynamics for demand relationships are conveniently restricted to where the lags in the variables are of one period. Accordingly, in terms of the general stochastic difference specification, the expression for consumption, C, in terms of income, Y, and the commodity's price P relative to the general price index D is given by:

$$c_t = \alpha_{20} + \alpha_{21}y_t + \alpha_{22}y_{t-1} + \alpha_{23}(p-d)_t + \alpha_{24}(p-d)_{t-1} + \alpha_{25}c_{t-1} + v_{2t} \qquad \ldots(28)$$

where lower case letters denote logarithms of corresponding capitals; where the expected signs are α_{21}, $\alpha_{22} > 0$; α_{23}, $\alpha_{24} > 0$; $0 < \alpha_{25} < 1$.

Since the growth rate of consumption depends on the expansion path of income, transformation of the above general specification to an "error correction mechanism," or ECM, specification provides a means by which to ensure theoretical consistency of the long-run equilibrium relationship with short-run observed behavior of demand (see Hendry, Pagan, and Sargan, 1984). Equation (11) can be transformed to an ECM form by imposing the restriction that $\alpha_{21} + \alpha_{22} + \alpha_{25} = 1$. Further transformation so that a "difference" formulation is nested in the levels form of the relative price terms yields:

$$\Delta c_t = \alpha_{20} + \alpha_{21}\Delta y_t + \beta_{22}(c-y)_{t-1} + \beta_{23}y_{t-1} + \beta_{24}\Delta(p-d)_t + \beta_{25}(p-d)_{t-1} + v_{2t} \qquad \ldots(29)$$

where $\beta_{22} = (\alpha_{25}-1)$, $\beta_{23} = (1-\alpha_{21}-\alpha_{22}-\alpha_{25})$, $\beta_{24} = \alpha_{23}$, $\beta_{25} = (\alpha_{23}+\alpha_{24})$, and where the expected signs on the new coefficients are $-1 < \beta_{22} < 0$, $\beta_{23} > \beta_{22}$, and β_{24}, $\beta_{25} < 0$. The term $\beta_{23}y_{t-1}$ accounts for any non-proportional response of demand for a commodity as a result of a change in the level of income. When $\beta_{22} < \beta_{23} < 0$, consumption is inelastic with respect to income; when $\beta_{23} = 0$ it has a unitary elasticity; and when $\beta_{23} > 0$ it is income elastic.

Important features of the above specification for the consumption relationship are, first, the disequilibrium adjustment mechanism in the third term corrects for any previous deviation of consumption from its steady-state path due, for instance, to some transient disturbance; second, the "short-term" income and market price effects are embodied in the second and fifth terms, as measured in first difference equations; third, the formulation avoids the problem of indeterminate equilibrium solutions in equations of differences only and, at the same time, it remedies the problem of spurious correlations associated with regressions of trending variables in levels (see for example Granger and Newbold, 1974); finally, it is theory-consistent in that the specification reproduces the equilibrium solution in equation (1.3a).

Steady-State Solution - On a steady-state growth path, $\Delta c = \pi_3$ and $\Delta y = \pi_4$ are the growth rates of consumption and income respectively. Since market prices would not be expected to have any long-run dynamic influence, their effect is constrained to zero so that $\Delta p = 0$ in the long run. Hence, following the procedure outlined in section 1 above, the long-run dynamic relationship implicit in equation (29) is found to be:

$$C = k_2 Y^{\gamma_1} (P/D)^{\gamma_2} \qquad \ldots(30)$$

where $k_2 = \exp\{-[(\alpha_{20} + \alpha_{21}\pi_4)/\beta_{22}]\}$. Furthermore, $\gamma_1 = 1-(\beta_{23}/\beta_{22})$ with an expected positive value, and $\gamma_2 = -\beta_{25}/\beta_{22}$ with an expected negative value. Therefore, on a steady-state growth path, the level of consumption depends on the rate of growth of income, as well as on the levels of income and the price of the commodity.

2.4 DEMAND FOR STOCKS

In theory, we postulated that agents seek to maintain stocks at a constant proportion of the level of consumption. However, Labys (1973: 62-71) has suggested that in commodity markets "inventories vary directly and proportionately with output." This relationship is motivated by the desire of producers to maintain reserves with which to avoid delay and provide continuity in supplies. We therefore consider alternative dynamic specifications for the demand for stocks, one in which agents adjust stock levels to consumption levels; the other, in which they adjust stock levels to output levels.

Demand for stocks is expected to have has a proportional response to changes in consumption or production of the commodity. This characteristic suggests that the estimated relationship should yield a unitary elasticity of demand for stocks with respect to consumption or production of the commodity in its long-run dynamic equilibrium solution. However, we shall allow for a test of proportionality when estimating the relationship.

The first specification postulates that stocks are held as a constant proportion of consumption. Transformation of the general stochastic difference equation so that demand for stocks, K^d, has an error correction mechanism driven by consumption, C, with a "differences" formulations of the general price level, D, interest rates, I, and income, Y, nested in their original levels form yields:

$$\Delta k_t^d = \alpha_{30} + \alpha_{31}\Delta c_t + \beta_{32}(k^d - c)_{t-1} + \beta_{33}c_{t-1} + \alpha_{34}\Delta d_t + \beta_{35}d_{t-1} + \alpha_{36}\Delta i_t + \beta_{37}i_{t-1} + \alpha_{38}\Delta y_t + \beta_{39}y_{t-1} + v_{3t} \quad \ldots(31a)$$

where the expected signs are α_{31}, α_{34}, β_{35}, α_{38}, $\beta_{39} > 0$, where α_{36}, $\beta_{37} < 0$, and where $-1 < \beta_{32} < 0$ and $\beta_{33} > \beta_{32}$. The term $\beta_{33}c_{t-1}$ tests for any non-proportional response of demand for a commodity to a change in the level of consumption.

The long-run dynamic equilibrium relationship implicitly in equation (31a) is:

$$K^d = k_3 C^{\gamma_8} D^{\gamma_9} I^{\gamma_{10}} Y^{\gamma_{11}} \quad \ldots(32a)$$

where $k_3 = \exp\{-[(\alpha_{30} + \alpha_{31}\pi_5)/\beta_{32}]\}$, $\gamma_8 = 1-(\beta_{33}/\beta_{32}) > 0$, $\gamma_9 = (-\beta_{35}/\beta_{32}) > 0$, $\gamma_{10} = (-\beta_{37}/\beta_{32}) < 0$, and $\gamma_{11} = (-\beta_{39}/\beta_{32}) > 0$.

The second specification postulates that stocks are held as a constant proportion of output, Q. Then the general form of the market price equation is:

$$\Delta k_t^d = \alpha_{30} + \alpha_{31}\Delta q_t + \beta_{32}(k^d - q)_{t-1} + \beta_{33}q_{t-1} + \alpha_{34}\Delta d_t + \beta_{35}d_{t-1} + \alpha_{36}\Delta i_t + \beta_{37}i_{t-1} + \alpha_{38}\Delta y_t + \beta_{39}y_{t-1} + v_{3t} \quad \ldots(31b)$$

where the expected signs of the coefficients are the same as those in equation (31a), and where the steady-state solution is given by:

$$K^d = k_3 Q D^{\gamma_7} I^{\gamma_8} Y^{\gamma_9} \qquad \text{...(32b)}$$

the parameters being defined as in equation (32a) above.

2.5 MARKET PRICE

When the commodity is perishable, price is determined by the equilibrium condition between production and consumption. As specified in equation (1.14), the market price might have a proportional response to a change in the general price level. A proportional response implies that the commodity terms of trade remains constant over time. In the dynamic specification of the relationship, we allow for a test of proportionality between changes in the commodity market price and the general price level.

As such, market price, P, has an error correction mechanism driven by the general price level, D, with a "differences" formulation of the general level of income, Y, as well as a trend, T, and major random disturbances, W:

$$\begin{aligned} \Delta p_t = \; & \alpha_{40} + \alpha_{41}\Delta d_t + \beta_{42}(p-d)_{t-1} + \beta_{43}d_{t-1} + \alpha_{44}\Delta y_t \\ & + \beta_{45}y_{t-1} + \alpha_{46}T + \alpha_{47}W_t + v_{4t} \end{aligned} \qquad \text{...(33a)}$$

where the expected signs are α_{41}, α_{44}, $\beta_{45} > 0$, where $-1 < \beta_{42} < 0$ and $\beta_{43} > \beta_{42}$, and where α_{46} and $\alpha_{47} \gtrless 0$. The term $\beta_{43}d_{t-1}$ tests for any non-proportional response of the commodity market price to a change in the general price level.

When the commodity can be stored for a long time period then its price is determined by the adjustment of actual stock levels to desired stock levels. If production and consumption are both related to the current price of the commodity, the solution given by equation (1.18) is a polynomial in price equal to $aP^{\gamma_1} + bP^{\varphi - 1} = K_t$, where a and b are constant terms composed of relatively complicated expressions of predetermined variables and their coefficients. The polynomial in price has powers that are real numbers which can be approximated through numerical methods.

The market price equation is simpler when there is a non-contemporaneous response to a price change in either production or consumption of a commodity. Then, the price equation is no longer a polynomial in price. In general, it is likely that production of a commodity has a non-contemporaneous response to market price changes. Delays in the response arise because of the time that elapses between when the price of a commodity changes and when a change in the level of production begins to occur. Then the solution for market price is:

$$P_t = \left[\frac{Q_t - \Delta K_t}{e^{\alpha_{20}} \, Y_t^{\alpha_{21}} \, Y_{t-1}^{\alpha_{22}} \, D_t^{-\alpha_{23}} (P/D)_{t-1}^{\alpha_{24}} \, C_{t-1}^{\alpha_{25}}} \right]^{\frac{1}{\alpha_{23}}} \quad \ldots(33b)$$

where the numerator of the expression in brackets is total supply of the commodity, and where the expression is raised to a power that is the inverse of the price elasticity of demand for the commodity.

Equation (33b) describes the way in which price changes may take place in a market. First, it should be noted that the expected sign of the price elasticity of demand α_{23} in the exponent of the term is negative, and so the term inside the bracket is inverted (the numerator becomes the denominator and vice versa). An increase in the difference between total supply and desired stocks will induce a fall in the market price, whereas any decrease in the difference will cause the market price to increase. It can also be observed from the equation that the market price will move in the same direction as a change in either income or the general price level.

When consumption responds with a lag to market price changes, then the general form of the relationship becomes:

$$P_t = \left[\frac{C_t + \Delta K_t}{e^{\alpha_{10}}\, Q_{t-1}^{\alpha_{11}}\, Q_{t-2}^{\alpha_{12}}\, D_t^{-\alpha_{13}}\, (P/D)_{t-n}^{\alpha_{14}}\, e^{\gamma_{15}T + \gamma_{16}W_t}}\right]^{\frac{1}{\alpha_{13}}} \qquad \ldots(33c)$$

where α_{13} is the short-term price elasticity of supply, and the coefficients in the denominator of the expression in brackets are defined as in the supply equation (25). The numerator of the expression in brackets is total availability of the commodity; the denominator represents the inverse supply function.

2.6 SUMMARY

This chapter has derived the dynamic specification of commodity market relationships for adjustment processes toward long-run equilibrium solutions that are consonant with the equilibrium specifications of the commodity trade theory formulated in Chapter 1. In particular, the relationship between commodity market theory and observations of market behavior is that observed behavior eventually converge to steady-state equilibrium growth if all change were to cease in variables used to characterize the underlying processes of commodity markets. However, the dynamics in the system introduce an additional effect that shows that dependent market variables respond, not only to changes in the level of the explanatory variables, but also to changes in the rates of growth of those variables that generate a steady-state response.

The dynamic processes of adjustment have been described by stochastic difference equations. The supply relationship is usually characterized by long and complicated lag structures. Since the nature of the response to price changes is central to its dynamic specification, the stochastic difference equation framework provides a convenient means which which to move from a general to a particular lag structure. For the consumption and stock demand relationships, the error correction mechanism offers a particularly appropriate means by which to characterize their data-generating processes within this class of equations.

SUMMARY OF DYNAMIC SYSTEM OF EQUATIONS FOR COMMODITY MARKETS

Notations -

C Consumption.
D General price level.
K^d Demand for stocks.
K^s Supply of stocks.
P Market price.
Q Production.
T Secular trend.
W Major disturbance.
Y Income.

I. Structural System of Equations

(Lower-case letters denote logarithmic values of variables)

(a) Production

$$\Delta q_t = \alpha_{10} + \beta_{11}q_{t-1} + \alpha_{12}q_{t-2} + \sum_{k=0}^{n-1} \alpha_{13+k}\Delta(p-d)_{t-k} + \beta_{14}(p-d)_{t-k-1} + \beta_{15}(p_o-d)_{t-m} + \gamma_{16}T + \gamma_{17}W_t + v_t \quad ...(26)$$

where $\alpha_{13+k} \lesseqgtr 0$, and $\beta_{14} > 0$ for the coefficients of the lagged dependent variable (a) $-1 < \beta_{11} < 1$, (b) $-1 < \alpha_{12} < 1$, (c) $\beta_{11}+\alpha_{12} < 0$, (d) $(1+\beta_{11})^2 \geq \alpha_{12}$.

(b) Consumption

$$\Delta c_t = \alpha_{20} + \alpha_{21}\Delta y_t + \beta_{22}(c-y)_{t-1} + \beta_{23}y_{t-1} + \beta_{24}\Delta(p-d)_t + \beta_{25}(p-d)_{t-1} + v_{2t} \quad ...(29)$$

where $\alpha_{21} > 0$, $-1 < \beta_{22} < 0$, $\beta_{23} > \beta_{22}$, and β_{24}, $\beta_{25} < 0$.

(c) Demand for Stocks

$$\Delta k_t^d = \alpha_{30} + \alpha_{31}\Delta c_t + \beta_{32}(k^d-c)_{t-1} + \beta_{33}c_{t-1} + \alpha_{34}\Delta d_t + \beta_{35}d_{t-1} + \alpha_{36}\Delta i_t + \beta_{37}i_{t-1} + \alpha_{38}\Delta y_t + \beta_{39}y_{t-1} + v_{3t} \quad ...(31a)$$

or

$$\Delta k_t^d = \alpha_{30} + \alpha_{31}\Delta q_t + \beta_{32}(k^d - q)_{t-1} + \beta_{33}q_{t-1} + \alpha_{34}\Delta d_t + \beta_{35}d_{t-1} + \alpha_{36}\Delta i_t + \beta_{37}i_{t-1} + \alpha_{38}\Delta y_t + \beta_{39}y_{t-1} + v_{3t} \quad \ldots(31b)$$

where the expected signs are α_{31}, α_{34}, β_{35}, α_{38}, $\beta_{39} > 0$, where α_{36}, $\beta_{37} < 0$, and where $-1 < \beta_{32} < 0$.

(d) Supply of Stocks

$$K_t^s = K_{t-1}^s + Q_t - C_t$$

(e) Equilibrium

$$K_t^d = K_t^s \quad \ldots(1.18)$$

II. Steady-State Solutions

(a) Production

$$Q = K_1(P/D)^{\gamma_5} e^{\gamma_6 T + \gamma_7 W} \quad \ldots(27)$$

where $K_1 = \exp[-(\alpha_{10}/\beta_{12})]$, $\gamma_5 > 0$, γ_6 and $\gamma_7 \gtrless 0$.

(b) Consumption

$$C = k_2 Y^{\gamma_1}(P/D)^{\gamma_2} \quad \ldots(30)$$

where $k_2 = \exp\{-[(\alpha_{20} + \alpha_{21}\pi_4)/\beta_{22}]\}$, $\gamma_1 = 1-(\beta_{23}/\beta_{22})$ with an expected positive value, and $\gamma_2 = -\beta_{25}/\beta_{22}$ with an expected negative value.

(c) Demand for Stocks

$$K^d = k_3 C^{\gamma_8} D^{\gamma_9} I^{\gamma_{10}} Y^{\gamma_{11}} \quad \ldots(32a)$$

or

$$K^d = k_3 Q^{\gamma_8} D^{\gamma_9} I^{\gamma_{10}} Y^{\gamma_{11}} \quad \ldots(32b)$$

where $k_3 = \exp\{-[(\alpha_{30} + \alpha_{31}\pi_5)/\beta_{32}]\}$, $\gamma_8 = 1-(\beta_{33}/\beta_{32}) > 0$, $\gamma_9 = (-\beta_{35}/\beta_{32}) > 0$, $\gamma_{10} = (-\beta_{37}/\beta_{32}) < 0$, and $\gamma_{11} = (-\beta_{39}/\beta_{32}) > 0$.

III. Reduced Forms of Price Equation

(a) Perishable Commodities:

$$\Delta p_t = \alpha_{40} + \alpha_{41}\Delta d_t + \beta_{42}(p-d)_{t-1} + \beta_{43}d_{t-1} + \alpha_{44}\Delta y_t + \beta_{45}y_{t-1} + \alpha_{46}T + \alpha_{47}W_t + v_{4t} \qquad \text{...(33a)}$$

where the expected signs are $\alpha_{41}, \alpha_{44}, \beta_{45} > 0$, where $-1 < \beta_{42} < 0$ and $\beta_{43} > \beta_{42}$, and where α_{46} and $\alpha_{47} \gtrless 0$

(b) Storable Commodities: Production and Consumption Respond to Current Price Changes

$$aP^{\gamma}1 + bP^{\varphi-1} = K_t$$

where a and b are complex constant terms composed of coefficients on predetermined variables, and the polynomial in price has powers that are real numbers.

(c) Storable Commodities: Consumption Responds to Current Price Changes; Production Responds with a Lag

$$P_t = \left[\frac{Q_t - \Delta K_t}{e^{\alpha_{20}}\, Y_t^{\alpha_{21}}\, Y_{t-1}^{\alpha_{22}}\, D_t^{-\alpha_{23}}(P/D)_{t-1}^{\alpha_{24}}\, C_{t-1}^{\alpha_{25}}}\right]^{\frac{1}{\alpha_{23}}} \qquad \text{...(33b)}$$

where the numerator of the expression in brackets is total supply of the commodity, and where the expression is raised to a power that is the inverse of the price elasticity of demand for the commodity.

(d) Storable Commodities: Production Responds to Current Price Changes; Consumption Responds with a Lag

$$P_t = \left[\frac{C_t + \Delta K_t}{e^{\alpha_{10}}\, Q_{t-1}^{\alpha_{11}}\, Q_{t-2}^{\alpha_{12}}\, D_t^{-\alpha_{13}}\, (P/D)_{t-n}^{\alpha_{14}}\, e^{\gamma_{15}T + \gamma_{16}W_t}}\right]^{\frac{1}{\alpha_{13}}} \qquad \text{...(33c)}$$

where α_{13} is the short-term price elasticity of supply, and the coefficients in the denominator of the expression in brackets are defined as in the supply equation (25).

PART II

THE INDIVIDUAL MARKETS

The structure of the commodity markets for which models have been developed in this study have distinct conditions affecting price formation. This part describes the market structure of the commodities and explains how the characterization of these markets has been incorporated into the general specification of the model developed in Part I.

Chapter 3

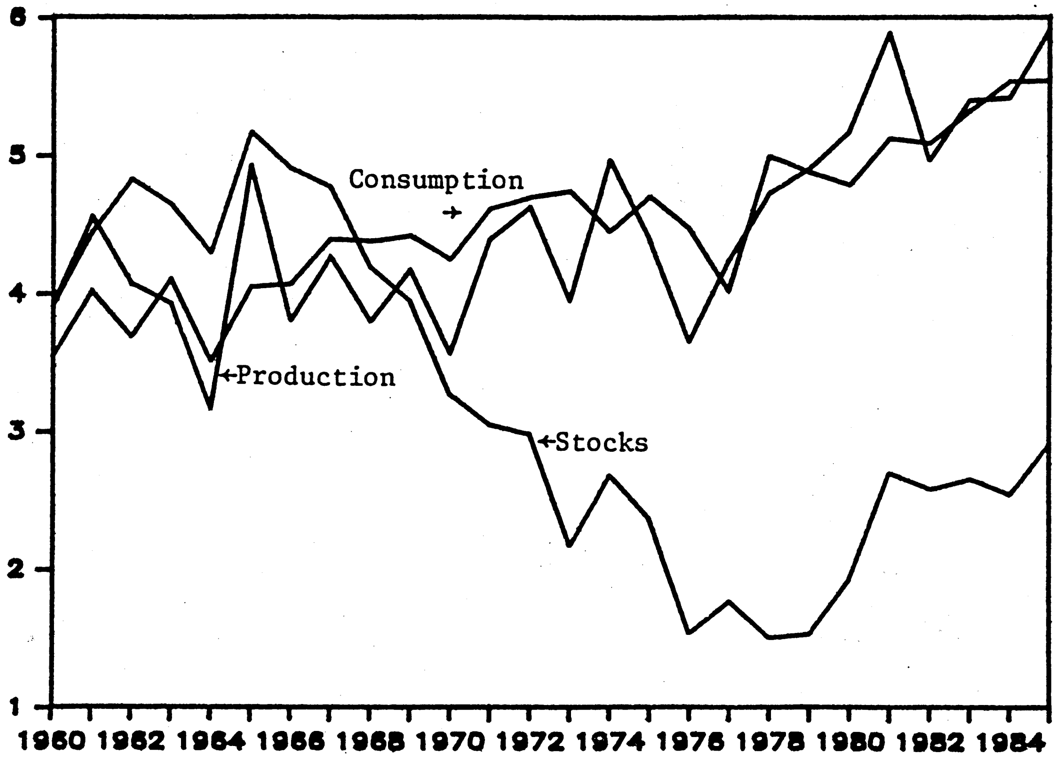
COFFEE

There are important differences in the time profile of response of coffee demand and supply to price changes. Whereas the consumption response is fairly rapid, production is slow to respond to price changes that occur as a result of either changes in consumption or changes in supply availability arising from natural disasters in major coffee producing countries. Since Brazil's crop accounts for 33 percent of world output and since the major coffee-producing states of this country are susceptible to frost and drought damage, output conditions in Brazil have a potentially large influence on world market prices.

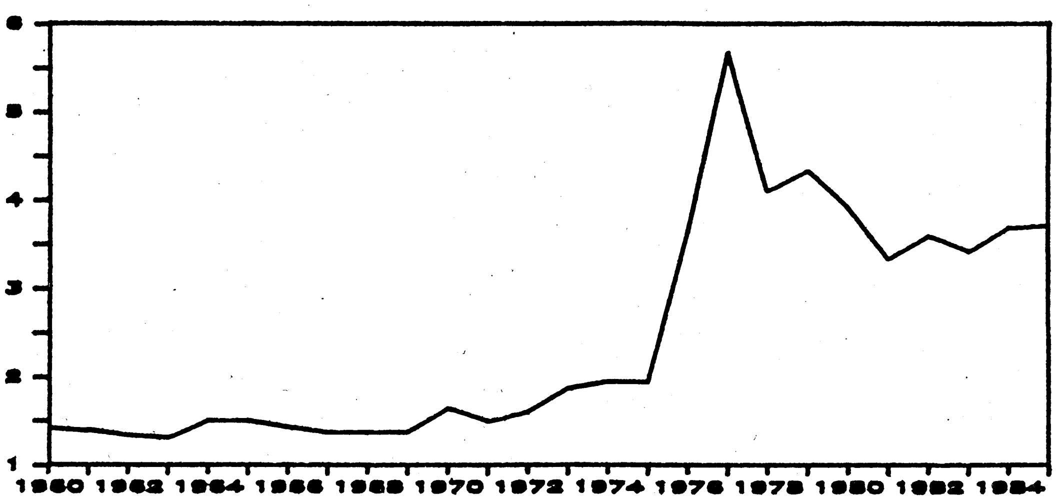
The lagged supply response to price changes brings about production cycles in the world coffee market. When prices are high, producers expand tree stocks and new plantings begin to bear fruit two to seven years later. The introduction of new production into the market tends to drive down the price of coffee. The converse holds when prices fall. Once production has been cut back, a shortage of coffee tends to

Figure 2

COFFEE: WORLD PRODUCTION, CONSUMPTION, AND STOCKS
(millions of metric tons)



COFFEE: WORLD MARKET PRICE
(thousands of dollars a metric ton)



Source: Appendix B.

develop, coffee prices rise, and the planting cycle begins once again. However, the lag between price and output changes tends to be greater when there is a price rise than when there is a price decline, the reason being that it is possible for producers to reduce their tree stocks in a relatively short period of time when prices are low.

3.1 PRODUCTION

Production of coffee is almost exclusively confined to tropical areas. Although grown in many developing countries, production is concentrated in a few countries. Brazil, Colombia, the Ivory Coast and Indonesia account for more than one-half of world coffee output. Some of these larger producers are also heavy consumers of coffee. Brazil, for example, consumes one-third of its production, and Colombia consumes about 15 percent of its output. However, the major world markets are industrialized countries. The United States and Western Europe together absorb 80 percent of total world trade.

Product Characteristics - Coffee crops are produced from two types of trees, arabica and robusta. Because coffee is sensitive to very cold temperatures and rainfall, climate plays a particularly important role in production. Arabicas are grown mainly in Latin America at higher altitudes or at farther distances from the equator than robustas because their cultivation requires temperatures below those found in lowland areas around the equator. This category of coffee is further separated into washed, or mild arabicas, and unwashed arabicas, depending on the treatment used to remove the coffee beans. "Washed" coffee fruit is depulped immediately after it is harvested, and then it is placed in water to remove any remaining pulp; "unwashed" coffee fruit is dried first and afterwards depulped to free the coffee bean. The end result of these processes is called green coffee. This is the typical form in which coffee enters the international market. The washed, or mild arabicas, is further characterized as "Colombian Milds" or "Other Milds," although this categorization has little technical relevance 1/.

Robusta coffee is primarily grown in Africa, Asia and Oceania. Soluble, or instant, coffee is produced from this type of tree. Robusta can can also be blended with arabica and sold as roasted coffee. This type has improved its position in the world coffee market because of increased demand for instant coffee and because robusta trees are less susceptible to disease than arabicas. According to data from the United States Department of Agriculture (USDA, 1984), the share of robustas in total world production of coffee has increased from 23 per cent in 1974 to 27 percent in 1984, whereas the share of arabicas has declined from 76 to 73 percent during the same period. Paralleling the expansion of robustas in the market has been the penetration of soluble coffee in world trade. Its share increased from 3.5 percent in 1974 to 4.4 percent in 1984. But coffee beans are the dominant transactions form, representing over 95 percent of total traded coffee.

1/ According to the World Bank (IBRD, 1982a), the 1967 International Coffee Agreement introduced automatic adjustment of export quotas of each coffee group based on price movements. At that time, Colombia accounted for 80 percent of mild coffee exports and could influence its export quota by changing official quotations so the Colombian authorities introduced a new category of mild arabicas coffee.

Planting Cycle - Unlike the relatively short planting and harvesting cycle of many agricultural commodities, coffee production is characterized by long-term cycles, which nevertheless are often interrupted by climatic factors. The cycle arises from the delay between the time that coffee trees are planted and when the first harvest occurs. For the robusta type, the average lag for the first harvest is two years; for arabicas, it is four years. However, mature yields do not occur until a few years later, the average lag between planting and the first yield being four years for the robusta type trees and seven years for the arabica type tree (Edwards and Parikh, 1976). Once a coffee tree begins to produce mature yields, it continues to produce beans regularly for the remaining 12 to 30 years of its normal life (Starbird, 1981).

3.2 BRAZIL IN THE WORLD COFFEE MARKET

Brazil is the largest coffee producing country in the world. Although its export market share has declined from 37 to 26 percent in the past twenty-five years, its production levels continue to have an important influence on world market prices of coffee. Changes in Brazil's output due to natural disasters, usually in the form of frost and drought damage to coffee trees, have been the major source of supply-related price fluctuations in the coffee market. Given the influence of Brazil in total world coffee production, it is important to take into account, on the one hand, any difference that may exist in its supply responsiveness to changes in market prices and, on the other, major frosts and droughts that have damaged its crop and subsequently affected the world price of coffee. Consequently, the market model for coffee has a separate supply function for Brazil from that of the rest of the world.

Supply levels and export revenues of Brazil decrease in the year of the frost or drought and it takes four to seven years for production to recover. However, this lag has been reduced in recent years by the shift of coffee production away from frost-prone areas in the southern part of the country to areas in the north. The dominant coffee-producing state of Parana, which at one time accounted for 60 percent of coffee output, now produces only 25 percent of Brazil's coffee. The implementation of governmental programs to rehabilitate damaged crops has also aided in reducing the frost recovery period.

When coffee production is interrupted because of frost or drought, prices rise sharply because of expectations of supply shortfalls. As a result, in modeling the world coffee market, a binary variable, whose values are 1 in years in which particularly severe frost and drought damages occurred (zero otherwise), was introduced into the supply function for Brazil.

In the short run, Brazil can rely on stocks to meet world demand. But once stocks are depleted Brazil can no longer satisfy demand. Moreover, the ability of Brazil to dampen supply-induced price rises by liquidating its stocks has diminished as a result of a government eradication program which reduced inventories from the 1965 level of 42 million bags to less than million bags in 1984.

3.3 PRICE STABILIZATION

The first international price stabilization agreement for coffee was introduced in 1962; subsequent agreements were signed in 1968, 1976, and 1983. The 1983 agreement is due to expire in 1989. This section describes how the latest International Coffee Agreement (ICA) operates.

The International Coffee Organization - The Agreement is administered by the International Coffee Organization (ICO) whose members produce over 99 percent of net world exports and absorb about 90 percent of net world imports. Important non-member importing countries include Eastern European countries, the Soviet Union and some countries in North Africa and the Middle East.

Quota Mechanism - The principal regulatory instrument of the ICA is the export quota system. The Council establishes an annual global export quota, determined by anticipated annual world consumption and changes in stocks of importing member countries. The quota may be altered during the year, depending on market conditions.

Member countries are allocated shares of the global quota every two years. Their portion of the global quota is expressed either in percentage terms or bags of coffee, depending on the importance of the country's exports in world trade. In the International Coffee Agreement of 1976, these shares were calculated according to a strict formula; however, in the 1983 Agreement they are negotiated biannually.

The larger exporting countries, those whose annual exports exceed 400,000 bags, receive an annual quota which is made up of fixed and variable parts. The fixed part, called the "basic quota," provides a percentage share of the global quota and comprises between 70 and 100 percent of the total quota. The variable part is made up of the remaining portion of the quota (between 0 and 30 percent) and is determined by the country's stocks at the end of the previous year. Fixed quotas are assigned to countries whose market shares are small, even though they these countries are often highly dependent on coffee for foreign exchange revenue. These quotas are expressed in terms of 60 kilogram bags of coffee.

Quarterly quotas are used to regulate the flow of coffee into world markets. If exports in one quarter do not fill the quota, then the balance --up to a limit established each year by the Council-- can be carried forward to the next quarter. The 1983 Agreement provided the following maximum quarterly carry-overs: a limit of 35 percent of the annual quota in the first quarter, a maximum of 65 percent in the second quarter, and no more than 85 percent in the third quarter.

Trigger Price System - In order to control short-term quota adjustments during the year, the 1983 Agreement established the composite indicator price (CIP). This price is computed daily and is based on an average of green coffee prices of other-mild-arabicas and robustas. The reference price uses a fifteen-day composite price, which avoids atypical trading days. Quota adjustments are implemented, or triggered, when the CIP exceeds or falls below the limits of the established "outer-price band," the agreed-upon range of world coffee prices. For the 1984/85 and 1985/86 coffee years, the band was set between $1.15 and $1.45 a pound of coffee. The main focus of the quota system centers around the "inner-price band," the range of prices which are believed to be the most effective in stabilizing the market. The price range for this band was set between $1.20 and $1.40 a pound of coffee for the years 1984/85 and 1985/86.

When the CIP falls below the price range or, in the absence of an established price range, when it falls 15 percent or more below the average price range of the previous year, the annual quota is reduced in order to contract supplies and raise the price. Conversely, if the CIP exceeds the ceiling price or, if there is no established price, when the CIP exceeds the average price range of the previous year by 15 percent or more, the global quota is increased in order to augment supplies entering the market and lower the price. Thus movements in the composite price indicator are said to have a "trigger" effect on shifts in world coffee exports.

Effectiveness of the 1983 Agreement - Prices were maintained between $1.20 and $1.40 a pound by the ICA during the first two years of its operation. However, the effectiveness of the three basic provisions of the Agreement was tested during the last months of 1985 when the Brazilian crop suffered from severe drought and prices rose above the ceiling set by the ICO Council. In November 1985, coffee prices rose above $1.40 a pound; an additional one million bags of coffee were then released into the world market, as provided for in the Agreement. Since the Agreement allows another million bags to enter the market if prices remain above the ceiling price for 15 days, this amount was released in December 1985 when the level of prices rose to $1.60 a pound. Nevertheless, the price remained high. The third provision states that quotas are to be suspended, and stocks to be sold in the market, if the price of coffee averages more than $1.50 a pound for 30 market days. Prices did remain high and quotas were suspended in February 1986. Since then exporting countries have released stocks, although the level of stocks released in April was lower than in March.

Chapter 4

SOYBEANS

World trade in the soybean industry operates under relatively free trade and, therefore, the price of soybeans and its products are relatively free to respond to market forces. However, some government intervention does exist, especially in the form of non-tariff barriers to trade. Moreover, price supports for soybeans and soybean products are part of overseas and domestic market storage programs implemented in some of the major producing countries.

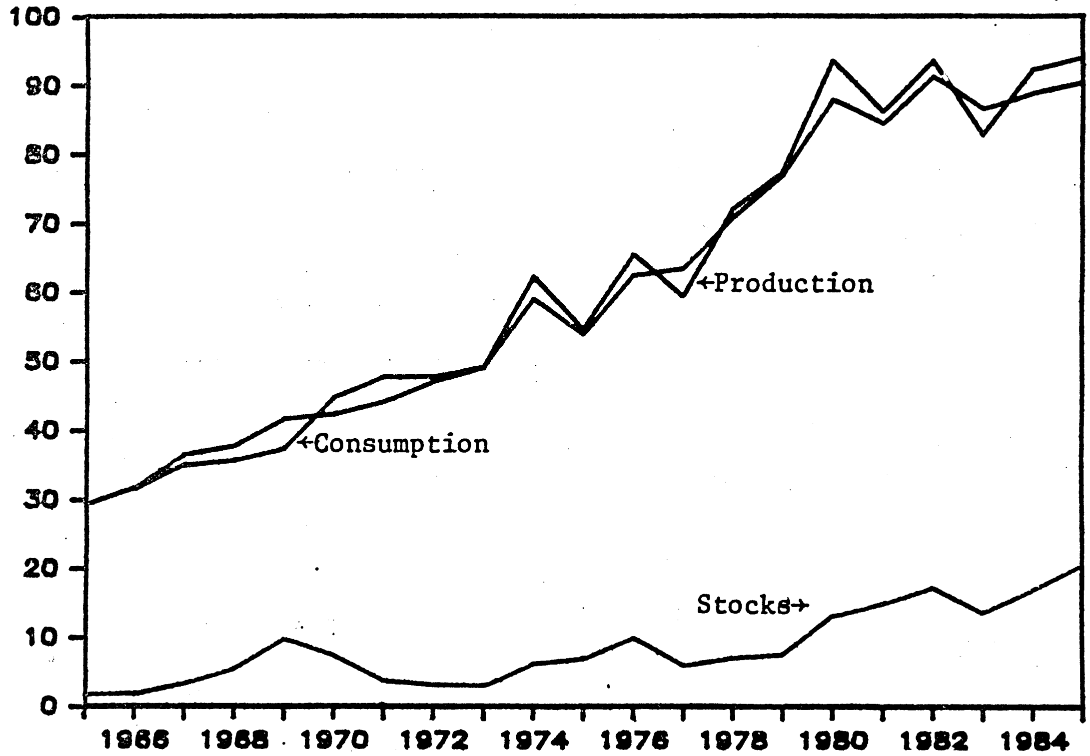
Figure 3 illustrates historical levels of world soybean production, consumption, stocks and price during the last twenty-five years. Soybean prices tend to be established in large commodity exchanges where contracts are available to traders in the form of beans, oil and meal. The largest exchange for these products is in Chicago; the major trading centers for Europe are in Rotterdam (a major delivery market) and in London.

4.1 PRODUCTION

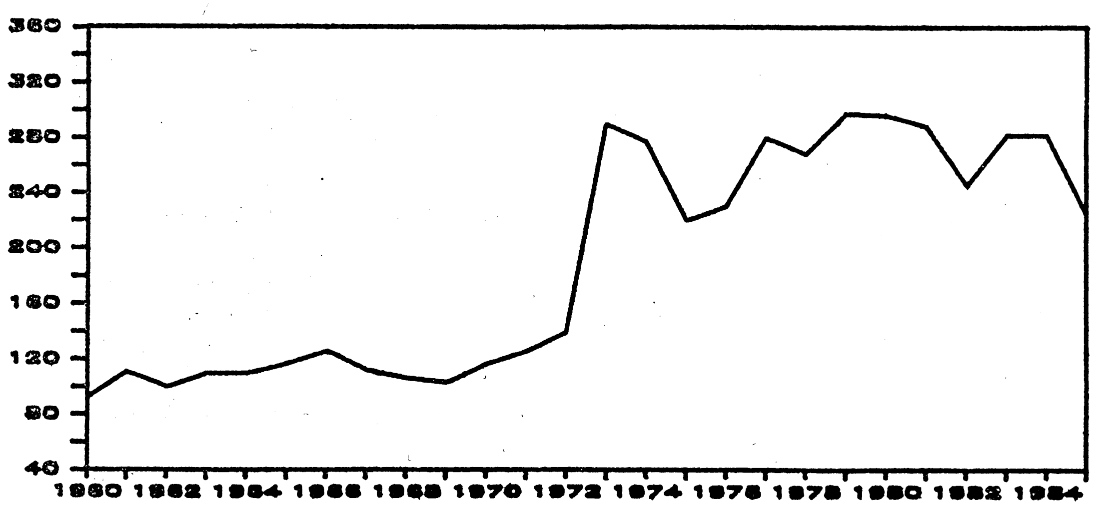
The emergence of soybeans as a major internationally traded commodity has been a relatively recent phenomenon. Production on a large scale began during World War II when access to soybeans and their products was cut off from traditional Asiatic producers. The United States responded to the shortage by improving technology for processing the product, which lowered costs and made it more profitable to produce. As a result of technological improvements, the United States emerged as

Figure 3

SOYBEANS: WORLD PRODUCTION, CONSUMPTION, AND STOCKS
(millions of metric tons)



SOYBEANS: WORLD MARKET PRICE
(dollars a metric ton)



Source: Appendix B.

the world leader in soybean production, a position it continues to maintain. In the first half of this decade it accounted for almost sixty percent of total world production.

Other major producers are Brazil, China, and Argentina. Brazil has taken the lead in expanding production and currently accounts for 17 percent of world soybean production. The increase in its market share is one of the major objectives of Brazilian agricultural policy. In China soybeans are an important source of food and production is therefore high in that country. Argentina and Paraguay also contribute significantly to the world soybean industry.

Product Characteristics - Soybeans have traditionally been classified in the legume product group because they have the property of extracting nitrogen from the air for use in their own growth and for storage in the soil. However, techniques and patterns for production, processing, and trading of soybeans are so similar to those of grains that soybeans are often associated with grains.

Many different varieties of soybeans are produced throughout the world but, according to Lager (1945), they are classified into three basic types: forage, commercial and vegetable. The forage type of soybeans produces an abundance of stems and leaves which are used for hay and green feeding. The food value of this type is comparable with alfalfa. Commercial, or industrial, soybeans have a high oil and protein content. The yellow-seed soybean is the dominant class of bean in commercial markets because its protein content is higher than that of the black- and brown-seed classes, which are discounted in commercial markets. The vegetable, or edible, type of soybeans are for human food. They are usually larger, easier to cook and have a better flavor than the commercial type.

The economic value of soybeans is not reflected in the beans themselves, but rather in their processed products-- soybean meal and soybean oil. The products are extracted by "crushing" the beans, which consists of cracking and flaking the bean, followed by soaking the broken material in a chemical solvent. The solvent extracts 99 percent of the oil from the flake to produce soybean oil. The remaining portion of the flake is desolventized, toasted and ground to produce soybean meal. To obtain a higher protein meal, the beans are dried, cleaned, and dehulled before the flaking process (see Chicago Board of Trade (CTB), 1982).

Planting Cycle - The optimal climatic conditions for soybean growth include a humid climate with extensive rainfall during the growing season and a dry season at harvest time. Soybeans are usually planted either at the same time as maize or after a maize harvest since they are considered a rotational crop. The planting cycle, which encompasses the period between sowing and harvesting, is about five months. Since the planting cycle is so short, soybeans can be planted and harvested almost year-round in certain parts of the world. In general, the harvest begins in August in the northern hemisphere, whereas in the southern hemisphere, the harvest begins around March. The yield of soybeans depends to a great degree on weather conditions during the growing period. In 1983, drought damaged crops in major producing countries, including Argentina and Paraguay.

Production decisions are based on the previous year's prices and the price guaranteed to producers by governments. One-year lagged price influences production because the marketing year of soybeans is a split year. For example, in the United States, where harvest occurs in August, the decision on the quantity of soybeans to be planted in the following year is based on the market price that was in effect during the harvest, or during the period prior to the harvest. In major producing countries, such as the United States and Brazil, production decisions are also based on government guaranteed minimum prices. According to Griffith (1982), the floor, or minimum, price in Brazil is maintained by intervention purchases; the price support mechanism is non-recourse loans in the United States.

An important determinant of soybean oil supply is the cost incurred in the processing procedure, since soybeans must be crushed to obtain oil. According to the CBT (1982), a formula, known as the gross processing margin, or "crushing margin," measures the cost of soybeans relative to the sales return on processed soybean oil and meal. At present, crushing facilities are concentrated in the industrialized economies. Some less developed countries are investing in crushing facilities as a means of increasing the value added to the soybean product.

4.2 CONSUMPTION

The United States and Brazil are also the major consumers in the world soybean market, accounting for 37 and 18 percent respectively of total world consumption. These two countries, along with the European Economic Community (EEC), mainly use soybeans as animal feed, whereas Japan and other Asian countries use them for human consumption.

Crush vs. Consumption - The amount of soybeans used is measured either by "crush" or consumption. Crush, or mill usage, indicates the portion of production that is processed to obtain soybean meal and oil. Consumption refers to a broader range of uses. It includes the crush, food use, animal feed and also seeds for planting. Consumption data are difficult to obtain. Consequently, world usage of soybeans refers to the crush.

Distribution Among End Uses - Soybeans are processed into two principal products, soybean meal and soybean oil. Yields of meal and oil vary according to different processing methods and levels of technology. Soybean meal either is used as a high-protein animal feed ingredient or is further processed into soy grits, flour or protein for human consumption. The hulls are processed into a low-protein, high-fiber product and are used in bulk feeds. Almost 98 percent of the soybean meal produced in the United States is used for animal feed; the remainder is allocated to human consumption and industrial uses (CBT, 1982). Poultry feed is the primary area of usage in animal feed, followed by hogs, cattle, sheep, and other livestock. According to Landell Mills Commodities Studies (LMC, 1983), soybean meal is an increasingly popular additive to protein animal feed because it does not discolor the flesh or eggs of animals that are fed the meal, nor does it disrupt the digestive systems of animals, which is a characteristic of other protein feeds. Since the beef market has been modeled in this study, beef prices were included in the supply function of the soybean market model.

Due to the increased use of soybean meal in the livestock industry, demand for soybeans is generally concentrated in the industrialized countries. In Japan, poultry and meat of swine are preferred over beef and therefore there is a large amount of soybean meal imports. The European Economic Community (EEC) is the largest importer of soybeans. The recent focus of the agricultural policy of the government of the Soviet Union has been to increase meat and poultry production, thereby increasing the import demand for protein animal feed.

Soybean oil is the by-product of crushing soybeans and is classified into the oils and fats product group. The principal purpose of refining soybean oil is for human consumption. In the United States, 92 percent of the oil is used in the food industry in products such as vegetable shortenings, margarine, and mayonnaise. The remaining 8 percent of the oil processed is allocated to industrial and household usage. Soybean cake is the residue of the mechanical process that extracts the oil from the raw bean. It usually contains between 10 and 12 percent soybean oil and is used in animal feed.

Relation between Soybean Oil and Soybean Meal - The refining process of soybeans simultaneously produces both oil and meal and, consequently, the demand for oil often depends on the demand for soybean meal since it is a by-product in the refining process. However, the demand for soybean meal depends on the intermediate product, livestock. Pollack (1981) has found that this relationship causes instability in the oils market because a strong demand for meal causes oil to be produced, whether or not it is needed. This instability is aggravated by price movements among the three products-- beans, meal and oil. Soybeans and soybean meal prices generally move in the same direction, whereas price movements of soybean oil are independent.

Relationship between Soybeans and Maize - The relationship between these two products is described in Chapter 9. Briefly, the most important use of soybeans and maize is as a high-protein feed in the livestock industry. In this capacity, soybeans are used in conjunction with maize in the preparation of feed for livestock. Consequently, they are complementary products. However, when used for human consumption, soybeans and maize can be substitutes for one another, as for example in the case of vegetable oils. Like maize, a certain portion of soybeans serves as an input for the preparation of products for human consumption. Finally, a certain portion of soybeans and maize is allocated to industrial usage.

Relation between Soybeans and Beef Prices - The demand for soybeans as an animal feed, like maize, is a derived demand. Because of the similarity of characteristics of soybeans and other grains, the extent to which soybeans are used in the composition of feed depends on the price of maize and other grains. Livestock prices and production are inversely related to soybean prices and production respectively (for details, see Chapter 9 on maize).

Chapter 5

COPPER

The copper industry has an oligopolistic market structure. The reason is that the principal method of ore extraction is open pit mining, which requires large-scale and capital-intensive investment. Thus, few companies tend to dominate the industry.

Some effort has been made by the Intergovernmental Council of Copper Exporting Countries (CIPEC) to regulate the market. However, its members do not have a sufficiently large market share to influence prices. Moreover, the objectives of its members are not always consistent with one another. Nor has there been an effective international agreement to regulate the copper market. Attempts to negotiate an agreement were suspended in 1980 because of disagreement between producers and consumers. Whereas producers wanted an international agreement that would contain economic measures, consumers favored the creation of an investigatory body that would examine problems and issues related to copper.

Copper is trade extensively throughout the world, but because it involves ores and concentrates, blister copper, and refined copper, there is often duplication in accounting for metal values on the basis of total world and individual country trade (Mikesell, 1979). For example, a major exporter of refined copper is Belgium-Luxembourg, which mines no copper and principally imports blister copper to be refined. Other major exporters of refined copper are Chile, Zambia, and Canada.

Major importing regions of refined copper are the United States and the EEC. The dominant trade flows which have evolved originate in Central Africa and South America and have Europe and Japan as destinations; there are flows within Asia, and from Australia to Japan. Movements in world production, consumption, stock index, and price during the last twenty-five years are illustrated in Figure 4.

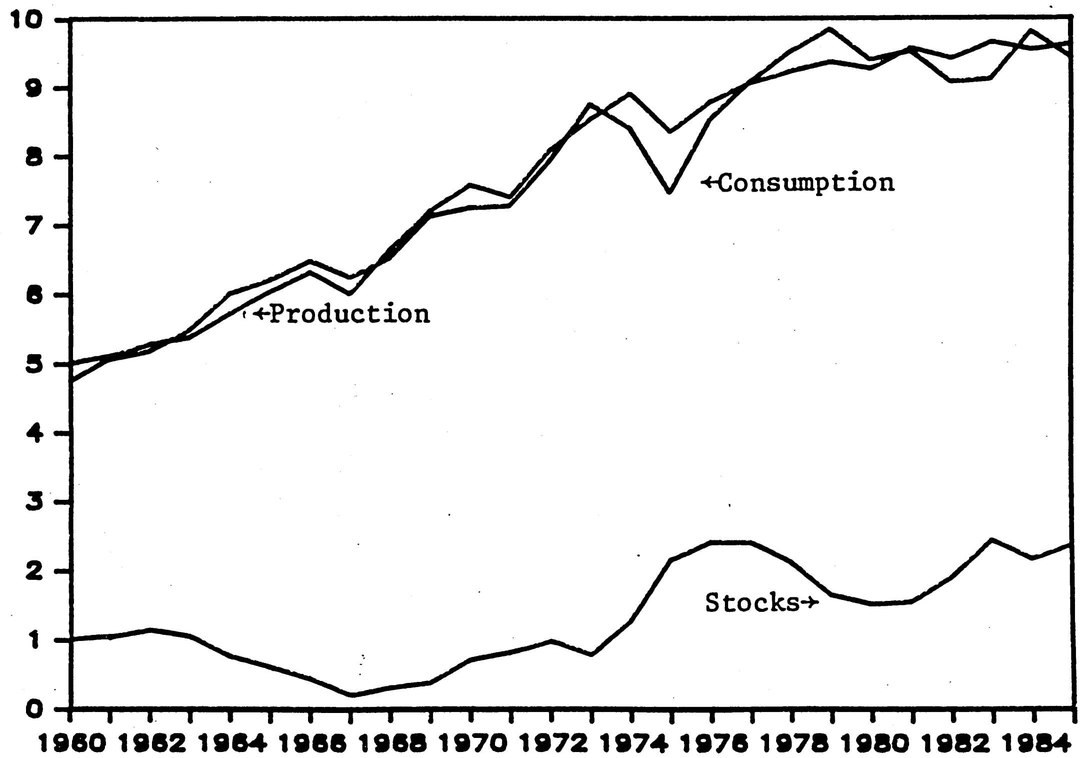
5.1 PRODUCTION

Mine production is concentrated in five countries: the United States, Chile, the Soviet Union, Canada and Zambia. The United States has historically dominated production in the world market, but Chile is now as large a producer; each country accounts for 15 percent of world mine production. The Soviet Union is the third largest producer, accounting for almost 13 percent of world copper output. Other important copper mining countries include Canada, Zambia, Zaire, Poland, Peru, and the Philippines. Shares in world production of refined copper differ somewhat from those of mining production due to the importation of raw material used in the refining process. The United States dominates the refined copper market, accounting for 18 percent of world production, whereas Chile only accounts for 9 percent of the total.

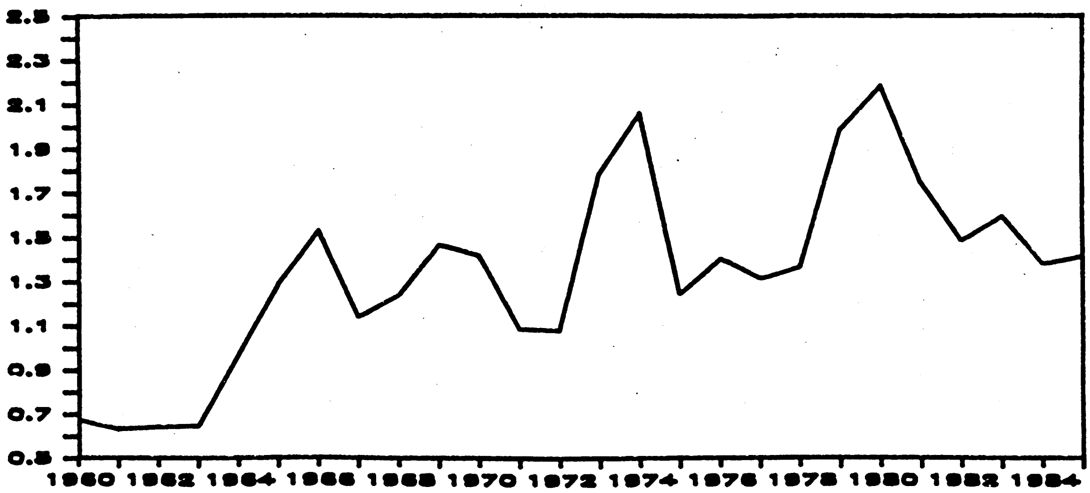
Product Characteristics - Copper possesses several unique characteristics, but above all it is noted for its high degree of electrical and thermal conductivity. Most grades of copper ore mined vary from 0.4 to 5 percent metal content, depending on the location, size of ore deposit, and method of mining.

Figure 4

COPPER: WORLD PRODUCTION, CONSUMPTION AND, STOCK INDEX
(millions of metric tons)



COPPER: WORLD MARKET PRICE
(thousands of dollars a metric ton)



Source: Appendix B.

Mining and Manufacturing - There are four principal stages in copper production: mining, which extracts the ore; milling, which crushes and grinds the ore to remove waste material in order to produce copper concentrates, which may contain up to 30 percent metal content; smelting, a process where concentrates are fed into furnaces to produce blister copper (about 99 percent copper content); and lastly, the refining process. Copper produced by these stages is referred to as primary copper. In the mining component, the normal loss of copper between ores and concentrates and refined copper is 7.75 percent (Mikesell, 1979).

Secondary copper is an important source of copper supplies and is considered an industry in itself. It is produced from two sources: scrap found from discarded copper-containing products, and scrap formed as a by-product of processing and manufacturing operations. According to Landell Mills Commodities Studies (LMC, 1983), total scrap accounts for almost 37 percent of world copper supplies.

Mine capacity expansion is fixed in the short run. The response of mine capacity to changes in London Metal Exchange (LME) copper prices can be separated into that which is to expand existing facilities and that which is to initialize new plants. In general, expansion of existing facilities takes three to four years and initiation of new plants takes six to seven years. Burrows and Lonoff (1977) have argued that these long lags between price changes and the effect on supply and demand help to explain the cyclical nature of the copper industry. High prices induce mine expansions because producers expect to generate greater revenues. However, mine output does not increase for several years, at which time demand may have slackened. The resulting closures and price reductions stimulate demand and a new cycle is started. In addition to price- inducements, investment decisions are based on the the discovery of ore funds and, in the case of foreign investment, the political environment of the host country.

5.2 CONSUMPTION

Several of the refined copper producers are also major consumers, depending on the degree of industrialization of the individual country. The United States is the largest consumer of refined copper, absorbing 20 percent of total world refined copper consumption. The share of the Soviet Union in total world consumption is 14 percent, while that of Japan is 13 percent. The Federal Republic of Germany and France are also among the most important consumers, each accounting for 8 and 4 percent of total world consumption respectively. Other important consumers of refined copper are China, and member countries of the European Economic Community (EEC) such as Italy, the United Kingdom, and Belgium-Luxembourg.

Distribution Among End-Uses - Copper is primarily used in five sectors: electrical, general engineering, transport, construction, and consumer and general goods. The electrical industry has traditionally absorbed most refined copper produced in Western Europe and Japan. The metal is used mainly as a conductor which, in turn, offers a wide range of applications (motors, generators, power distribution and communication equipment). However, in the United States the building and construction sector has recently been the leading industry in copper and copper-alloy metal products (Klinger, 1983).

Demand for Copper - Because copper is a metal used in the basic industrial infrastructure of the industrialized countries, its demand is closely associated with the trend of industrial production. Copper consumption has grown more slowly than industrial production in recent years and, coupled with the increased use of substitutes, industrialized economies are using copper less intensively than in previous years. However, certain areas of the world economy are presently experiencing growth in copper demand. According to Klinger (1983), materials applications that require that a metal have high conductivity and strength, resistance to corrosion and wear are returning to copper products. In the United States, even though the use of copper in automobile radiators has declined, the use of electronically controlled devices requiring copper connectors and wiring has grown dramatically.

Copper Substitutes - The major substitute for copper is aluminum. Plastics have also been used as a copper substitute in piping and water tubing. However, recent efforts in research and development have revealed a new, more imposing threat, that of optical fibers.

Aluminum has traditionally been a competitor of copper because its physical and electrical properties are similar to those of copper. The replacement of copper for aluminum has been most successful in the area of overhead cables, which rely on conductivity per unit weight and price per unit of electricity conducted. Aluminum is only two-thirds as conductive as copper and is bulkier, but it is only one-third as dense as copper, so that half the weight of aluminum is required to conduct a given amount of electricity (LMC, 1983). However, technical rigidities make complete substitution difficult because of sizable capital expenditures that accompany new investment in machinery. For this reason, the price elasticity of substitution for copper relative to aluminum tends to be low.

Since the early 1980's fiber optic technology has been developing rapidly and is being implemented in certain industrial sectors, especially the telecommunications industry. It is based on the transmission of coded information through glass tubing by means of light, which is first processed to sounds and images and then to other forms of output. The development of this technology is closely linked to growing technology in microprocessing, large-scale integration and computer software.

A recent study by Tan (1986) describes the superior properties that fiber optics have over copper and explains why fiber optics have penetrated traditional copper-using industries. Optical fiber allow a large volume of data to be transmitted at rapid speeds. There is lower attenuation, as well as smaller size and weight with the use of fiber optics. Fiber optic technology also offers users greater reliability and ease of installation than copper, and the use of glass in this technology renders the system more secure.

5.3 PRICES

Market Pricing Systems - There are three major price quotations in the world copper market: the London Metal Exchange (LME), or free market, price, the United States producer price, and the Commodity Exchange (COMEX) price.

In the United States, primary refined copper is sold to domestic buyers at a price set by United States producers. Consequently, the price set by United States producers determines the supply of primary copper in this country. United States consumers who are unable to pay the producer price may import copper at the LME price, or purchase scrap based on the LME price. The LME copper price, in particular, the spot price for wirebars, is the most important price for buyers involved in the world copper market.

The United States price can be either above or below the LME price, although arbitrage tends to align the price with that of the LME price. There are three reasons for the close link between the two prices, according to Fisher et al. (1971). First, secondary suppliers of copper in the United States deal at the LME price. Second, there are significant trade flows in copper between the United States and the rest of the world. Lastly, producers consider that a large difference between the LME and United States producer price is indicative of disequilibrium in the United States market.

However, even though United States producers adjust their prices to the LME price, they do so as a last resort. According to LMC (1983), when LME prices exceed the United States producer price the first reaction is to limit the quantity of copper that can be purchased, rather than to increase the producer price. The motivation behind this action is, first, that maintaining low prices will discourage substitution and, second, that vertical integration of the copper industry will cause losses from low copper prices to be offset by gains in higher prices for end-products.

Pricing Arrangements-- Copper is usually bought and sold through long-term contracts and commodity exchanges. Most copper is sold by private firms which establish strong ties with their consumers. Copper which cannot be sold by contract is usually traded on the two major commodity exchanges where copper can be traded, the London Metal Exchange (LME) and the Commodity Exchange (COMEX) in New York. The LME establishes the copper price on a bid and ask basis. Being an open market, the LME has many types of investors which buy and sell copper for various reasons, such as the protection of cash holdings and short-term investment. As such, several factors influence the market --interest rate differentials, exchange rates, and movements in other commodity and financial markets (UNCTAD, 1982). The LME mainly offers investment opportunities for hedging and speculation, although some buyers purchase and receive copper directly from the LME because they avoid dealing directly with a terminal market and are assured of high-quality copper. Like the LME price, the COMEX price is established on a bid and ask basis. There is only one type of contract (electrolytic cathodes), whereas the LME offers two contracts (copper wirebars and copper cathodes). COMEX is primarily used as a clearing house market where merchants and consumers trade copper of a lower grade than that which is permitted by the LME.

Chapter 6

IRON ORE

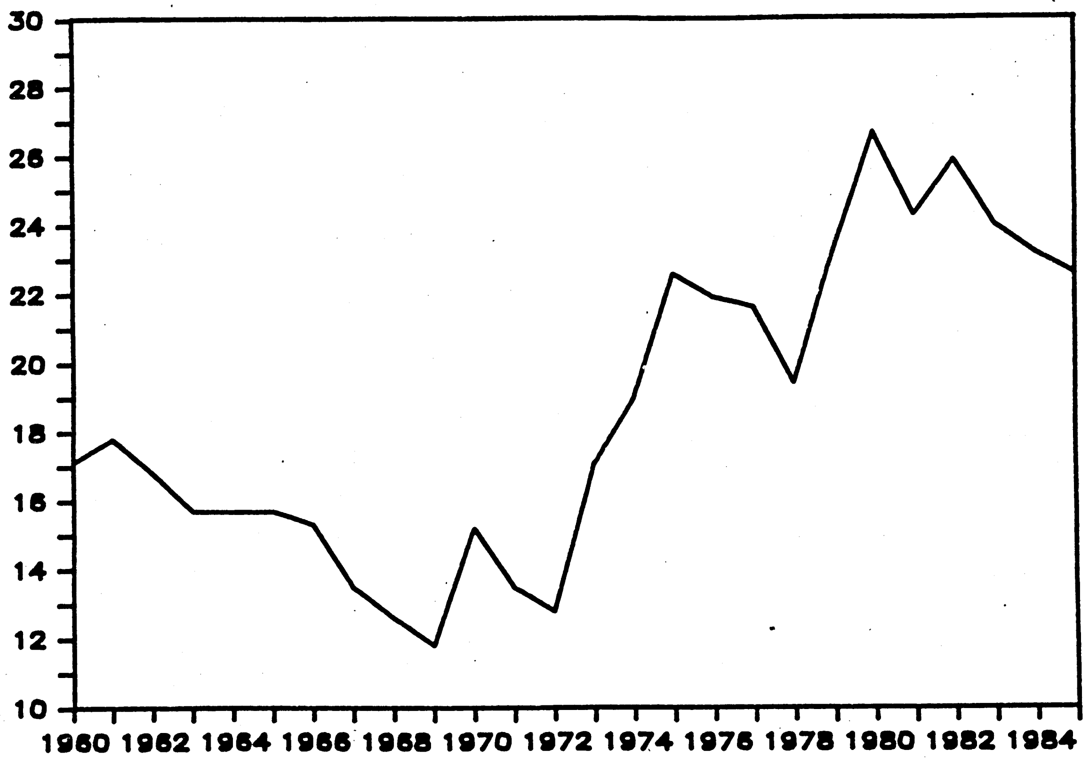
Iron ore is produced in a vertically integrated industry dominated by relatively few major companies. Because data differentiating consumption from stock changes in utilization are unavailable, modeling the market is difficult.

During the last twenty years, changes in industry charactersitics have caused iron ore mining and processing to adopt new technologies. Requirements and restrictions have become more regulated because there is a greater world demand for high ore content. Moreover, in the United States, there has been a depletion of high grade ores and a greater supply of taconite, an iron-bearing mineral. Additionally, world demand for uniform chemical composition and physical structure has increased. These changes have caused manufacturers in the iron ore industry to invest more than in the past in plants and equipment. Increased labor costs have compounded the rise in expenditures, and higher operating costs have caused prices to rise over the long term (see Figure 5).

While iron ore industries of certain countries are expanding, those of others --particularly the United States and members of the European Coal and Steel Community-- are contracting. Increased foreign competition and rising costs of domestic production in face of declining demand, coupled by recession in the industry during 1959, 1977 and 1982, have caused many production facilities, including mines, blast furnaces, and steel industries, to permanently shut down.

Figure 5

IRON ORE: WORLD MARKET PRICE
(dollars a metric tons)



Source: Appendix B.

According to Klinger (1985), nearly 40 percent of world iron ore production is traded internationally. This proportion represents a significant increase over that traded twenty years ago, due in large part to a shift in major producing areas. In the past, large steel-producing countries such as the European Economic Community and the United States dominanted international trade, but recently these countries have decreased production. In contrast, Brazil and Australia have sharply increased their output of iron ore and, consequently, increased their world market shares. The Soviet Union, Canada, Sweden, India, and Liberia are also major producers. The industrialized countries are the principal importers of iron ore. Japan is the leading importer, followed by the Federal Republic of Germany.

6.1 PRODUCTION

The leading producer of iron ore is the Soviet Union, which accounts for almost 30 percent of world iron ore production. Brazil, the largest developing country producer, accounts for 11 percent of the world market. Other leading producers include Australia, the United States, China and France.

Product Characteristics-- Iron ore is a mineral commodity and is referred to as crude ore in its natural state. Crude ore can be traded with or without minimal processing; when it is processed, it is referred to as direct-shipping ore. The final ore product of a mining operation, whether it is extensively or minimally processed, is referred to as usable ore or marketable ore.

There are three types of marketable iron ore: lump ore, sinter feed, and pellet feed. Lump ore has a high iron content and consists of particles measuring at least a quarter of an inch or more. This type of ore is used as a feed for direct charging to a blast furnace. Sinter feed is a fine grade of ore and consists of particles that are less than a quarter of an inch in size. The third type of ore is pellet feed, which is finer than the other two types or ore.

Grades of the different types of iron ore are measured by the iron content of the mineral and vary depending on the mine and region. As noted by the World Bank (IBRD, 1982b), high grade ores are found in expanding mining areas, such as Brazil where iron ore has 65 to 66 percent iron content. Australia, which has also expanded production capacity, is mining ore having 64 percent iron content. Ores having low grade ore content are mined in France, Canada, and the United States, typically with iron ore content between 26 and 32 percent.

Mining and Processing-- About 85 percent of world production of iron ore is mined from open pits; the remaining amount is mined from underground mines (Klinger, 1985). Mined crude iron undergoes a "beneficiation" process which increases its iron ore content, reduces impurities and improves its physical structure. This process includes crushing, screening, drying, and washing the ore, and in some cases, it leads to another process called "agglomeration." Agglomeration aids in transportation and handling of iron ore, as well as improving permeability before it is taken to the blast furnace. The extent of processing depends on the use of the end product.

Production decisions about how much iron ore to produce, unlike many other commodities, appear to be unrelated to market prices. Iron ore is produced and stored in the form of stocks in the producing countries. The steel industry accesses the stocks or on-line production when it is needed.

6.2 CONSUMPTION

The largest iron ore consumer, measured by pig iron production, is the Soviet Union, absorbing nearly one-quarter of world output. The

Federal Republic of Germany accounts for 16 percent of world production, while the United States is the third largest pig iron producer, using 13 percent of total iron ore.

Data Measurement-- Data for iron ore consumption are difficult to obtain. Estimates are based on one ot two methods, according to the World Bank (IBRD, 1982b). The first method is based on apparent consumption, calculated as production minus exports plus imports. This method is unreliable because there are frequent changes in levels of stocks and many data sources are used. The second, more reliable method is based on readily available statistics of pig iron production, which is one of the principal products derived from iron ore. Iron ore consumption derived from pig iron production uses input-output coefficients.

Demand for Iron Ore-- Iron ore is used almost exclusively for the production of pig iron which, in turn, is used to produce steel. The demand for steel depends on market forces but, as mentioned earlier, iron ore is produced and stockpiled to meet current and future demand.

6.3 PRICING ARRANGEMENTS

There are no commodity trading exchanges for iron ore because most of it is sold under long-term contracts negotiated directly between produces and users. According to UNCTAD (1983), long-term contracts predominate because of the large investment required to mine the ore and the need of steel industries to be assured of access to supplies. In order for steel companies to obtain financing for large-scale mining operations, they must pledge contracts guaranteeing iron ore sales for a sufficient number of years to ensure solvency. The duration of a contract is normally ten to twelve years, although some contracts extend over twenty years.

The primary interests of both buying and supplying parties involved in long-term contractual arrangements are quantity, quality and price. Method of payment and arbitration are matters of secondary importance. The actual quantity delivered can exceed the agreed-upon amount by 5 to 10 percent, which assures the buyer of shipment. However, this strategy has led to excess supply in recent years because iron ore processing industries have not been working at full capacity.

The price of iron ore is negotiated according to the market price for iron, based on each "fe" unit (which equals one 10-kilogram unit of metal content). In Europe, iron ore reference prices are determined through negotiations between the largest steel manufacturer in Brazil and European steelmakers. Other producers, such as those from Sweden and Africa, align their prices to these reference prices, after adjusting for transportation cost and quality. Quality depends on the chemical and physical composition of the ore. Within this pricing framework, there has been little interest shown by producers and consumers in establishing an internatioanl commodity agreement to regulate prices in the market.

6.4 MODELING THE MARKET

Since world consumption and stock data are unavailable for iron ore, the market price of iron ore has been estimated from a reduced-form equation. The reduced-form price equation was derived as follows: Consider the supply and distribution identity:

$$Q_t + (K_t - K_{t-1}) = C_t$$

where C denotes consumption, Q represents production, and K is stocks. Since stocks of ore are mostly held by producers, changes in stocks (the term in parenthesis) are, in large part, passive. Because users or iron ore do not hold stocks for transactions, precautionary, or speculative reasons, the right-hand-side of the above equation is demand for iron ore, and the left-hand-side is total supply. Hence, the equilibrium condition is that total demand must equal total supply.

It is therefore possible to obtain a solution for the market price of iron ore. As a first step, a production equation is estimated in order to indentify the lag structure of the price response. Then consumption and production contain the predetermined variables of the general model specification, which includes the current market price. Finally, a solution for price is obtained in terms of a reduced form equation.

Chapter 8

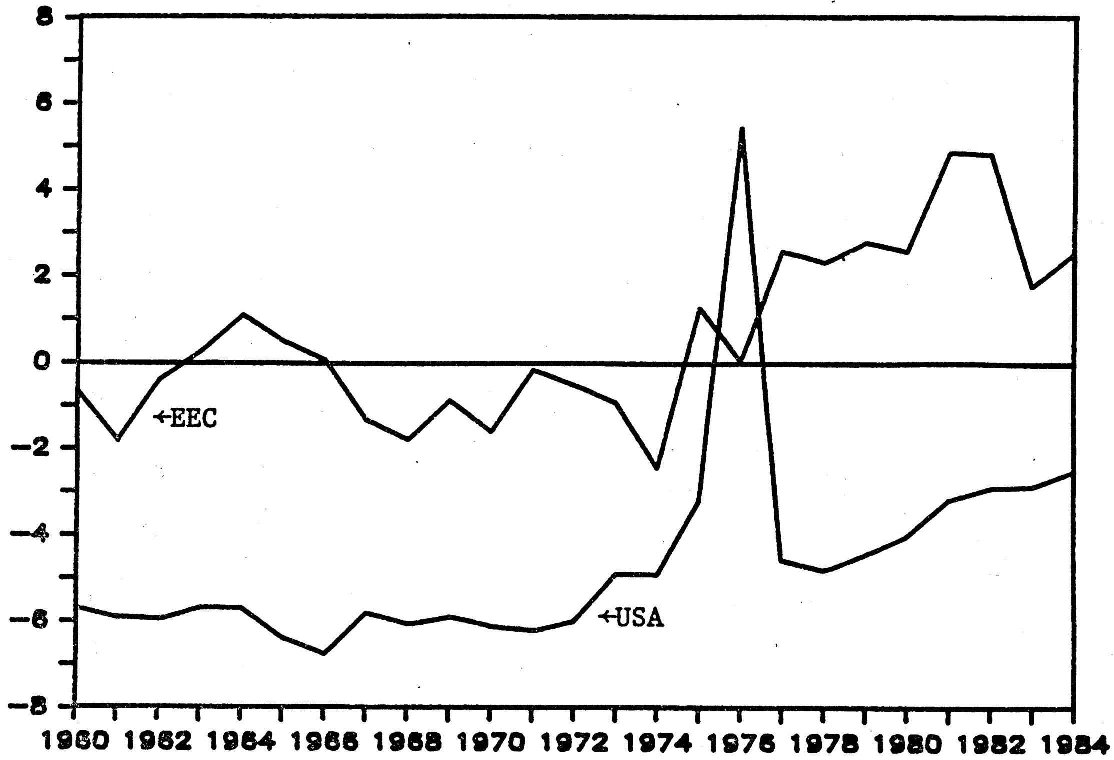
SUGAR

The three major components of the sugar market are (a) the United States market, (b) the European Economic Community (EEC) market, and (c) the free market along with Soviet Bloc trade. Price support mechanisms existing in the United States and EEC markets have warranted their distinction in the sugar market model. Production in the United States, which is a net importing country, has been separately estimated from production in the rest of the world; similarly, consumption in the EEC, which has become a major net exporting country, has been separately estimated from the rest of the world consumption. Figure 6 illustrates the United States deficit and the EEC surplus in the world sugar market, while Figure 7 demonstrates overall trends in the world market.

One of the major changes that has taken place in the sugar market in recent years has been the penetration into the market by high fructose corn syrup (HFCS). An important feature in the present framework for analyzing the sugar market is the consideration of HFCS as part of the sugar market, rather than as an alternative sweetener. The rationale for this approach is analogous to that which considers sugar beet and sugar cane to be the same commodity. When sugar beet was first introduced in the nineteenth century it too, like HFCS, was considered a substitute. However, it eventually became classified as sugar. Following this rationale, HFCS production and consumption have been converted to sugar equivalents and included as such in the sugar market model.

Figure 6

SUGAR: UNITED STATES DEFICIT AND EEC SURPLUS
(millions of metric tons)



Source: International Sugar Organization.

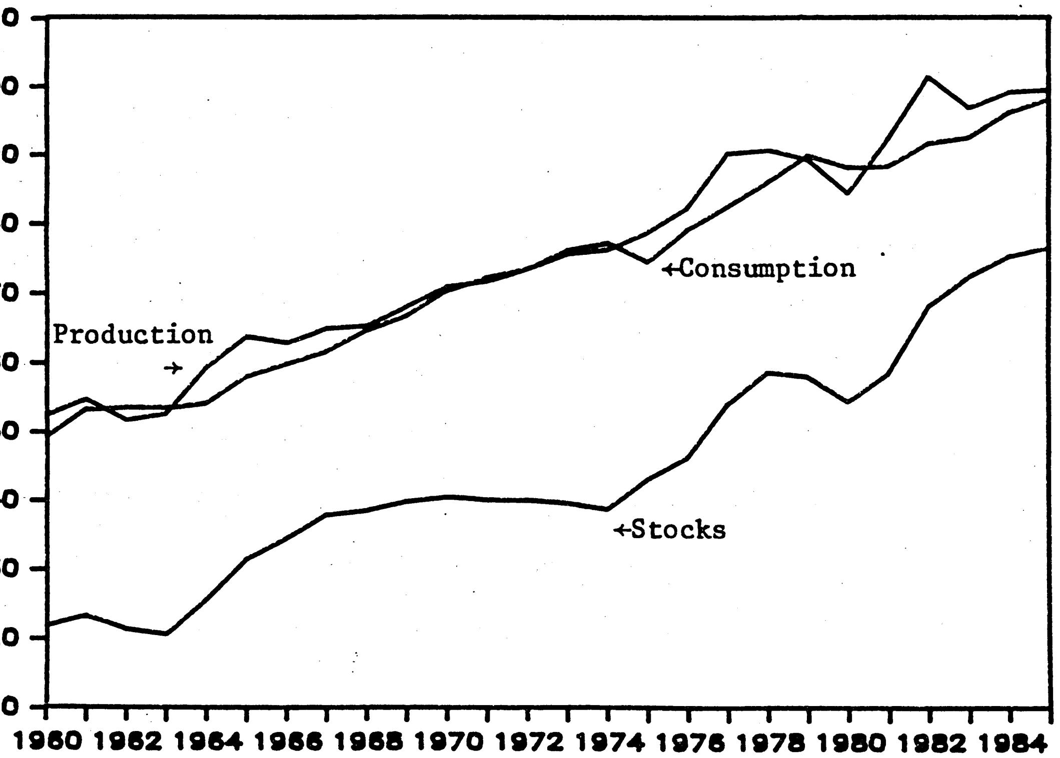
7.1 UNITED STATES MARKET

The United States is one of the largest sugar producers, as well as one of the four largest sugar importers, in the world; others large producers are the Soviet Union, China and Japan. About two-thirds of the sugar consumed in the United States is produced domestically and the balance is imported.

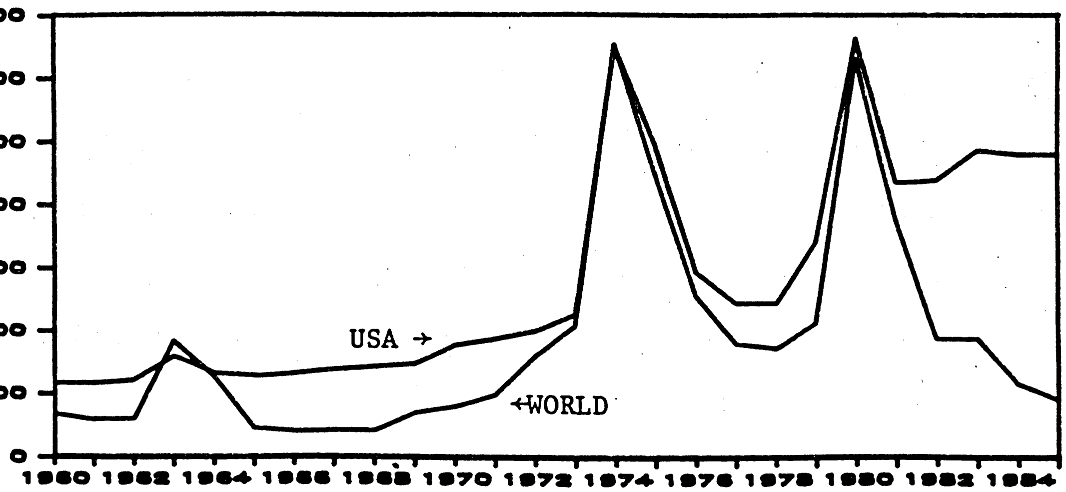
The United States sugar industry has traditionally been regulated by legislation, especially during periods of low world sugar prices, with the objective of stabilizing sugar prices at levels remunerative to domestic producers.

Figure 7

SUGAR: WORLD PRODUCTION, CONSUMPTION, AND STOCKS
(millions of metric tons)



SUGAR: WORLD MARKET PRICE
(dollars a metric ton)



Source: Appendix B.

<u>Present Regulations</u> - Legislation currently governing the sugar industry in the United States was established under the Food Security Act of 1985, the so-called Farm Bill. The Farm Bill covers the 1986 through 1990 crop years. The principal mechanism used to support prices of both sugar cane and sugar beet is the loan program, which sets loan rates per pound of sugar and thus determines the lower limit for market prices of domestic sugar. The loan rate for raw cane sugar has been fixed at 18 cents a pound for four more years. The price mechanism to support domestic sugar beet is the non-recourse loan program, which sets the loan rate in relation to the sugar cane loan rate. Non-recourse loans are provided in the event of forfeiture. No interest accrues and the proceeds from the sale of the sugar collateral fully satisfy the obligation to the Commodity Credit Corporation (CCC), even if the sugar has to be sold at a loss.

<u>Price Support Mechanism</u> - During periods when the "world" sugar price is low, sugar stocks are often forfeited or sold to the Commodity Credit Corporation (CCC) in order to serve as collateral on loans. A <u>market stabilization price</u> (MSP) has been established for raw sugar above the loan rate to minimize the risk of such forfeiture. The MSP is considered to be the minimum market price required to discourage sale or forfeiture of any sugar to the CCC. The MSP is 21.5 cents a pound for the fiscal year 1985/86. The difference between the loan rate and the MSP covers the cost of freight and related marketing expenses for raw sugar, the interest required to redeem a loan, and an incentive factor to encourage processors to sell sugar in the marketplace rather than to sell or forfeit it to the CCC.

United States versus World Sugar Prices - The United States domestic sugar price diverges from the free market price at times when world prices are low (see Figure 7). The difference between the "world" price (International Sugar Association price, f.o.b. and stowed at greater Caribbean ports) and the United States domestic price of raw sugar represents the premium of the United States market over the world market which arise from import quotas, fees, and duties. Quotas are usually set at a quantity that will achieve a domestic market price at least equal to the MSP.

United States Quotas - When world sugar prices plummeted in 1982, a restrictive import quota system was adopted for the first time since 1974 and has remained in effect since that time. Individual country quotas were apportioned among exporting countries according to their exports to the United States during the seven years prior to 1982. The domestic market price remained above the MSP for the first two years in which there were quotas. However, under 1983/84 quota regulations the domestic price fell below the MSP because of excess supply. Shortly after the 1984/85 quota was announced, Coca Cola and Pepsi authorized the use of 100% corn syrup for its sweeteners in bottled and canned drinks. This incident, coupled with revised upward United States production estimates, resulted in an excess supply of domestic sugar estimated at over 500,000 short tons for the fiscal year, according to estimates by the U.S. Department of Agriculture (USDA, 1985). To correct this situation the 1984/85 import quota was extended from a twelve month period to a fourteen month period and import fees were reintroduced in January 1985 at rates of .2875 cents a pound for raw sugar and 1.2875 cents a pound for refined sugar (Presidential Document, 1985). Similarly, quotas for 1985/86 were extended by three more months. Import fees are not in effect and refined sugar has a duty of one cent a pound.

7.2 THE EEC MARKET

The European Economic Community (EEC) and the African, Caribbean and Pacific (ACP) countries together account for 23 percent of world sugar production. The European Community's sugar policy provides EEC and ACP producers with a support price. It also guarantees a level of 1.3 million tons of annual sales to the ACP countries at a minimum price identical to that which it sets for its own producers (EEC, 1985). Like the United States price support system, the EEC price support mechanism provides a premium price to domestic and foreign sugar suppliers when world sugar prices are depressed; but, unlike the United States system, it has produced a major surplus in its market. The EEC became a net sugar exporter after 1977 and, at present, the EEC net export balance represents one-fourth of free market trade.

Present Regulation - The EEC Sugar Policy is part of the Common Agriculture Policy (CAP) implemented in 1968. Its aim is to create self-sufficiency in the domestic sugar industry through a system of trade barriers and production subsidies. The CAP establishes domestic price supports and production quotas, and it imposes variable import levies in order to protect domestic high-cost sugarbeet producers. It has undergone two major revisions since its implementation, and it currently operates under a 1981 regulation which extends through the

1987/88 crop year. As part of the renegotiations which took place to extend the CAP through 1988, production quotas remained unchanged throughout 1988 and will be maintained up to 1991.

Price Support Mechanisms- Five price support mechanisms are used in the EEC Sugar Policy: a target price, a threshold price, an intervention price, a basic beet price, and a minimum beet price. These prices are fixed annually and are in effect for during each marketing year (July 1 to June 30). The target price is the theoretical price at which supply and demand would balance under free market conditions, and it serves as a reference for the intervention price, which is the minimum price guaranteed to producers and is fixed at 5 percent below the "target price". The basic beet price (or if the price is net of certain production levies, the minimum beet price) applies to beet processors and is set each marketing year for growers. Finally, the threshold price serves as a minimum import price and is safeguarded by a system of variable import levies [1/] (EEC, 1985).

The intervention price is important to the system because agencies in each EEC country are required to purchase sugar offered to them within the maximum production quota. However, in practice, the importance of the intervention price has been small; instead, the export refund system has become the major instrument of domestic price support.

1/ The prices are set in the following ways: "Basic Price" = Minimum price + storage levy; "Intervention price" = Basic price + transportation costs + processing costs - molasses revenues; "Effective Support Price" = Intervention price + storage levy; "Target Price" = Intervention price + 5% ; "Threshold Price" = Target price + storage costs + transportation costs.

Under this system, traders bid for the refund (restitution) they need to be able to compete in the world market. According to Schmitz (1985), refunds are granted on quantities assumed to be in surplus of internal needs whenever the world market price is below the threshold price. Import subsidies are put into effect whenever the world market price is greater than the threshold price.

The EEC Quota System- Sugar production is controlled though a system of quotas that regulate production in the EEC, the French Overseas Department, and the ACP countries. This system contains three types of quotas which are allocated on an individual country basis, then are apportioned to particular refiners and, in turn, to growers. The fixed basic quota, called an "A" quota, on average equals about 95 percent of each member country's consumption. However, the basic quota may vary in each country. This quota receives the greatest price support in the form of guaranteed prices for growers and export subsidies for refiners. The "B" quota is directed at exports and also receives a price support; it is fixed in each country as a percentage of the "A" quota. The third type of quota, the "C" quota, affects any sugar produced in excess of the A and B quotas. It receives no price support or export subsidy, it cannot be sold in the producing country, and it must be exported at the world sugar price before January following the marketing year in which it was produced.

7.3 SOVIET BLOC MARKET AND FREE MARKET TRADE

Sugar produced in the world market not subject to special market conditions or preferential trade arrangements forms the "free market."

Even though net sugar exports or imports of all countries outside preferential trade systems comprise this market, there is still a certain part of this trade that is influenced by other arrangements. Countries often maintain long-term bilateral arrangements at preferential prices. According to Schmitz (1985), as much as 50 percent of world sugar trade is conducted under long-term contracts, mainly between governments. Recent increases in bilateral trade arrangement have further reduced free market trade.

The International Sugar Agreement (ISA) ceased to govern trade in the free market in 1984. The instruments used to regulate the market proved ineffective in preventing the world price from fluctuating from a high of 41 cents a pound in October 1980 to 5.5 cents a pound in June 1984. In particular, export quotas were ineffective in holding the sugar supply of ISA members down to import requirements. Negotiations recently held to establish a new agreement were unsuccessful. Instead, an "administrative" agreement was concluded for 1985-86, although it does establish a platform for negotiation of another agreement.

An important characteristic of the free market is its dominance by a few countries. The EEC has emerged as the largest net exporter to the free market. Trade of Soviet Bloc countries is included with this market because any surplus or deficit that emerges after barter trade between member countries is sold to the free market. Consequently, Soviet Bloc countries are active participants in the price adjustment mechanism of the free market.

The most important sugar agreement in the Soviet bloc, or COMECON countries, is that between Cuba and the Soviet Union. Under this agreement, which is negotiated each year, Cuba ships almost half of its sugar production to the Soviet Union at prices far above those of the world market. In 1983, the Soviet Union paid Cuba an average of 49.7 cents a pound of raw sugar, while paying other suppliers only 12.6 cents a pound. However, COMECON countries do not usually pay in convertible currencies. As a result, Cuba tends to treat the free market as its preferred market because currency received from COMECON cannot be used to purchase capital and consumer goods outside that area.

7.4 HIGH FRUCTOSE CORN SYRUP

One of the major influences on sugar consumption patterns in the United States and EEC markets is the increasing use of alternative sweeteners --primarily in the form of high fructose corn syrup (HFCS). The use of alternative sweeteners in these two markets has risen rapidly because of their lower cost relative to that of domestically refined sugar. Prices of HFCS have been more than 30 percent below refined sugar prices. High sugar prices in the United States has enabled manufacturers of alternative sweeteners to sell their products at lower rates, thereby encouraging food and beverage manufacturers to use HFCS.

The United States continues to dominate world output and growth of HFCS, especially since HFCS has been almost totally implemented throughout the United States soft drink industry. Substitution by alternative sweeteners is expected to take place in the future within the Japanese market since the HFCS price is almost 40 percent below the price for refined sugar (LMC, 1985). However, there is strong reluctance by government officials to increase HFCS use since the soft drink market has been small in Japan.

No major shifts towards HFCS are foreseen over the medium term in other areas, namely developing countries and the Middle East. In these areas industrial (liquid) use of sugar is limited, as is the availability of corn; and marketing, distribution, and storage systems are presently inadequate.

7.5 MODELING THE MARKET

Two features distinguish the sugar market model from the general market model developed in Part I. The first is that separate considerations have been given to the United States and European Economic Community markets because of the distortions produced on consumption and production by their price support mechanisms. The second is the manner in which HFCS has been introduced as a determinant of the sugar price. The world market price of sugar is determined by the demand for and supply of sweeteners, so that HFCS has been converted to its sugar equivalent and added onto world consumption and production of sugar.

<u>Production</u> - Since the United States is one of the largest markets for sugar and since a sugar price support mechanism operates there, a separate production function was estimated for that market. Price lagged one and two periods was found to be the most appropriate for this production function, which is compatible with the nature of the sugar

production response. A binary variable with a value of 1 in 1973, zero otherwise, was included to represent the anticipated termination of the United States Sugar Policy in 1974.

The United States price was separately explained by an equation linking it to the world price. The United States price follows the world market price in periods when the latter is above the United States support price, but it departs from it when the world market price is below the support price. Major departures occurred in 1965 and 1982 and a less significant departure took place in 1976. The two major departures were captured by binary variables, whose coefficients had an expected positive sign.

The equation for rest-of-world production has a longer lag to price changes than does that of the United States. The adjustment of cane production to price changes is slow because it occupies the soil from five to twenty years, depending on the ratooning practices being followed (Grissa, 1976: 79-82). The large fixed cost of sugar cane production also slows down the response time to market price changes. When prices increase beyond mill capacity, it takes between two and four years for new capacity to come on stream. On the other hand, when prices fall below cost, production will continue as long as variable costs of harvesting, processing, and marketing are met. Only in the long term will production cease if total average cost is not met, since such cessation requires mill closures and relocation of workers.

Consumption - Distortions produced by administered prices in the European Economic Community are considered too great for consumption to be able to respond to income and market prices. For this reason, no attempt has been made to explain consumption patterns in this market on the basis of economic factors. Instead, consumption has simply been related to a trend variable and a binary variable used when there were major departures from the trend in the past. Accordingly, the world consumption function for sugar excludes countries in the European Economic Community, but it does include the United States. The rationale for the inclusion of the United States is that domestic prices have historically followed free market prices except during major downswings. Consumption in the United States has therefore for the most part been able to respond to income and price changes.

Chapter 8

BEEF

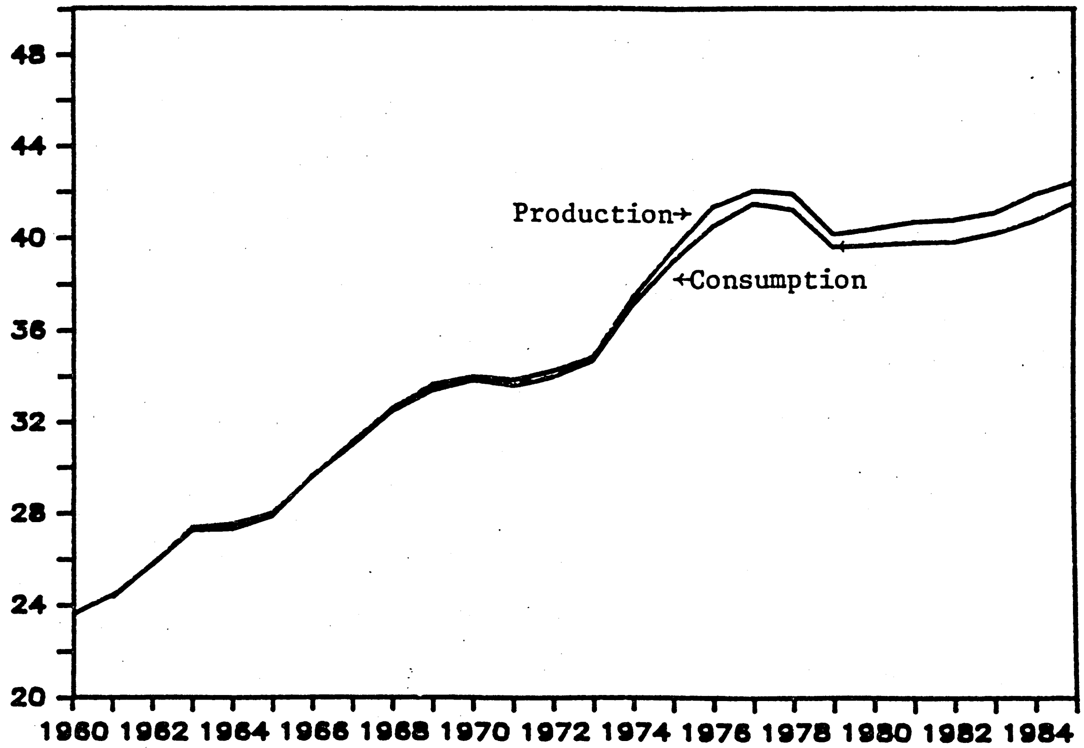
The market price of beef is strongly influenced by deficits or surpluses that arise because of differences in the time it takes for production and consumption to respond to price changes. This situation occurs in a number of commodities in which production has a lagged response to price changes. However, the situation in beef is aggravated because of the so-called cattle cycle. Production has a negative response to prices in the short-run (two to three years), so that production and consumption initially move in the same direction when there is a price change. The situation is remedied in the long run when production responds positively to a price change and thereby instigates a return to long-run equilibrium in the market.

8.1 PRODUCTION

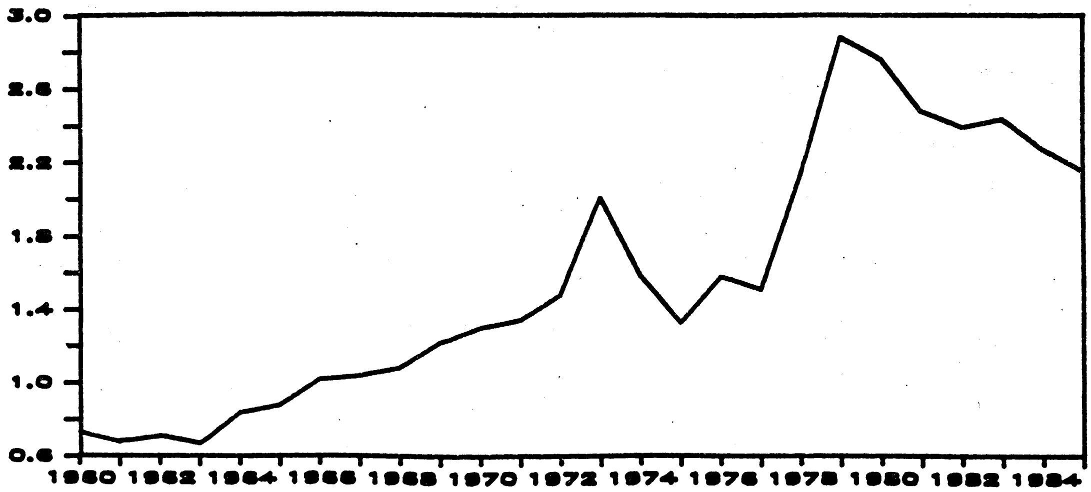
Types of Beef - Cattle are raised to produce either milk or beef, but unproductive dairy cattle are often slaughtered for their meat. From an economic viewpoint, the principal characteristic that distinguishes heifers (cows or female cattle) from steers (male cattle) is that steers directly produce beef. Heifers, on the other hand, can produce beef directly by being fattened for slaughter or indirectly by bearing calves which may themselves be fattened for slaughter. Calves raised for slaughter produce veal. According to DeGraff (1960), this type of cattle has a more flexible marketing period than other types of cattle because steers and heifers must wait until they attain a proper weight before being sent to the market.

Figure 8

BEEF: WORLD PRODUCTION, CONSUMPTION, AND STOCKS
(millions of metric tons)



BEEF: WORLD MARKET PRICE
(thousands of dollars a metric ton)



Source: Appendix B.

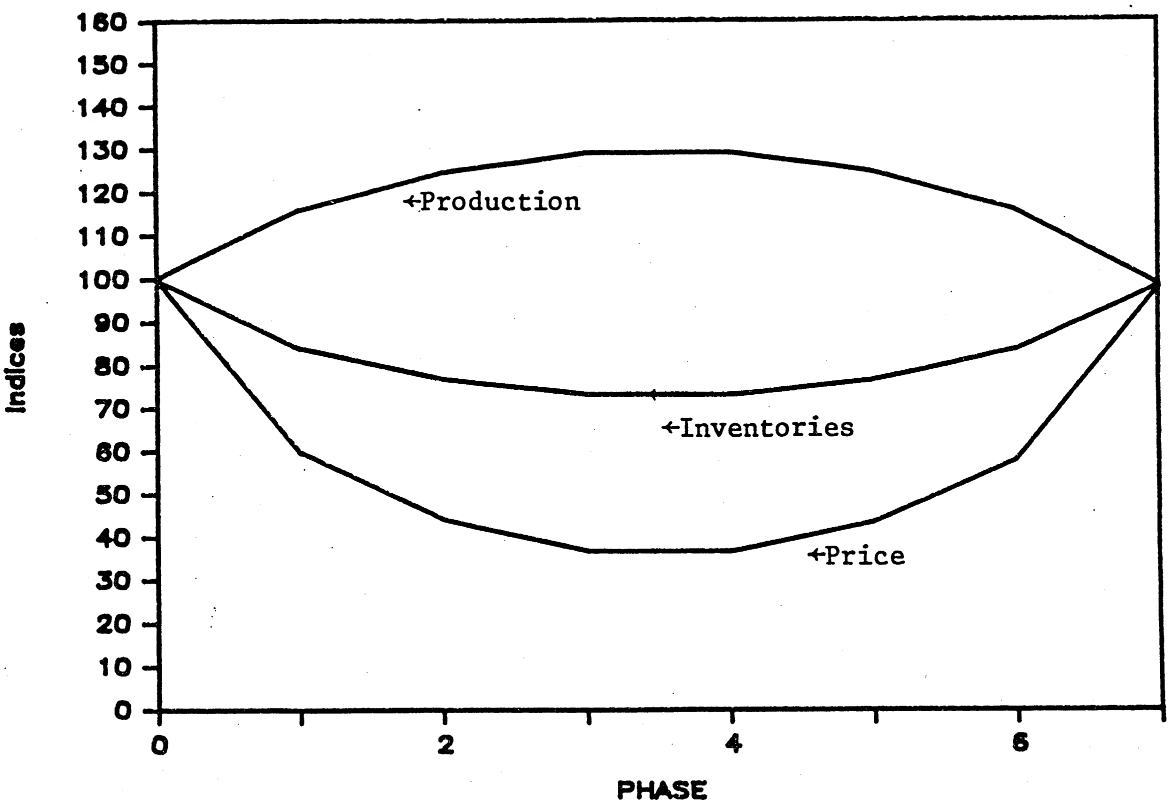
The Cattle Cycle - The most widely accepted economic explanation of the cattle cycle has been given by Jarvis (1974) (see also DeGraff (1960), McCoy (1979), Simpson and Farris (1982)). Although the length of the cycle can vary among countries, the phases are similar (see Figure 9). The beginning of the cycle occurs when a price fall causes losses in revenues to producers who are then forced to reduce inventories to lower costs and meet their expenses. Feed costs play an important role in the decision as to whether to retain cattle. Maize and soybeans are two animal feeds whose markets are modeled in this study. Thus they provide the means by which animal feed prices can be included in the beef supply function.

Phase I in the cycle is therefore characterized by a reduction in inventories concurrent with the price fall. The reduction in inventories is accompanied by an increase in slaughter, or production. Increased production stimulates a further fall in price, which stimulates incentives to lower inventories, thereby further augmenting production (Phase II). Hence there is a negative short-run response of production to prices changes, in contrast to the supply response of most other commodities.

Phase III occurs two to three years after the initial downturn in price. It is characterized be a deceleration of slaughter rates once the cattle herd has been depleted. A shortage of production then begins to appear in the market. The upswing in prices begins Phase IV. At first, prices rise moderately and then accelerate (Phase V) as producers hold back heifers in order to breed them to increase inventories. As

Figure 9

THE CATTLE CYCLE



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slaughter cattle prices improve, the expectations of producers become more optimistic toward prices. This optimism stimulates an increase in inventories by the reduction of slaughter, causing the price rise to accelerate further (Phase VI). The increase in inventories requires three to five years because of the time it takes cattle to reach marketable weights (Phase VII) 1/. Therefore during the upswing in

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1/ For example, when a rancher decides to increase production by holding back female cows, there is a 9-month gestation period, followed by a period of 15 to 24 months before a calf can enter the breeding phase. Then the calf goes through another gestation period of 15 to 36 months before it is marketable (Simpson, 1982). In areas where cattle breeding is intensive, this lag may total four years. However, in Argentina and Australia, the lag is seven years, in the European Community the lag is seven to eight years; it may require up to ten years in North America to produce beef from the time the decision is made to produce additional beef (IBRD, 1981a).

prices the production response is negatively related to price changes. As more and more cattle are held back from the market, slaughter eventually becomes unavoidable. The slaughter rate rises, supply fills market, and prices eventually begin to fall, thus marking the beginning of a new cycle.

8.2 CONSUMPTION

Quality Differentiation - Differentiation in beef is often accomplished through the process of grading different carcasses and retail cuts of beef. A separate type of differentiation arises from health aspects of the meat such as sanitation in processing facilities, disease-free animals and correct labeling.

Trade in fresh, chilled and frozen beef is divided between two geographical areas, the "disease-free" and "non-disease free" zones. The disease refers to the hoof-and-mouth disease (aftosa) which plagues cattle herds and has caused major shifts in trading patterns due to health restrictions imposed by importing countries. Major producing countries whose export potential is greatly influenced by this disease include Argentina, Brazil, Paraguay and Uruguay. Export revenue for these countries is generated mostly from sales to Europe and the Soviet Union. Producer countries which have remained free from aftosa include Australia, New Zealand, and Mexico and certain Central American countries, which channel their beef products primarily to the United States and Canada.

<u>**Meat Substitution**</u> - The quantity of beef consumed in the world market can be influenced by prices of substitutes. The cross-price elasticity between poultry and red meats has been found to be low (McCoy, 1979). There appears to be a greater effect from changes in pork prices on the purchase of beef.

8.3 STOCKS

Beef inventories (as well as those of cattle) appear to be important in modeling the market. Despite the limitations of cold storage facilities and the relatively short period of time over which beef stocks can be held, data on production and consumption differences suggest that there has been a considerable increase in beef stocks over the last twenty-five years. Since beef stock data are unavailable, the stock of beef was derived from the stock identity and an index was constructed.

Chapter 12

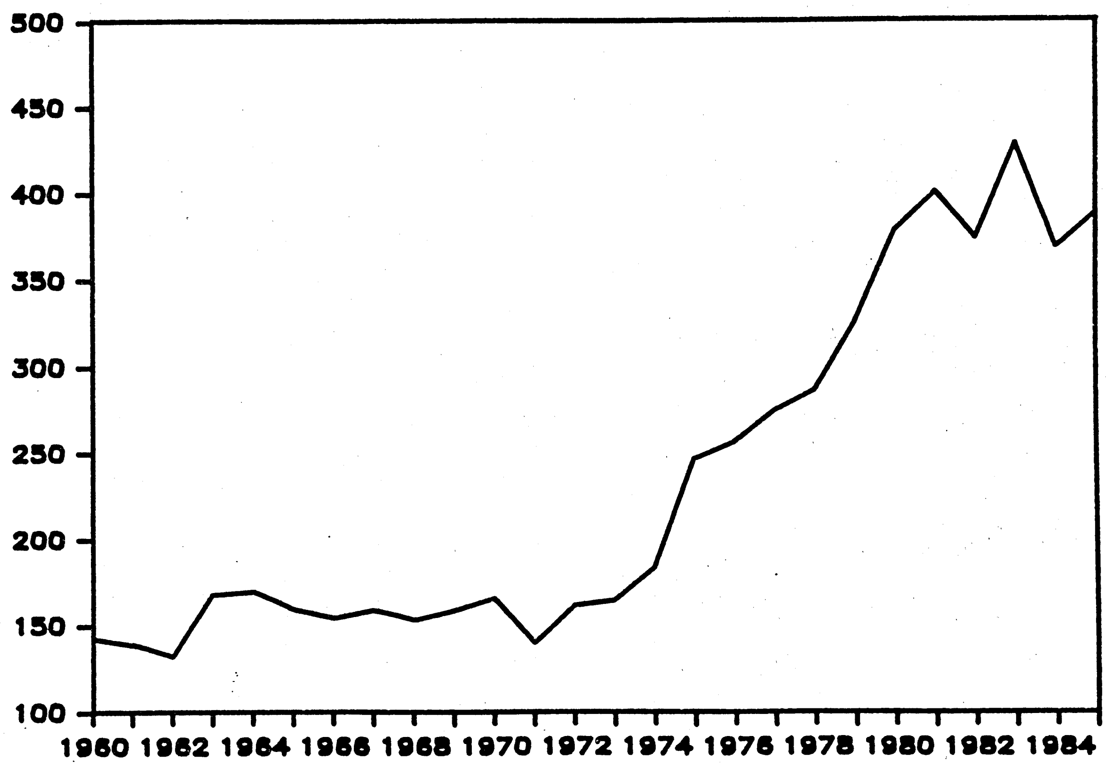
BANANAS

Bananas are traded almost entirely between developing and industrialized countries. The major exporting region is Central America. Ecuador has traditionally maintained the dominant export position, although its share has declined in recent years. The largest banana importer is the United States, followed by the EEC. Strong growth is shown in the Japanese market, where bananas are furnished primarily by the Philippines. Many restrictions impinge on banana trade because of such factors as high perishability, the fragility of the fruit and, consequent, high transportation costs.

The price of bananas is one of the most stable of all commodities because of the ease and rapidity with which Ecuador can expand production. The reason why Ecuador can readily vary its output has been described by Kawata (1975). The banana sector in Ecuador is less capital-intensive than the large plantation systems in Central America. Consequently, fixed costs are low. Ecuador also has a comparative advantage over the integrated production and marketing complex that exists in Central America in that production is distributed among many independent producers. This system encourages producers to maintain plantings with which to quickly expand production when a supply deficit appears in the market.

Figure 10

BANANAS: WORLD MARKET PRICE
(dollars a metric ton)



Source: Appendix B.

9.1 PRODUCTION

Production is restricted to tropical regions and is concentrated in a few areas: Brazil, India, Philippines and Central America and Panama. Bananas are a fragile fruit and great care must be taken during all steps of the marketing process --from protecting the crop from heavy rain and diseases, to proper packing once the harvest is completed-- in order to ensure that the fruit remains unbruised.

Product Characteristics - Production depends heavily on environmental factors such as temperature, moisture, soil characteristics, and freedom from damaging wind and floods. Temperature range in producing areas is a major determinant of whether a banana crop is produced year-round or on a seasonal basis. This range also influences crop yields to a great extent, as banana plants respond very well to humid weather. Banana trees are cultivated as a perennial crop in areas where the temperature ranges between 55 and 105 degrees Fahrenheit. In areas where there are both warm and cold seasons, production is stagnant in the cooler months as trees cannot withstand temperatures below 50 degrees Fahrenheit (May and Plaza, 1958).

As noted by the World Bank (IBRD, 1982c), a profitable tree produces an average of 9 to 12 bunches, or "hands" of bananas. Each bunch consists of 18 to 22 bananas, or "fingers." This tree crop is known for producing very high yields. Bananas are cut while they are green to ensure proper ripening by the time they reach the consumer. The fruit is not allowed to ripen on the tree because of the possibly of attracting insects and because of its perishability.

Planting Cycle - The planting cycle of bananas is relatively long. On average, eleven to fifteen months are necessary to produce a bunch of bananas. Usually three harvests can be obtained from one banana tree. The original tree is planted from a seed; subsequent trees are grown by cutting down the tree after each crop is harvested in order to propagate new growth.

Factors influencing decisions to produce bananas, which consequently reflect the exportable supply of a producing country, depend on prices and marketing initiatives. As noted by the World Bank

(IBRD, 1982c), if world demand for bananas increased, many banana exporting countries already have the land capacity to expand production without significantly raising average farm costs. In addition, banana trees offer the unique production characteristic of being able to reproduce trees by cutting unproductive plants, thereby allowing more flexibility in adjusting production.

9.2 CONSUMPTION

Consumption of bananas is concentrated in the major producing countries. Brazil, the single largest consuming country, absorbs over 15 percent of total world consumption. India is also an important consumer of bananas. The Philippines, United States, and Thailand each average around 5 percent of world consumption.

Distribution - The majority of bananas is traded as fresh fruit because producing countries have not developed marketing systems for large volumes of processed products. However, as the World Bank (IBRD, 1982c) notes, more than 80 percent of the world banana production remains in developing producing countries where bananas are a staple part of the diet. Industrialized countries, which consume about 15 percent of total production, do not consider bananas an integral part of the diet and consume bananas as fruit. Centrally planned economies account for only about 3 percent of total world consumption.

According to Grunwald and Musgrove (1970), the principal banana products traded are dried bananas, which are primarily sold to Europe and Japan, and banana puree, which is imported primarily by the United

States. Banana puree is mainly used in the preparation of baby foods. Experimental processing has led to products such as banana flour, chips and wine, but these products are of minor importance.

Substitution Between Bananas and Other Fruits - Consumption of bananas depends on the total amount of fresh fruit eaten by consumers and on the price of bananas relative to the price of other fresh fruits. According to Grunwald and Musgrove (1970), substitution between bananas and other fresh fruits such as apples and oranges appears to be less than among other fresh fruits for given changes in relative prices. Banana consumption in industrialized countries has been less affected than consumption of other fresh fruits by changing consumer preferences to processed fruits and juices, although this change is difficult to quantify. Marketing initiatives have improved the position of bananas relative to that of other fruits by changing quality, packaging, and advertising.

Other Factors Influencing Consumption - Trade policies of banana exporting and importing countries influence price, quality and, consequently, the amount of bananas consumed. However, the most important factor in determining consumption is the level of income. Both Grunwald and Musgrove (1970) and the World Bank (IBRD, 1982c) agree that the demand for bananas is quite income-elastic at low incomes (those countries having per capita gross national product of $1,500 or less). As income rises, the effect on consumption decreases until demand becomes almost saturated at the level of 8 to 10 kilograms per capita consumption. Most importing countries have already reached saturation level.

9.3 MODELING THE MARKET

Annual stocks of bananas do not exist because of the perishability of the production. As a result, production is equal to consumption plus waste. In modeling the banana market, world production was assumed to equal consumption, which presupposes that waste is negligible and insignificant in the determination of market prices.

The market price can be obtained from its solution in the equality between production and consumption. In the general specification of the model developed in Part I, demand depends on constant dollar income and own price, while production is determined by the constant dollar price of bananas and a trend variable. The implicit-function theorem conditions are assumed to exist, which allow for the existence of a price function in the neighborhood of an equilibrium in which current price is endogenous and all other variables are predetermined.

Chapter 10

MAIZE

10.1 PRODUCTION.

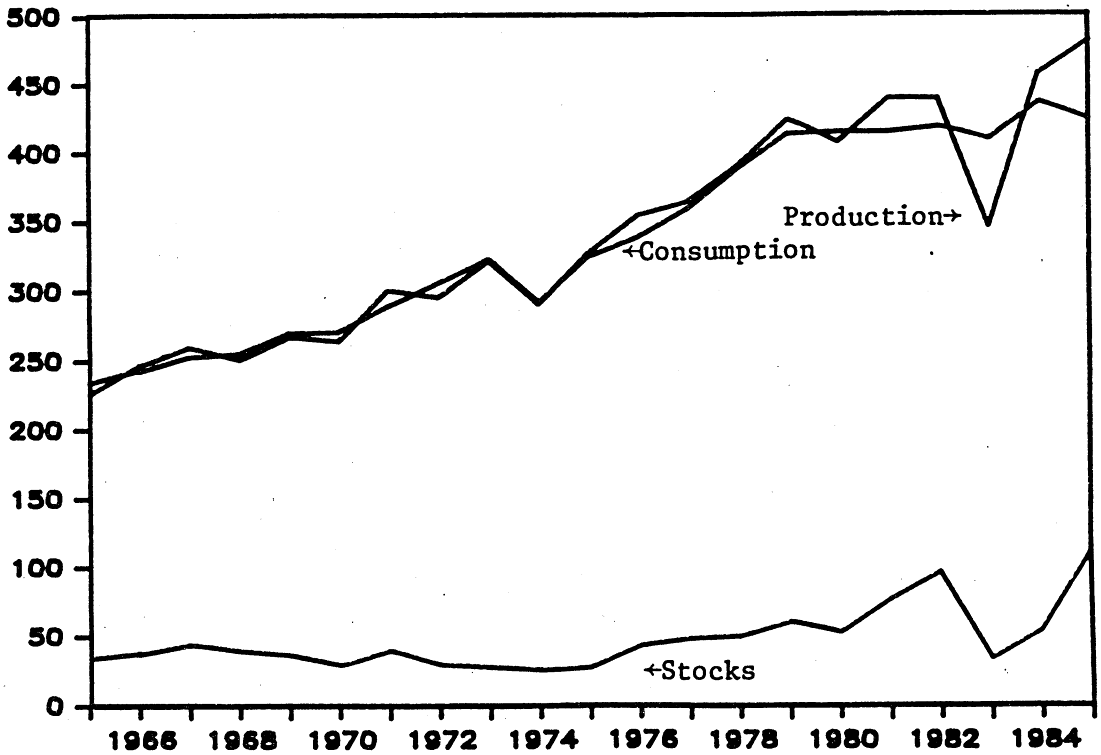
Although maize is grown throughout the world, production is concentrated in five areas: the United States, China, Eastern Europe, the EEC, and Brazil. The United States, the leading producer and exporter of maize, continues to dominate the world market and currently accounts for over 40 percent of the world maize production. Maize is an important source of food in China and production is therefore high in that country. Eastern Europe, which accounts for nearly one-tenth of world production, is expanding output in order to become self-sufficient. Brazil is the major developing country that produces maize and is continuing to expand production in an attempt to reduce its dependence on foreign supplies. The major consuming countries are the United States, China, Western Europe, and the Soviet Union.

Product Characteristics - Grains have traditionally been divided into two product groups: wheat and coarse grains. The distinction between the two groups arises from end use differences. Wheat is predominantly used in the production of bread and other food products; coarse grains are mainly used as animal feed. The coarse grain group is made up of maize (or "corn" as it is known in the United States), oats, barley, sorghum, rye, and millet. Maize is often analyzed separately because it yields more than twice the amount of grain than other coarse grains.

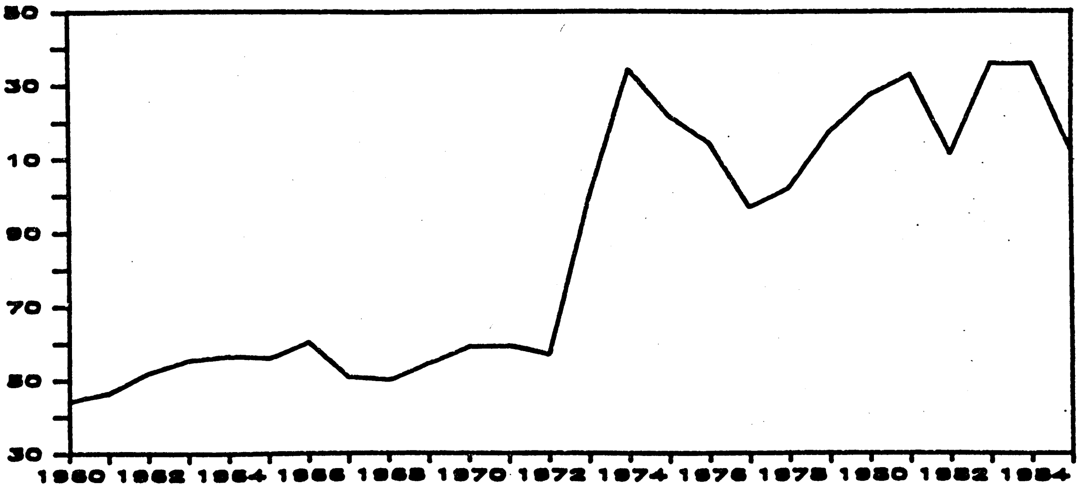
There are three basic types of maize in the world market: dent corn, flint corn, and waxy corn. In addition there is sweet corn, which

Figure 11

MAIZE: WORLD PRODUCTION, CONSUMPTION, AND STOCKS
(millions of metric tons)



MAIZE: WORLD MARKET PRICE
(dollars a metric ton)



Source: Appendix B.

is differentiated by consumers but is not a basic type of corn. Federal grain standards have classified dent corn into white, yellow, or mixed corn. In commercial grain markets, yellow corn is the dominant type traded, although white corn is often preferred by some refiners. Mixed corn is the least available type. Flint corn is produced in South America, especially in Brazil and Argentina; it has a hard, or "flinty," layer covering the starch in the center of the kernel. This type of corn is often preferred by European refiners but not by those in the United States. Waxy corn, the third basic type of corn, has a chemical structure that differentiates it from the other two types; it produces a starch which is frequently used in food processing (for details, see Chicago Board of Trade (CBT), 1982).

The most rapidly growing method of maize processing is corn wet-milling, which converts and separates the kernel into various products --such as sugar, alcohol, and industrial products-- after it is steeped in water. One of the most important products resulting from this conversion process is high fructose corn syrup (HFCS), whose use as a sugar substitute is rapidly growing (see Chapter 4). By-products found at all levels of the milling process are used in conjunction with other grains to make several types of animal feed.

Planting Cycle - Maize is planted, cultivated and harvested in virtually all parts of the world as a field crop. The planting cycle for maize is short: the plant pierces the soil about three weeks after the seeds are planted and growth is rapid thereafter, depending on the amount of nutrients in the soil and moisture content.

Harvesting occurs year-round throughout the world. In the northern hemisphere, maximum growth is reached by August and the harvest is completed by November, at which time new seeds are planted. In the southern hemisphere, the harvest occurs around March. Production decisions are based on prices in the previous year because the marketing year of maize is a split year. For example, in the United States, where the harvest occurs in August through November, the decision of the quantity of maize to plant in the following year is based on the market prices which were in effect during the harvest, or during the period prior to the harvest.

Technology - Major technological innovations which have affected the production of maize in recent years include photosynthesis enhancement, which is a technique that improves the growth rate of crops by speeding up the natural process through which plants from carbohydrates and absorb nitrogen for protein synthesis. According to Simpson and Farris (1982), other innovations have focused on improved crop hybrids, new pest control methods, better fertilizer and water management systems, and the genetic development of plants that can be produced in saltwater.

Relation Between Maize and Soybeans - Maize and soybeans are considered to be compliments to one another in both human consumption and animal feed use. Soybeans were traditionally considered a legume, but because their uses approximate those of maize, it has been considered a grain. Uses of soybeans are similar to those of maize: foods, animal feed, industrial goods, and seed for future crops. However, the majority of soybeans produced is allocated to animal feed because it is a high-protein feed meal. Soybeans, in conjunction with maize, are key elements in cattle production. As such, the price of soybeans has been included in the supply equation of the market model for maize.

10.2 CONSUMPTION

The United States, China and Western Europe are the major consumers of maize. The United States, the largest consumer, absorbs more than 30 percent of world maize production. China's consumption averages more than 15 percent of the world total, Western European countries nearly 10 percent, and the Soviet Union over 5 percent.

Distribution Among End Uses - Maize usage is primarily divided between human consumption and animal feed. Sixty-three percent of the maize produced in the world market during 1980-84 was used for animal feed consumption and 37 percent was used for human consumption. This proportion has remained virtually unchanged throughout the post-World War II period.

Maize is primarily used as feed for cattle, hogs and poultry in most industrialized countries, the Soviet Union, Brazil and Argentina. Insofar as maize is used as an animal feed, so that supply depends in part on the price of beef, as well as on the own price of maize, the price of beef has been included in the supply equation of the market model for maize.

In most developing countries, especially Central America, maize is principally used as a staple ingredient in the human diet. In the industrialized economies, maize also serves as a major input in the manufacture of beer or liquor, breakfast cereals and commercial sweeteners.

<u>Substitution Among Coarse Grains</u> - The products which comprise the coarse grain group --maize, barley, oats, rye, sorghum and millet-- are often considered to be homogeneous and therefore substitutes for one another. However, they are imperfect substitutes because of different end uses.

All coarse grains are used to a certain extent for human consumption and animal feed, but certain grains are employed for one use more than another. For example, the majority of oats produced is destined for animal feed, whereas a large share of the barley produced is used in the brewing industry. Furthermore, quality differentiation within a particular grain itself impairs substitution. For example, each type of maize provides different amounts of protein. According to the World Bank (IBRD, 1982d), yellow maize is used for high protein animal feed, whereas white maize is mainly used as a supplement to animal feed because it lacks sufficient protein. The third type of maize, sweet corn, is consumed as a fresh or processed vegetable. Barley also is used for different purposes. The barley used in the beverage industry exhibits different grain and price characteristics than that of barley used in animal feed. The price elasticity of substitution among coarse grains is consequently not (negative) infinite, as would occur among perfectly substitutable products.

Relation Between Maize and Beef - The demand for maize is a derived demand when it is used as an animal feed. Thus, maize is an integral part of the cattle industry. Grain-fed cattle are considered to have a higher quality and shorter production cycle than grass-fed cattle. Grain is often preferred to grass as a feed because it allows greater control in raising cattle and consequently accelerates the marketing process. As a result, grain-fed cattle tend to provide more revenue to beef producers than grass-fed cattle. However, the cost of grains influences the extent to which grains are used as feed. When the price of cattle falls relative to the price of maize, the proportion of grain-fed cattle declines. Conversely, when the price of cattle increases relative to the price of maize, there is an increase in the proportion of grain-fed cattle.

Changes in the ratio of grain-fed to grass-fed cattle influence the production of beef. As maize prices fall relative to cattle prices, the increased demand for maize induces an expansion in beef production because of the shorter production cycle associated with grain-fed cattle. The converse occurs when prices rise relative to cattle prices.

Chapter 11

COCOA

The market shares of the five major cocoa producing countries have changed dramatically in the last two decades. Between the early 1960's and early 1980's, three producing countries sharply increased their market shares: the Ivory Coast from 11 to 41 percent, Brazil from 11 to 15 percent, and Cameroon from 8 to 11 percent. In contrast, the market share of Ghana dropped from 48 to 19 percent and that of Nigeria fell from 22 to 14 percent over the same period. These changes have been the result of administered producer prices which often do not reflect the market price and of decisions by low-cost producers --the Ivory Coast and Brazil-- to increase their penetration into the world cocoa market.

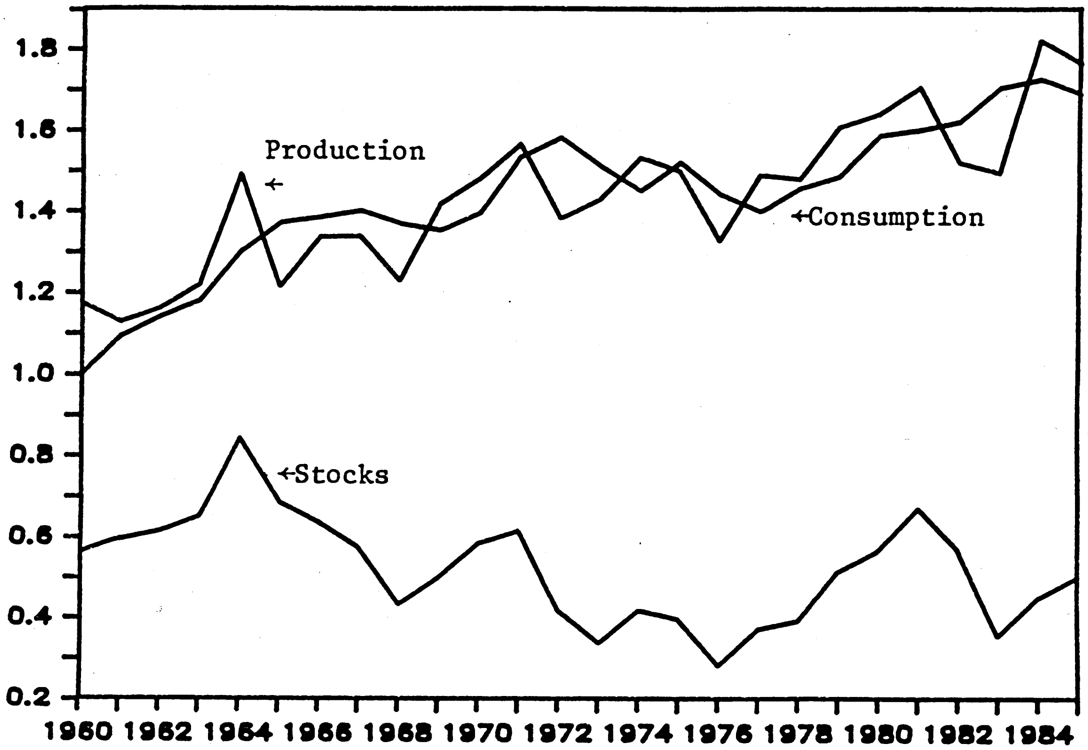
Producers usually export cocoa in its raw form (beans), and processing of cocoa end-products is completed in the industrialized countries. Although much effort has been made to finance facilities to process the beans in semi-processed form such as cocoa liquor, powder and cake in developing countries, industrial countries account for about 80 percent of world imports of cocoa beans. The Soviet Union and Eastern Europe absorbs almost all the rest of traded cocoa beans.

11.1 PRODUCTION

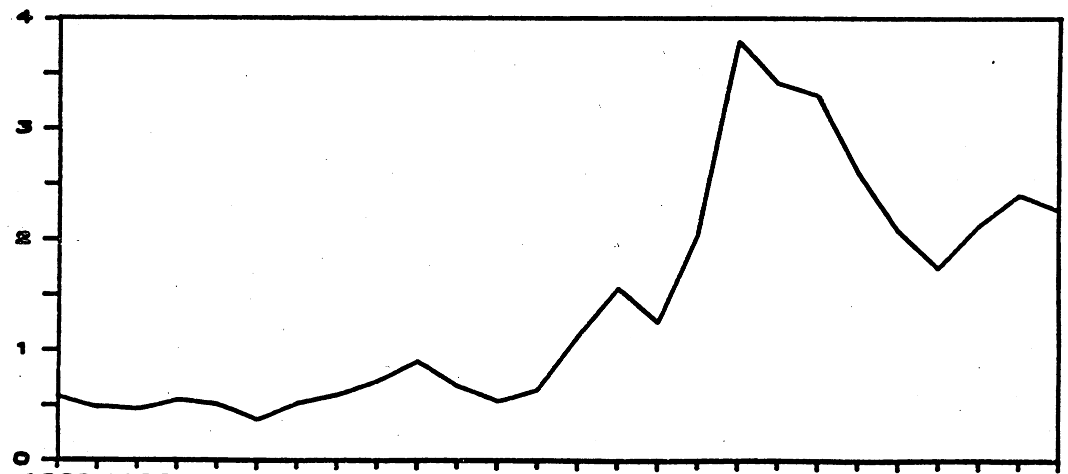
Both production and consumption of cocoa are characterized by a high degree of concentration in geographical areas. Production is almost entirely confined to developing tropical countries. More than 75 percent of world cocoa output is concentrated in five countries:

Figure 12

COCOA: WORLD PRODUCTION, CONSUMPTION INDEX, AND STOCKS
(millions of metric tons)



COCOA: WORLD MARKET PRICE
(thousands of dollars a metric ton)



Source: Appendix B.

Brazil, the Ivory Coast, Nigeria, Ghana, and Cameroon.

Types of Cocoa - There are several types of cocoa trees, but only the theobroma cocoa species is of economic and commercial importance. Within this species, there is much variety in the size of the cocoa pod, texture and color, which has resulted in the classification of two fundamental groups, the criollo group and the forastero group. The trinitario type of cocoa is a third type of cocoa and is a hybrid of the criollo and forastero groups. Commercially, these types of cocoa are classified according to "quality" and "flavor." Quality is determined by methods of cultivation and freedom from pests and diseases. Flavor is assessed by the manufacturer and is developed during the roasting process (Simmons, 1976).

Planting Cycle - According to the World Bank (IBRD, 1982e), traditional varieties of cocoa trees produce cocoa beans approximately five years after planting and the hybrid variety has a gestation period of about three years. Yields continue to increase sharply after the initial crop, until the eighth or tenth year, when disease begins to affect some of the weaker trees. Yields increase noticeably until the twentieth year, when they level off and begin a gradual decline. Some trees may live up to thirty or fifty years, although maintenance and harvesting costs often outweigh the revenue they produce. In most cocoa-producing countries, there are two harvests. One in the rainy season (October-February) and the other is in the dry season (May-August).

Cocoa is difficult to grow, not only because of temperature, soil and rainfall requirements, but also because the plants are very susceptible to pests and diseases. The most common diseases for mature trees are caused by insects and fungi (Weymar, 1968). More information related to growing conditions is available for cocoa than for most other crops, and such information was included in the supply function. A "bad-weather" binary variable was included with a value of one was assigned to years in which there were bad crops as a result of poor weather, a value of zero being otherwise included; a "good-weather" binary variable was included with a value of one for each of the five years in the sample when favorable weather generated record-high harvests. The combination of natural influences into only two variables yield imprecise measures of their influences in particular years, but the gains in degrees of freedom derived from this approach compensate for the loss in precision.

11.2 CONSUMPTION

The final grinding of the cocoa bean leaves the processor with a paste called **cocoa liquor**. When the cocoa liquor solidifies, it takes the form of hard brown blocks, lumps, or tablets. In this state, it can be used to make chocolate or processed further to make cocoa butter, cake and powder. The standard conversion factors for cocoa products into cocoa bean equivalents are as follows:

cocoa butter... 1.33	cocoa liquor... 1.25
cocoa powder/cake... 1.18	chocolate...... 0.50

11.3 THE INTERNATIONAL COCOA AGREEMENT

Until the first the International Cocoa Agreement (ICCA) was established in 1972, cocoa prices were subject to market forces relatively free of governmental intervention. The 1972 Agreement was renewed in 1976 and in 1980. The current ICCA is an extension of the 1980 Agreement and must again be renegotiated by September 30, 1986. Even though the ICCA was renegotiated several times, its ability to stabilize market conditions through its economic provisions was never tested, as the world market price was significantly higher than the ceiling price provided by the Agreement.

The 1980 Agreement differs from all previous agreements in that it operates solely under the buffer stock mechanism. The defended price range is between \$1.06 and \$1.46 a pound of cocoa. Thus if the buffer stock accumulated 100,000 tons of cocoa within one year of the operation of the Agreement, the lower intervention price, set at \$1.10, would be lowered to \$1.06 and the upper intervention price would be raised from \$1.40 to \$1.46 a pound of cocoa. If an additional 75,000 tons were purchased in a subsequent year, the lower intervention price would fall to \$1.02 and the upper price would fall to \$1.42.

Further attempts to purchase cocoa from the market in order to lower prices failed. The Agreement allotted the buffer stock manager a maximum capacity of 250,000 cocoa beans equivalent and later called for an increase on the export levy to two cents a pound of cocoa. However, the cocoa bought from the buffer stock manager did not lower prices, and the last purchase made by the buffer stock occurred in 1982.

Chapter 12

COTTON

12.1 PRODUCTION

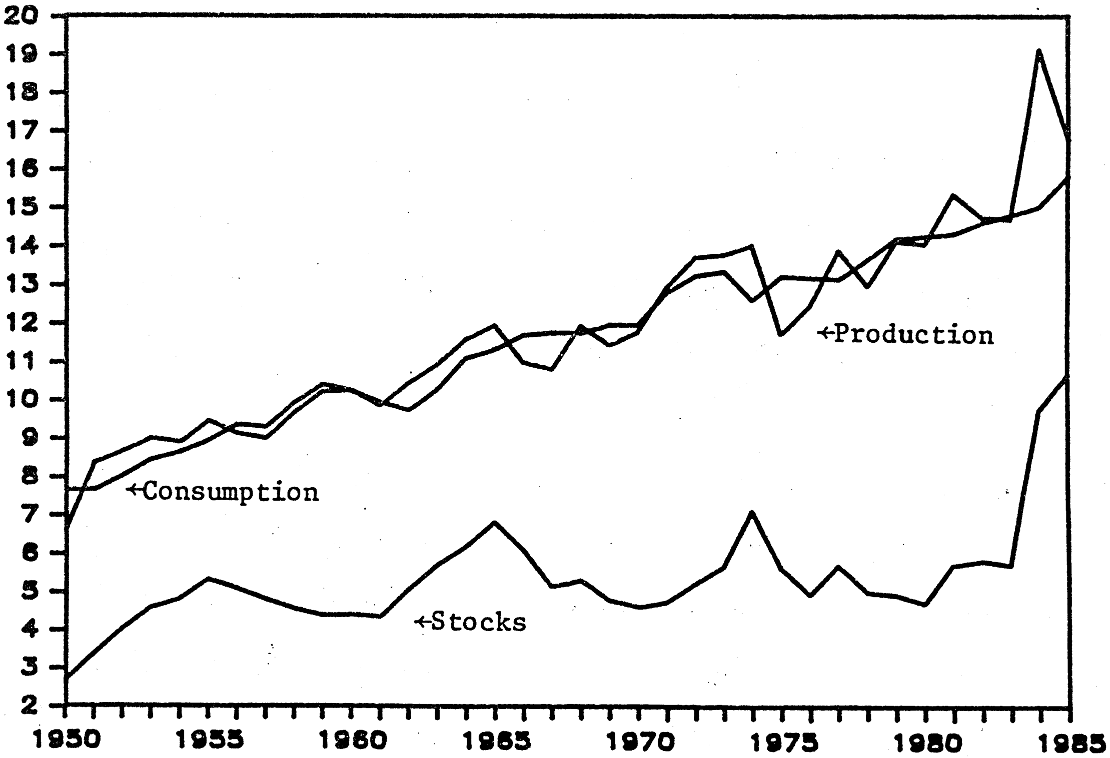
Cotton is produced on a large scale in almost every region of the world except Western Europe. Production of cotton is concentrated in China, the Soviet Union, and the United States. Together, these three countries account for more than half of the world cotton supply. Traditionally, the United States and the Soviet Union have vied for the leading cotton producer position, but China has recently become the dominant producer as a result of government policies to promote increased foreign exchange earnings.

Product Characteristics - Several types of cotton are produced throughout the world. Classification of cotton types is based on several criteria, the most important of which is the staple length, or length of the cotton fiber. The greater the length of a cotton fiber, the higher the quality of yarn that can be spun. According to the International Cotton Advisory Council (ICAC, 1985), there are five basic categories of fibers: coarse, or short, staple is for fibers that are less than 13/16 in length; medium staple, for fibers between 13/16 and 1 inch; medium-long staple, for fibers between 1-1/32 and 1-3/32 inches; long staple for fibers between 1-1/8 one and 1-5/16 inches; and extra long staple for fibers longer than 1-3/8 inches.

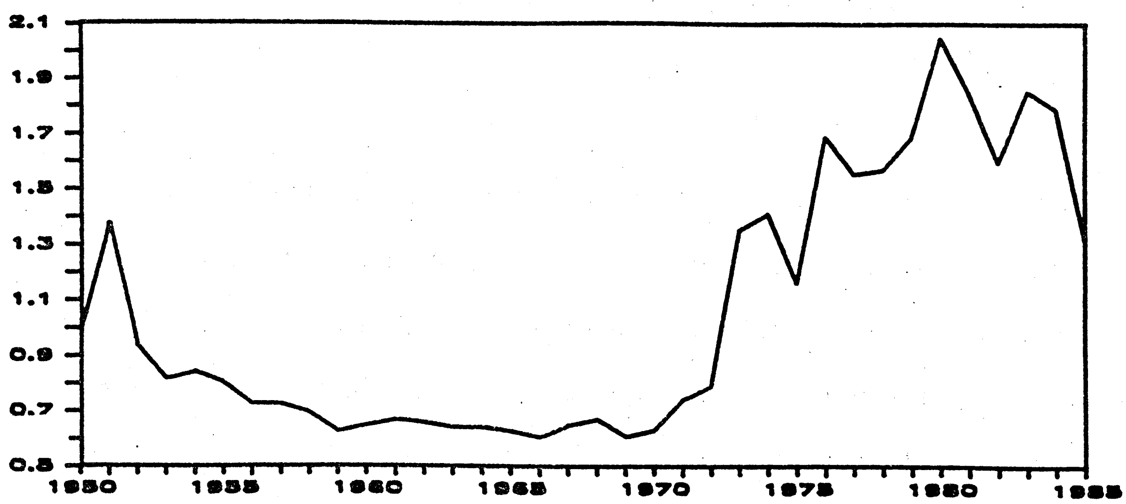
Three other important classification criteria are color, growth and finesse. Color refers to the degree of whiteness in the fiber. There

Figure 13

COTTON: WORLD PRODUCTION, CONSUMPTION, AND STOCKS
(millions of metric tons)



COTTON: WORLD MARKET PRICE
(thousands of dollars a metric ton)



Source: Appendix B.

are six major color groups, each of which is divided into grades. Grades differentiate between the amount of leaf and other foreign matter in the fiber, as well as in the quality of ginning preparation. Growth refers to the geographical area where the cotton was grown, as cotton produced in one region has characteristics that differentiate it from cotton grown in another region. For example, "American Upland" cotton is grown in the United States and is usually of medium or long staple length. Finesse is a cross-sectional measurement of the fibers to judge the maturity of the cotton fibers.

Planting Cycle - Cotton is an annual crop in most areas of the world, although it is produced as a perennial crop in certain tropical areas. Production of cotton requires about five to six months and harvesting occurs year-round throughout the world. In China, planting takes place between April and June, harvesting during the months of September to October. In the United States, planting also takes place between April and June, but the harvest period is much longer --between September and February. Perennial plants are produced in Brazil, where the harvest is year-round.

According to LMC (1983) and the World Bank (IBRD, 1981), production decisions are based on previous-year movements of cotton prices and of the prices of cotton relative to those of soybeans and grains. Relative price changes are especially important in the United States, where farmers can alter plantings between cotton and other crops. Since soybeans are a possible substitute for cotton land use and since the markets for this commodity has also been modeled in this study, its price was included in the supply equation of the cotton market model.

12.2 CONSUMPTION

Many major cotton producing countries are also major consumers. China uses more than one-fourth of world production. The Soviet Union consumes almost 15 percent of the world output, followed by India which consumes almost ten percent of the total. Other leading consumers of cotton are the United States, Japan, and Western Europe is the other major market.

Mill Usage versus Final Consumption - Data on consumption of cotton do not indicate the entire range of usages by the cotton industry because of the differences between mill and final consumption. Mill usage of cotton is the amount of cotton that is processed into yarn, which is the primary raw material input of the textile industry. Final consumption refers to a broader range of uses. It includes the mill usage and by-products that are derived from cotton, such as cottonseed meal and oil. World cotton use, as defined by the International Cotton Advisory Committee (ICAC, 1985), refers to raw cotton consumed by spinning mills and other factories, plus estimates of non-commercial or household consumption.

Distribution Among End Uses - Cotton is produced primarily for the value of its principal product, fiber, which is used in the textile industry. However, cotton by-products such as cottonseed oil and cottonseed meal, which are obtained by crushing the cotton seed, are also important. Cottonseed oil has become the second largest vegetable oil used for human consumption in products such as margarine and salad oil. Cottonseed meal accounts for approximately six percent of the world's crude protein supplies used in animal feed.

The demand for cotton is a derived demand of products which contain cotton. In the United States, the most important industry that benefits from cotton production is the apparel industry which accounts for over one-half of the cotton consumed, according to the World Bank (IBRD, 1981). Home furnishings absorbed another 35 percent on average of the total, and the remaining amount (15 percent) is directed to industrial uses.

Substitution Among Cotton and Other Synthetic Fibers - Mill usage of cotton has declined in industrial countries during recent years due to increased technology in the production of man-made synthetic fibers. The increased use of man-made fibers has been concentrated in industrialized economies and is attributed to the capital-intensive and knowledge-intensive nature of the textile industry. The producers of such products are typically part of large and diversified multinational chemical companies which operate in an oligopolistic market; in contrast, there are a large number of natural-fiber producers in the world.

The impact of synthetic substitution is evident in the apparel industry, especially in the United States. For example, polyester, which is the most well-known and important competitor of cotton, is noted for its characteristic of ease of care. In other parts of the world, however, cotton continues to remain the preferred fiber in the apparel industry.

Substitution in consumption between synthetic fibers and cotton has been considered in the market model for cotton. A good proxy for synthetic fiber prices, according to unpublished information from the World Bank, is the price of manufactured exports from industrial to developing countries, the so-called MUV index. This index was used as a proxy for the price of synthetic fibers in the consumption equation.

PART III

EMPIRICAL RESULTS

Chapter 13

THE DATA

The commodities coverage is described in Table 1 in accordance with the Standard International Trade Classification, Revision 2 (SITC, Rev. 2). The first seven commodities are classified as basic foods; the last three as raw materials. Maize is used almost exclusively for animal feed throughout the world, except in Latin America where it is an important source of food. Soybeans are processed into soybean oil, which is mainly used for edible purposes, and soybean meal, which is widely used in the preparation of livestock feeds.

The world market price used for commodities are normally those that are representative of trade between markets that dominate international trade (see Table 2). If these markets are protected by import quotas or tariffs then a price quotation in the free market is instead selected as the indicator of movements in aggregate supply and demand. There are exceptions. Sugar in the free market has had its supply regulated since 1953 during several periods by international sugar agreements aimed at stabilizing price fluctuations. Iron ore is traded under long-term contracts. Brazilian iron ore producers begin negotiation with European steel producers at the end of each year then proceed to negotiate with Japanese steel producers for delivery of iron ore in the next year under long-term contracts.

Table 1

DESCRIPTION OF COMMODITIES

Product	SITC Rev. 2	DESCRIPTION
Coffee	071.1	Coffee, whether or not roasted or freed of caffeine; coffee husks and skins; coffee substitutes containing coffee in any proportion.
Soybeans	081.31; 222.2	Oil-cake and other residues (except dregs resulting from the extraction of vegetable oils of soya beans); soya beans.
Copper	287.1; 682	Copper ores and concentrates; copper matte; cement copper; copper.
Iron Ore	281	Iron ore concentrates.
Sugar	061.1; 062.2	Sugars, beet and cane, raw, solid; refined sugars and other products of refining beet and cane sugar, solid.
Beef	011.1	Meat of bovine animals, fresh, chilled or frozen.
Bananas	057.3	Bananas (including plantains), fresh or dried.
Maize	044	Maize (corn), unmilled.
Cocoa	072	Cocoa, which encompasses the following types:
	072.1	Cocoa beans, whole or broken, raw or roasted.
	072.2	Cocoa powder, unsweetened.
	072.31	Cocoa paste (in bulk or in block), whether or not defatted.
	072.32	Cocoa butter (fat or oil)
Cotton	263.1	Cotton (other than linters), not carded or combed.

Table 2

DESCRIPTION OF MARKET PRICES

Product	Type	DESCRIPTION
Coffee	Brazilian	I.C.O. indicator price, unwashed Arabicas (Brazilian Santos 4), ex-dock N.Y. for prompt shipment.
	Colombian	I.C.O. indicator price, Colombian mild Arabicas (Colombian Mams), ex-dock N.Y. for prompt shipment.
	Guatemalan	Prime washed, ex-dock N.Y. for prompt shipment.
	Other Milds	I.C.O. indicator price, arithmetic average of the quotations: Angola Ambriz 2 BB + Uganda Standard, ex-dock N.Y. for prompt shipment.
Soybeans	United States	c.i.f. Rotterdam.
Copper	London Metal Exchange	Standard electrolytic wire bars, settlement price.
Iron Ore	Brazilian	Europe, 65% c.i.f. North Sea ports; prior to 1975 68%.
Sugar	World	ISC daily price, f.o.b. and stowed at greater Caribbean ports; prior to 1961, New York World Contract No. 4, f.a.s. Cuba.
Beef	United States	Imported frozen boneless, 90% visible lean cow meat, f.o.b., port of entry; as of December 1975, 85% chemical lean.
Bananas	Any origin	From 1979 onwards, first class green stems from Central America to Ecuador, importer to jobber of processor, f.o.b. port of entry, 40lb boxes; prior to 1979, Ecuadorian, c.i.f. Hamburg.
Maize	United States	No.2 yellow, f.o.b. Gulf ports.
Cocoa	Ghanaian	ICCO daily price, average, New York and London, nearest 3 future trading months.
Cotton	A Index	Middling (1-3/32"), c.i.f. N. Europe.
	United States	Middling 32 (1"), Orleans/Texas, c.i.f. N. Europe.

The main exogenous variables used in the model are gross domestic product (GDP), the rate of interest, and the general price level. The variable used to measure the general price level in the world economy is the manufactured unit value (MUV) index of industrial country exports to developing countries. The use of this index might at first appear heuristic. But insofar as primary commodities often serve as inputs to manufactured goods, movements between the two types of goods would be expected to be fairly similar. To test this hypothesis, we examined the correlation between changes in the price of the two types of goods over the last twenty-five years (1960-84). For the thirty-three commodities monitored by the World Bank (IBRD, 1985), the correlation with the MUV index was 0.96; for the ten commodities modeled in this study the correlation was 0.93, with correlation between individual commodities and the MUV as follows:

	Correlation Coefficient		Correlation Coefficient
Coffee	0.93	Beef	0.91
Soybeans	0.94	Bananas	0.96
Copper	0.61	Maize	0.94
Iron Ore	0.91	Cocoa	0.90
Sugar	0.71	Cotton	0.97

The generally close relationship that exists between changes in prices of the ten commodities, except sugar and copper, and the MUV index is convenient for our purposes. Forecasts of the MUV index over a ten-year period are prepared semi-annually by the World Bank, thereby providing forecasted data of this exogenous variable for the market models.

Chapter 15

RESULTS FOR CONSUMPTION

The empirical results for the consumption equation indicate that the general dynamic specification provides a good representation of the data-generating process in commodity markets. Appendix tables A.2 and B.2 present the results of the final form of the estimated equations and the solved coefficients in their original levels form. In this chapter, we examine the implied elasticities in the consumption function, as well as the short-term price and income elasticities in the consumption equations.

The main parameters of the consumption function are presented in Table 3. Its is important to emphasize that the income elasticities reported in this chapter are measured on the basis of total, rather than per capita, gross domestic product (GDP). The results show that the average income elasticity for eight of the commodities which were estimated in their structural form is 0.9. However, the range of elasticity estimates varies greatly, between 0.4 and 1.9, so that it would be misleading to make generalizations about elasticities on the basis of an average. Instead, a pattern may be discerned among the commodities. Soybeans, sugar (which includes HFCS and therefore represents "sweeteners"), copper, and beef have income elasticities that are greater or equal to unity. On the other hand, coffee, cocoa, cotton, and maize have income inelastic consumption functions. These findings conform to the characterization of the markets for these commodities in Chapters 3 to 12.

Table 3

CONSUMPTION FUNCTIONS

	Price Elasticity	Income Elasticity a/	Growth Coefficient b/
COFFEE	-0.03	0.33	0.0
SOYBEANS	0.00	1.86	0.0
COPPER	-0.09	1.00	3.9
SUGAR	-0.04	1.00	0.6
BEEF	-0.29	1.00	0.0
MAIZE	0.00	0.80	1.1
COCOA	-0.13	0.65	1.1
COTTON	-0.33	0.48	0.0

a/ Measured with respect to a change in aggregate, rather than per capita, gross domestic product (GDP) for basic foods and industrial production for raw materials.

b/ Refers to the coefficient for π_3, the rate of growth of income, in equation (2.30).

Source: Appendix A: Table 2

In addition to the effect on consumption brought about by a change in the level of economic activity, several of the commodities have a positive, dynamic effect arising from changes in the rate of growth of economic activity. This effect is shown in the column labeled "Growth Coefficient." For example, where the long-term rate of growth of world economic activity to decelerate from 5 per cent a year, as roughly characterized the pre-1973 period, to 2.5 per cent a year, as in the post-1973 period, the intercept of the copper consumption function would shift downward, specifically, from and intercept of exp[5 + 3.9(0.05)], or 180, to exp[5 + 3.9(0.025)], or 164. Thus changes in the rate of growth of economic activity can produce substantial shifts in the consumption functions of sugar, copper, maize, and soybeans, though no such dynamic effects were found to exist in the consumption functions of coffee, cotton, beef, or soybeans.

The price elasticities of demand for all commodities are, on average, -0.11. They range from a low of -0.03 for coffee and -0.04 for sugar to a high of -0.30 for cotton and beef. Soybean and maize consumption do not respond to price variations over the long run. These results are examined in more detail in the commodity-specific analysis that follows.

Coffee - Consumption takes one year to adjust to a new level of income., and the adjustment to the new level of consumption follows an oscillating path. The total change in coffee consumption is less than proportional than the change in income, as would be expected from the description of the coffee market in Chapter 3.

Nominal price changes are more significant than constant dollar price changes in affecting consumption of coffee. However, the extent of the response to nominal price changes was only found to be significant at the ninety percent level of confidence.

Sugar - World consumption, excluding that in the EEC market, has a proportional response to income changes in the short run (see Table 4),

Table 4

SHORT-TERM PRICE AND INCOME ELASTICITIES

	Price Elasticity	Income Elasticity a/
COFFEE	-0.08	0.82 b/
SOYBEANS	-0.12	1.79 b/
COPPER	-0.05 b/	2.26
SUGAR	-0.02	0.47
BEEF	-0.10	0.34 b/
MAIZE	-0.21	0.76
COCOA	-0.12	0.59
COTTON	-0.09	0.67 b/

a/ Measured with respect to a change in aggregate, rather than per capita, gross domestic product (GDP) for basic foods and industrial production for raw materials.

b/ One-period lag.

Source: Appendix A: Table 2

but the estimated income elasticity of demand was equal to unity in the long run. As with coffee, nominal prices changes are more statistically significant in explaining consumption levels than are constant dollar price changes.

Copper - Copper consumption has a greater response to changes in the level of economic activity in the short run than in the long run. These results are based on coefficient estimates that are significant at the one percent level. The pattern of response which the findings suggest is that buyers initially respond strongly, for instance, to an expansion in economic activity, in a sense over-reacting to the change in market condition; then they reduce their consumption in subsequent years until the total new level of consumption is in line with the new level of economic activity. The total response is proportional to the change in the level of economic activity in the long run. Again nominal, rather than constant, prices were statistically more significant in explaining copper consumption.

Cotton - An important difference between the consumption function for cotton and that of other commodities was the inclusion of a proxy variable for the price of substitutes, synthetic fibers. The estimated coefficient of this variable was significant and has a positively-signed coefficient.

Consumption of cotton responds to changes in economic activity with a one-year lag, yet the response in that first year is somewhat greater than the total response to the new level of economic activity. Like copper consumption, this finding suggests that consumers over-react initially and then adjust consumption to the level desired in the long run.

Beef - Consumption of beef adjusts to changes in income with a one year lag. The total effect response is proportional to the change in income. Price changes, measured in nominal dollar terms, were significant at the one percent level.

Maize - Most of the adjustment in maize consumption (95 per cent) occurs in the same year as a change in the level of economic activity. The total response of consumption is less-than-proportional to a change in economic activity. The price effect was not found to be statistically significant in the long run. However, there is a transient short-term response of consumption to a change in the constant dollar price of maize.

Soybeans - As with beef, coffee and cotton, consumption of soybeans responds with a one year lag to a change in the level of economic activity. As expected from the analysis of conditions characterizing the soybean market in Chapter 10, soybean consumption has a more-than-proportional response to changes in economic activity.

Soybean consumption was found to respond to changes in prices only in the short run, which means that the response is only transient. A dummy variable was introduced to eliminate the observation for 1975 since the equation seriously overestimated the change in consumption in that year.

Cocoa - The final form of the estimated equation for consumption of cocoa was the same as that of the general specification, the only exception being that the nominal, rather than constant, dollar price of cocoa was more statistically significant.

Chapter 15

RESULTS FOR PRODUCTION

The two fundamental questions concerning the supply of a commodity relate to its price elasticity and its lag structure. The difference between the price elasticity in the short run and the elasticity in the long run is important since the effect of some policies, such as commodity price stabilization, depends on the short-run elasticity while that for others, such as cartelization and balance of payments adjustment policies, depends on the long-run elasticity. The lag structure of supply is often characterized by multiple, complex, delayed responses to price changes. For instance, a price rise could induce a short-term response in production from new plantings, higher yields, or stock depletion; it could induce a medium-term response from an expansion in installed capacity; and it could induce a long-term response from initiation of new capacity. This chapter presents the results for price elasticities and lag structures of the eight commodity markets whose system of equations were estimated in their structural form.

A rational lag structure was applied that suitably represented the underlying nature of the response suggested by the analysis of the commodities in Chapters 3 to 12. That analysis resulted in the application of the following rational lag structures:

Commodity	Lag(s) of dependent supply variable	Lags of explanatory price variable	Commodity	Lag(s) of dependent supply variable	Lags of explanatory price variable
Coffee	1	4	Beef	1,2	4
Soybeans	1	1	Maize	1	2,3
Copper	1	0	Cocoa	1	4,7
Sugar	1,2	2,3	Cotton	1	1

The lag coefficients that emerge from the rational lag structure can be obtained by the method shown in Griliches (1967:23). For the general stochastic difference equation:

$$q_t = \underbrace{\alpha_1 q_{t-1} + \ldots + \alpha_r q_{t-r}}_{\text{lagged dependent variable}} + \underbrace{\beta_0 p_t + \ldots + \beta_n p_{t-n}}_{\text{lagged explanatory variable}} \qquad \ldots(34)$$

the lag coefficient δ_d for the price variable is given by the formula

$$\delta_d = \sum_{i=1}^{\min(d,r)} \alpha_i \delta_{j-1} + \beta_j \qquad \ldots(35)$$

where d is the lag and the price, p, is measured in constant dollars. The coefficient δ_o of the price variable in the current period t is equal to β_o .

A one-period lag of the dependent supply variable produces a <u>dampened smooth approach</u> to the new equilibrium solution, while a two-period lag produced a <u>dampened cyclical approach</u> to the new equilibrium solution. More than two-period lags of the dependent variable are seldom used in empirical econometrics because, as noted by Griliches (1967), they produce lag structures that are very sensitive to the parameter values.

Table 5 summarizes the price elasticities and lag structures of the eight commodities for which market models were estimated in their structural form.

Table 5

PRODUCTION FUNCTIONS

	Price Elasticity		Average Lag		No.of Periods for:	
	Impact 1/	Total 2/	Mean	Median	75% of response	90% of response
COFFEE						
Brazil	0.19 (t-5)	0.20	5.0	4.5	4.8	4.9
Rest-of World	0.13 (t-3)	0.14	3.1	2.5	2.8	3.0
SOYBEANS	0.31 (t-0)	0.45	1.4	0.7	1.3	2.0
COPPER	0.08 (t-0)	0.33	3.6	3.4	5.2	6.9
SUGAR						
U.S.A.	0.13 (t-1)	0.23	1.6	0.9	1.6	2.0
Rest of World	0.05 (t-3)	0.03	2.6	2.3	2.4	2.5
BEEF	0.05 (t-4)	0.18	5.3	4.7	5.6	6.4
MAIZE	0.23 (t-2)	0.29	2.2	1.6	2.0	2.6
COCOA	0.03 (t-4)	0.16	6.5	6.4	6.8	7.3
COTTON	0.13 (t-1)	0.13	1.02	0.51	0.8	0.9

1/ The impact elasticity measures the first-period response of production to a change in price. The notation in parenthesis indicates the period in which production first responds to a change in price.

2/ The total, or long-run, elasticity measures the cumulative response of production to a change in price.

Source: Derived from Appendix B, Table 2.

Price Elasticities - The first two columns of Table 5 give the impact and total price elasticities of supply for the commodities. The impact elasticity is the first-period response of supply to a change in the market price. It is similar to the short-run elasticity in that it measures the first response of supply to a price change; it is different in that the first response to a price change does not take place for several years in some commodities. The number of periods that elapse until the first response occurs is indicated in parenthesis beside the impact elasticity. For example, the initial response to a price change in coffee production occurs five years after the change.

The total price elasticity of supply is the same as long-run price elasticity. Since the supply equation was estimated in the log-linear functional form, the coefficient estimates were shown in equation (2.27) to be equal to the price elasticity of supply. Accordingly, the long-run elasticity of a commodity can be simply calculated as the sum of the trade-weighted average of the derived lag coefficients 1/.

1/ The long-run price elasticity can also be directly calculated, as suggested by Griliches (1967:23), from the derived coefficients of the stochastic difference equation:

$$A(L)q_t = B(L)p_t + e_t$$

as the ratio of the two polynomials evaluated at $L = 1$:

$$\frac{B(1)}{A(1)} = \frac{\beta_0 + \beta_1 + \ldots + \beta_s}{1 - \alpha_1 - \alpha_2}$$

where the lag polynomials $A(L)$ and $B(L)$ are defined in the form $1 - \alpha_1 L - \alpha_2 L^2$ and $\beta_0 + \beta_1 L + \beta_2 L^2 + \ldots + \beta_s L^s$ respectively. (The lag operator is defined as $Lp_t = p_{t-1}$, $L^2 p_t = p_{t-2}$, and so forth).

Lag Distribution -- The lag coefficients, which determine the way in which supply responds to a change in price, are derived from solved coefficients of the estimated stochastic difference equations. How quickly and in what manner export supply adjusts to a price change naturally differ among commodities. In addition, considerable variation can occur in the speed and path of adjustment of different exporters of the same commodity.

There are four statistics reported that help to describe the shape of the lag distribution. The first two are the mean and median lags. The mean lag, μ_d, is the average of the time for the response and is calculated as a lag-weighted average 1/:

$$\mu_d = \sum_{d=o}^{\infty} d\delta_d / \sum_{d=o}^{\infty} \delta_d$$

where δ denotes the lag coefficient and d denotes the number of lagged periods. The major limitation of average mean lags, as Hendry, Pagan, and Sargan (1984) point out, is their inability to describe asymmetrical lag distributions and their erroneous results when the lag coefficients are not all of the same sign. For this reason they recommend other summary statistics to describe a response, say for example the time taken for a certain portion of the total response to occur or the amount of response that has transpired at the mean lag.

1/ The mean lag can be calculated directly from the derived coefficients of the estimated equation, as shown by Harvey (1981:234), with the formula:

$$\mu_d = \frac{B'(1)}{B(1)} - \frac{A'(1)}{A(1)}$$

where a prime denotes differentiation of the lag polynomial.

The median lag is the number of time periods it takes for one-half of the adjustment to be completed. Formally, it is the number of lagged periods at which point the interim response, the sum of the normalized lag coefficients, equals 0.5 1/. Normalized lag coefficients are the ratio of the lag coefficients to their total. By construction, the normalized lag coefficients sum to unity. Consequently, the first step to the identification of the median lag of the supply response to price changes is to calculate the normalized lag

---

1/ The usual practice is to calculate the median lag directly from the derived coefficients of the estimated equation (see for example Pindyck and Rubinfeld, 1981: 233-234 and Harvey, 1981: 234). However, when the explanatory variables are lagged the formula used will lead to erroneous results. The resulting error can easily be demonstrated. The total response in the second order case was shown to equal:

$$\frac{B(1)}{A(1)} = \frac{\beta_0 + \beta_1 + \ldots + \beta_s}{1 - \alpha_1 - \alpha_2}$$

The interim response is equal to:

$$\frac{\beta_0 + \beta_1 + \ldots + \beta_s[1 - (\alpha_1 + \alpha_2)^{d+1}]}{1 - \alpha_1 - \alpha_2}$$

(Recall that $\alpha_1 + \alpha_2 < 0$ is a necessary restriction for a non-negative lag distribution in the supply equation (2.26). Hence the <u>standardized</u> interim response equals the ratio between the interim response and the total response, which yields $1 - (\alpha_1 + \alpha_2)^{d+1}$. The median lag is found at the point where $1-(\alpha_1+\alpha_2)^{d+1} = 0.5$. The solution for d at that point equals:

$$d \ln(\alpha_1 + \alpha_2) + \ln(\alpha_1 + \alpha_2) = \ln 0.5$$

or

$$med_d = \frac{\ln 0.5}{\ln(\alpha_1 + \alpha_2)} - 1$$

It follows directly that if $\alpha_2 = 0$, such that the lag distribution follows a dampened smooth path, then $med_d = \ln 0.5/(\ln \alpha_1) - 1$. When $\alpha_1 + \alpha_2 < 0.5$ the median lag will be negative, in which case Harvey (1981: 234) recommends that it be rounded to zero.

coefficients. Next the interim response is computed. Finally, since often half of the total response does not occur at one of the discrete intervals, the median lag is determined by interpolation.

A comparison of the mean and median lags can give an idea of the shape of the lag distribution. If the lag distribution were symmetrical the mean lag would equal the median lag 1/. When the mean lag is greater than the median lag, it is an indication that the lag coefficients decline over time. This "tailing off" in asymmetrical distributions is observed in the response of agents operating in the eight commodities in Table 5. The present behavior of agents becomes less affected by the behavior of an explanatory variable the farther in the past its occurrence. The extent of the difference between the mean and median lags provides an indication of how rapidly the effect is abated. The more rapid the convergence of the lag coefficients to zero the greater will be the difference between the mean and median lags.

Coffee -- The search for the structure of the response of production to price changes was carried out with an Almon lag technique. Prices lagged four, five, and six years for Brazil, and prices lagged two, three, and four years for the rest of the world were identified as the major determinants of production. These prices were included in the production function as an arithmetic average. The goodness-of-fit of both equations was found to be better with nominal, rather than

1/ In a symmetrical lag distribution the observed lags around the median are identically distributed. In particular, a distribution is symmetrical about the mean μ if for any constant c the values $\mu - c$ and $-(\mu - c)$ have the same lag distribution.

constant, dollar prices. Binary variables were introduced to capture years in which particularly sever frost damage affected output.

Coffee production of all countries except Brazil, on average, responds to changes in the market price after a three year lag, and that of Brazil responds after a five year lag (see Figure 14). A 1.0 percent change in the price of coffee induces production of Brazil to change by 0.20 percent and that of the rest of the world to change by 0.14 percent, and over 90 percent of both of these responses occur in the first year of the response. Although production responds with a three to five year lag to a change in the market price, there is very rapid adjustment once it is initiated.

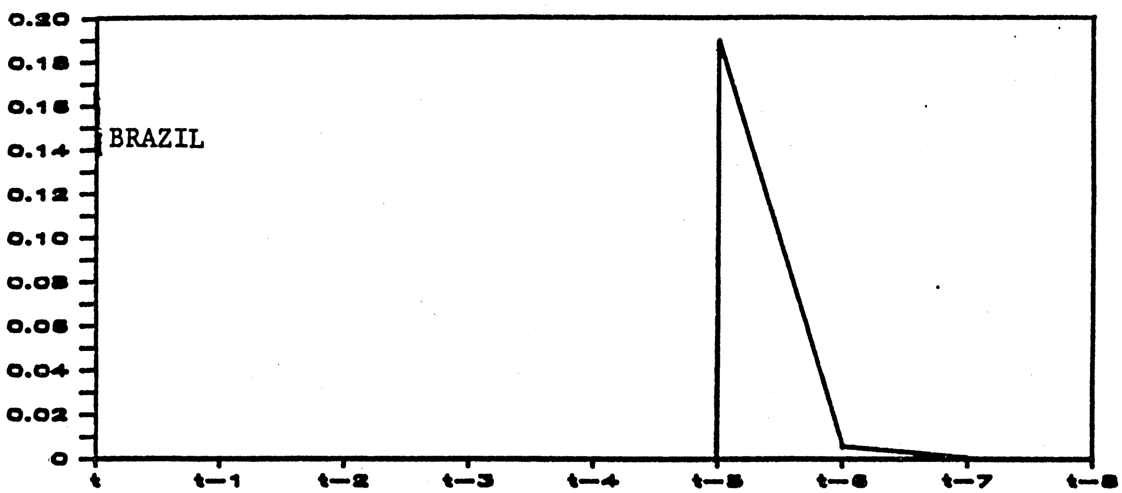
Soybeans - The final production equation confirms that the most relevant price to the farmer is that in effect at the time of planting. However, full adjustment to the price change takes three years to complete. The adjustment is characterized by a dampened smooth response. The method used to calculate the lag structure is based on equation (35). The response follows a dampened smooth path. To illustrate, consider the results of the estimated stochastic difference equation in the original levels form for soybean production, Q, in terms of its nominal dollar price, P, and the nominal dollar price of beef, P_o, as reported in Appendix B: Table 1:

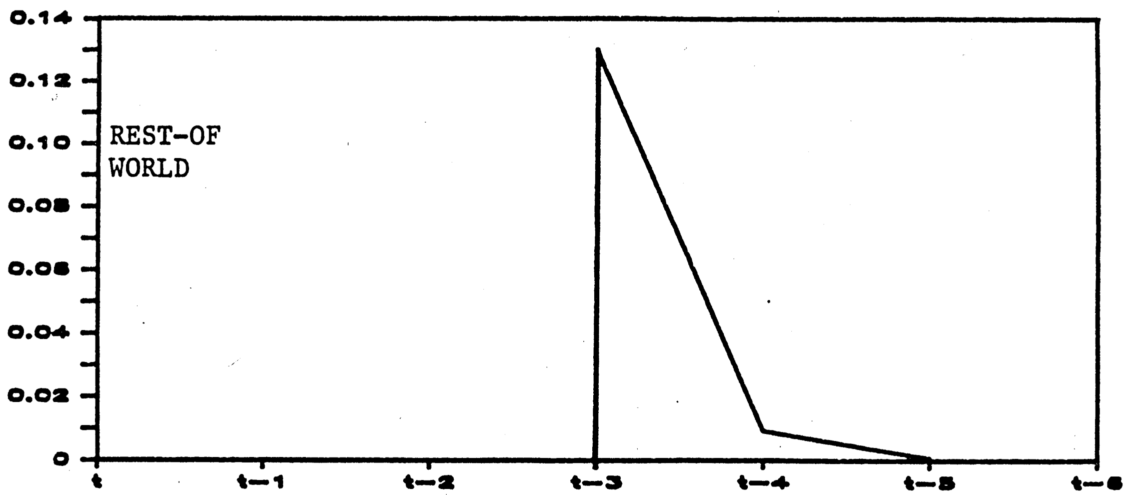
$$q_t = 4.2 - 0.31q_{t-1} + 0.31p_{t-1} + 0.22p_{o,t}$$

where lower-case letters denote logarithms of upper-case letters. The

Figure 14

COFFEE: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE





LAG	t-0	t-1	t-2	t-3	t-4	t-5	t-6	t-7
Lag Coefficient:								
Brazil						0.19	0.01	0.00
Rest-of-World				0.13	0.01	0.00	0.00	0.00
Normalized Lag Coefficient:								
Brazil						0.97	0.03	0.00
Rest-of-World				0.93	0.07	0.00	0.00	0.00
Cumulative Effect:								
Brazil						0.19	0.20	0.20
Rest-of-World				0.13	0.14	0.14	0.14	0.14

derived lag coefficients are obtained by application of the formula given in equation (35):

$$\delta_1 = 0.31$$

$$\delta_2 = 0.31(0.31) = 0.10$$

$$\delta_3 = 0.31(0.10) = 0.03$$

$$\delta_4 = 0.31(0.03) = 0.01$$

$$\delta_5 = 0.31(0.01) = 0.00$$

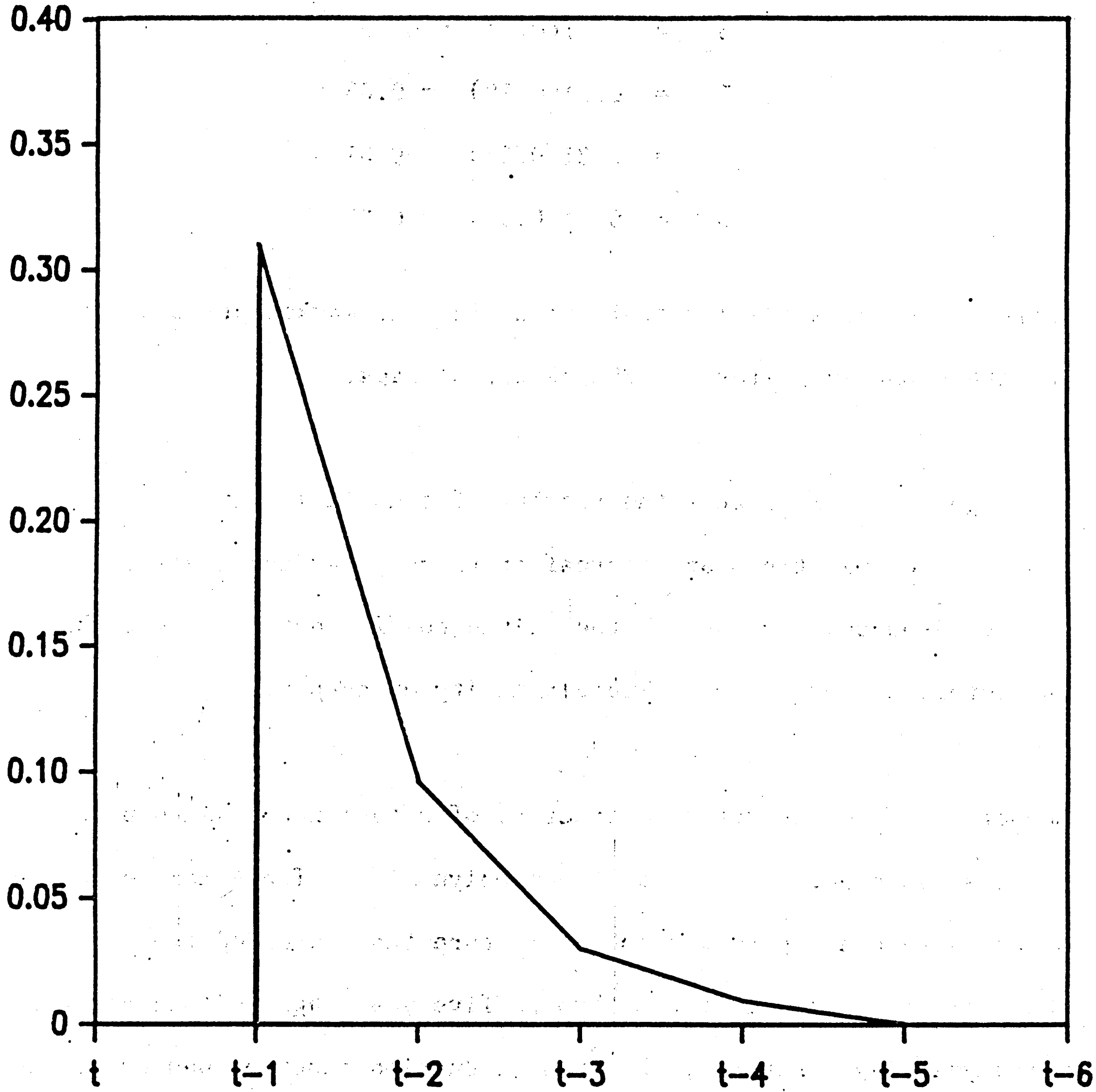
where δ denotes the lag coefficient for the market price of soybeans and the subscript refers to the number of lags.

Figure 15 illustrates the results of these calculations. A price rise induces plantings and thereafter there is an exponential decline in the response. The sum of the solved coefficients is 0.45, which is the total, or long-term, price elasticity of supply.

Copper -- A search for the structure of output response to price changes was conducted with an Almon polynomial. The Almon technique showed a second-degree response structure that extended over four yearly lags, these being two through five year lags, with a peak in the third year lag. However, when the production function was estimated using the specification in equation (2.26) above, changes in current price and price lagged four and seven years explained the behavior of supply better than was suggested by the findings of the identification search procedure.

Figure 15

SOYBEANS: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE



LAG	t-1	t-2	t-3	t-4	t-5
Lag Coefficient	0.31	0.10	0.03	0.01	0.00
Normalized Lag Coefficient	0.69	0.21	0.07	0.02	0.01
Cumulative Effect	0.31	0.41	0.44	0.45	0.45

In addition, the 1967 strike in the United States caused production to fall below what market price movements would have warranted. This event could only be introduced into the model through a qualitative variable. The variable used was a binary variable in which a value of one was assigned to 1967 and zero in all other years.

The (dependent) production variable entered the equation with a one period lag. The dampened smooth approach to steady-state equilibrium will be illustrated here for the estimated equation for supply of copper, Q, in terms of its market price, P, based on the solved coefficients of the estimated equation in Appendix B, Table 2:

$$q_t = -10.7 + 0.39q_{t-1} + 0.08p_t + 0.08p_{t-4} + 0.04p_{t-4}$$

Application of the formula given in equation (35) above yields the solved lag coefficients:

$$\delta_0 = 0.08$$
$$\delta_1 = 0.39(0.08) = 0.03$$
$$\delta_2 = 0.39(0.03) = 0.01$$
$$\delta_3 = 0.39(0.01) = 0.00$$
$$\delta_4 = 0.39(0.00) + 0.08 = 0.08$$
$$\delta_5 = 0.39(0.08) = 0.03$$
$$\delta_6 = 0.39(0.03) = 0.01$$
$$\delta_7 = 0.39(0.01) + 0.04 = 0.04$$
$$\delta_8 = 0.39(0.04) = 0.02$$
$$\delta_9 = 0.39(0.02) = 0.01$$
$$\delta_{10} = 0.39(0.01) = 0.00$$

where δ denotes the lag coefficient for the market price of copper and its subscript refers to the number of lags.

The results, graphed in Figure 16, suggest that production responds in the short run through changes in existing capacity utilization. The four-year lagged response in production to price changes explains the time lag required to change existing capacity, and the seven-year lagged response indicates the time lag required to initiate new capacity.

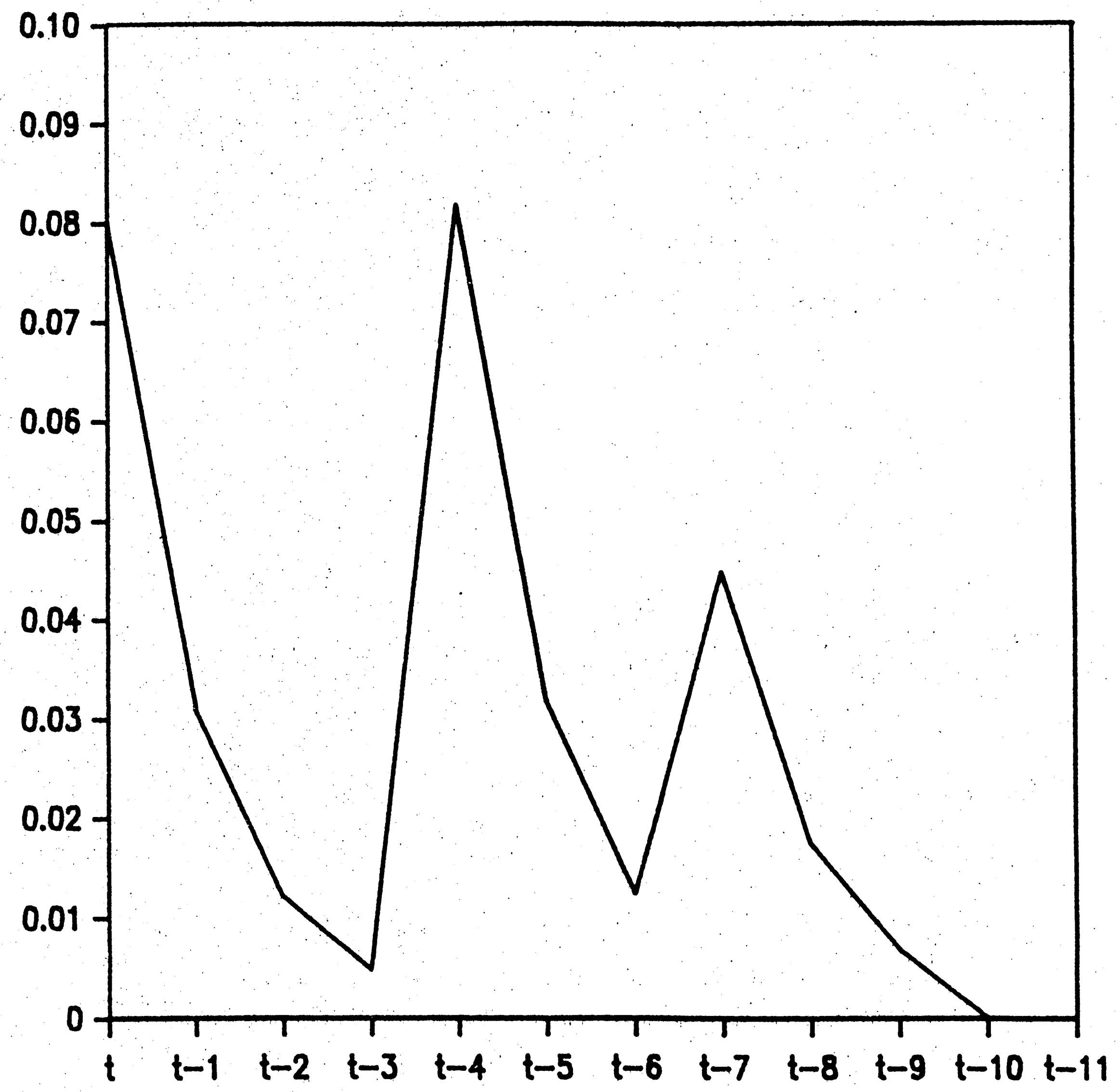
Iron Ore -- Production was found to respond to concurrent and lagged price variations. One-year and seven-year lagged responses were identified. The current and one-year lagged responses to price changes are associated with underutilized existing capacity. However, even existing capacity requires some time to activate, a fact which is borne out by the resulting greater price response in the year following the price change than in the same period as the price change. The long, seven-year lag is associated with capacity adjustment.

The trend variable in the production function was found to be significant and positive. Additionally, the introduction of a polynomial of the second degree in the trend variable helped to explain production changes over the period of the sample. It means that production has increased over time, regardless of price rises, but at a decreasing rate. This finding is consistent with the description of the industry in Chapter 6.

Sugar -- The production equation for the world, excluding United States production and EEC production for domestic consumption, is a second-order difference equation in the production variable. The

Figure 16

COPPER: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE



LAG	t-0	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t-8	t-9	t-10
Lag Coefficient	0.08	0.03	0.01	0.00	0.08	0.03	0.01	0.04	0.02	0.01	0.00
Normalized Lag Coefficient	0.25	0.10	0.04	0.01	0.25	0.10	0.04	0.14	0.05	0.02	0.01
Cum. Effect	0.08	0.11	0.12	0.13	0.21	0.24	0.25	0.30	0.32	0.32	0.33

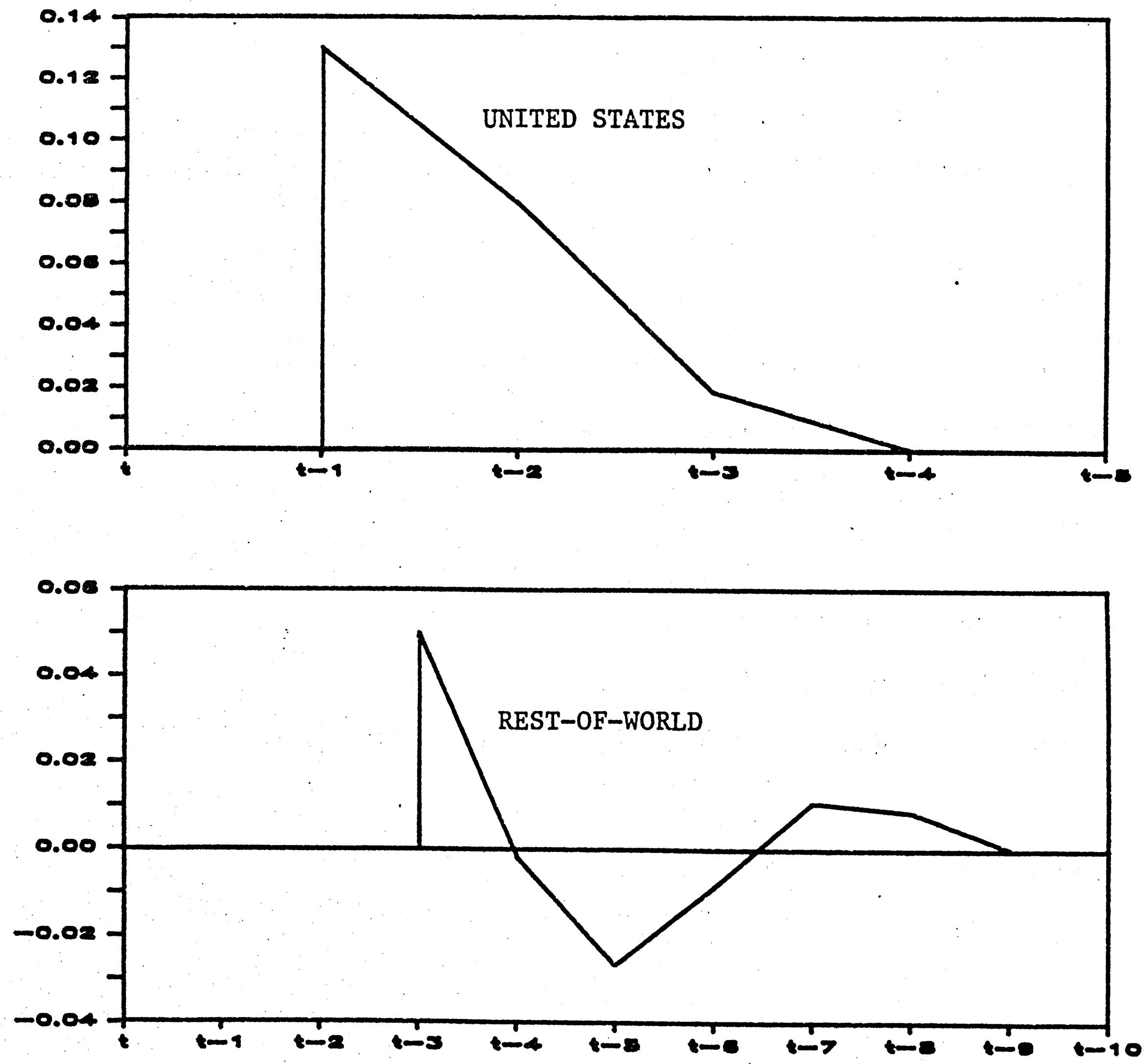
results indicate that the convergence property of this particular equation exhibit a dampened oscillating pattern toward its long-run dynamic equilibrium. The reson is that production lagged one and two periods was included in the equation. A second-order stochastic difference equation can produce discrete oscillations of the dependent variable around its long-run dynamic equilibrium path, a result that is plausible in a dynamic context provided the fluctuation do not lead to divergence. These oscillations dampen when the absolute value of the conjugate complex roots is less than unity. Hence, rather than an exponential decrease in the response of production to a change in any one of the explanatory variables, there is a dampened cyclical response of production.

The response of production to price changes was, as expected from the discussion in Chapter 7, to be greater than would otherwise occur in the planting cycle. The first response was found three years after a price change, and the long-term response was not found to begin until four years after the price change has taken place. A second-order polynomial in the trend variable was included, which implies that the rate of growth of production has accelerated over time, although at a very small rate.

United States production has a faster response to price changes, as measured by nominal domestic prices. A short-term response occurs after one year, then there is another response in the following year, after which the effect of the price change on production declines exponentially. The difference between the United States and

Figure 17

SUGAR: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE



LAG	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t-8	t-9
Lag Coefficient:									
United States	0.13	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Rest-of-World			0.05	0.00	-0.03	-0.01	0.01	0.01	0.00
Normalized Lag Coefficient:									
United States	0.56	0.34	0.08	0.02	0.00	0.00	0.00	0.00	0.00
Rest-of-World			1.71	-0.07	-0.91	-0.29	0.37	0.29	-0.09
Cumulative Effect									
United States	0.13	0.21	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Rest-of-World			0.05	0.05	0.02	0.01	0.02	0.03	0.03

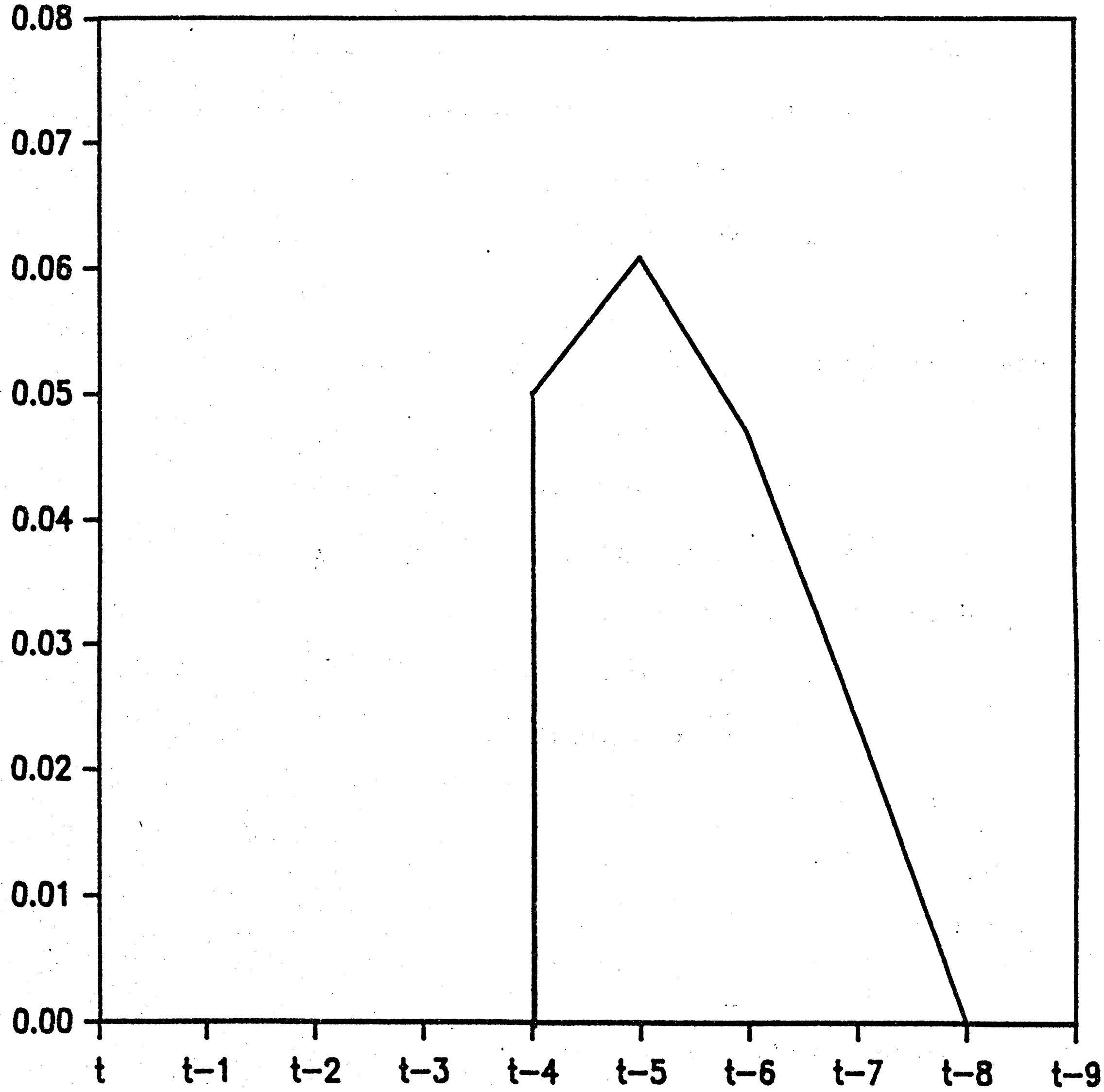
rest-of-world responses to a price change is shown in Figure 17. In addition to the domestic prices, a positive coefficient for a trend variable in the United States supply equation indicates that output has tended to increase over time, regardless of price movements. Finally, a binary variable was included to account for the end of United States Sugar Policy in 1974 and domestic farmer incentives to expand production in the year preceding its termination.

The United States price was explained by an equation linking it to the world price. It follows the world price closely when the world price is above the domestic floor price, but it departs from the world price when the latter falls below the floor price in the United States. Divergences between the two prices occurred particularly in 1965 and 1982-84, and these two major divergences were captured by binary variable. In both cases the coefficients were positive.

Beef -- Production of beef was found to be best explained by nominal price lagged four years, a result which is consistent with the "cattle cycle" explanation of the beef market (see Figure 18). The nominal, current price of soybeans was also statistically significant in explaining changes in production of beef. The positively-signed variable implies that when soybeans are more expensive, slaughter increases and more beef is produced, a result consistent with the "cattle cycle" described in Chapter 8; when soybeans prices rise, cattle feeding becomes more expensive (in the areas of the world where such a feed is used); then, it may become more profitable for the cattle farmers to slaughter.

Figure 18

BEEF: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE



LAG	t-4	t-5	t-6	t-7	t-8
Lag Coefficient:	0.05	0.06	0.05	0.02	0.00
Normalized Lag Coefficient:	0.27	0.33	0.25	0.13	0.02
Cumulative Effect:	0.05	0.11	0.16	0.18	0.18

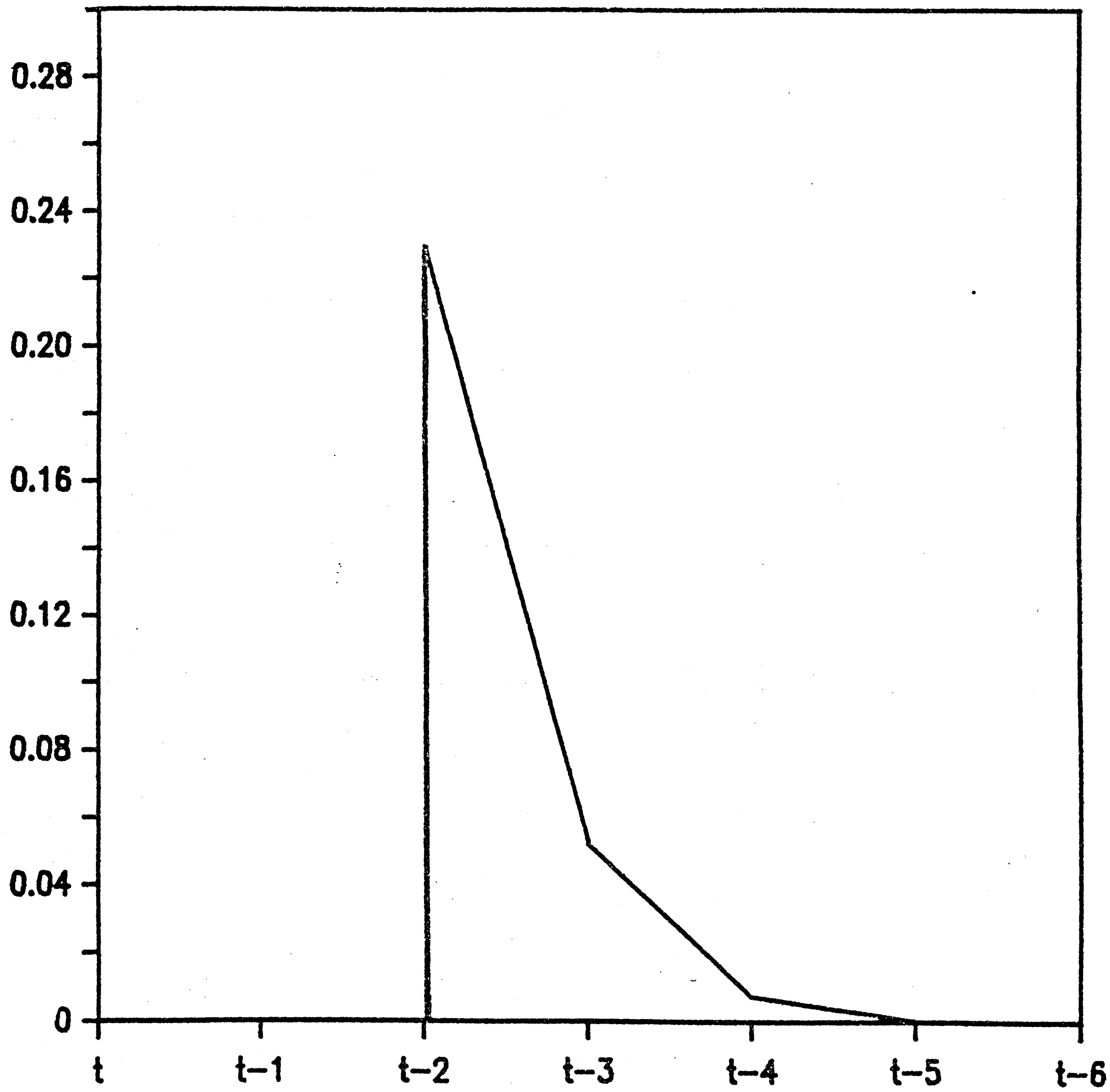
Maize -- Production responds to changes in the nominal market price of maize lagged two and three periods, and adjustment takes four years to be completed (see Figure 19). Additionally, production is determined by the current, nominal price of beef. As described in Chapter 9, one of the characteristics of the maize market is that producers respond to changes in the price of beef as an indication of changes in demand cattle feed at the time of planting.

Cocoa -- Producer prices are more appropriate than world market prices in the estimation of the price responsiveness of major producing countries that administer the price received by domestic producers. As such, an attempt was made to estimate the world supply function on the basis of an output-weighted average producer price of the five major producers. However, when the composite producer-price index was used the overall goodness-of-fit actually deteriorated compared to that of an equation in which the world market price was used. Two weather-related binary variables significantly improved the goodness-of-fit.

Individual country supply equations were also estimated with producer prices for each major producing country. The results of the estimates indicated that Ghana and Brazil were the only countries that showed significant responses to changes in constant local currency cocoa prices. The other three producing countries did not have a statistically significant response to variations in constant local currency prices. The apparent insensitivity of these three producing

Figure 19

MAIZE: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE



LAG	t-2	t-3	t-4	t-5
Lag Coefficient:	0.23	0.05	0.01	0.00
Normalized Lag Coefficient:	0.79	0.17	0.03	0.00
Cumulative Effect:	0.23	0.28	0.29	0.29

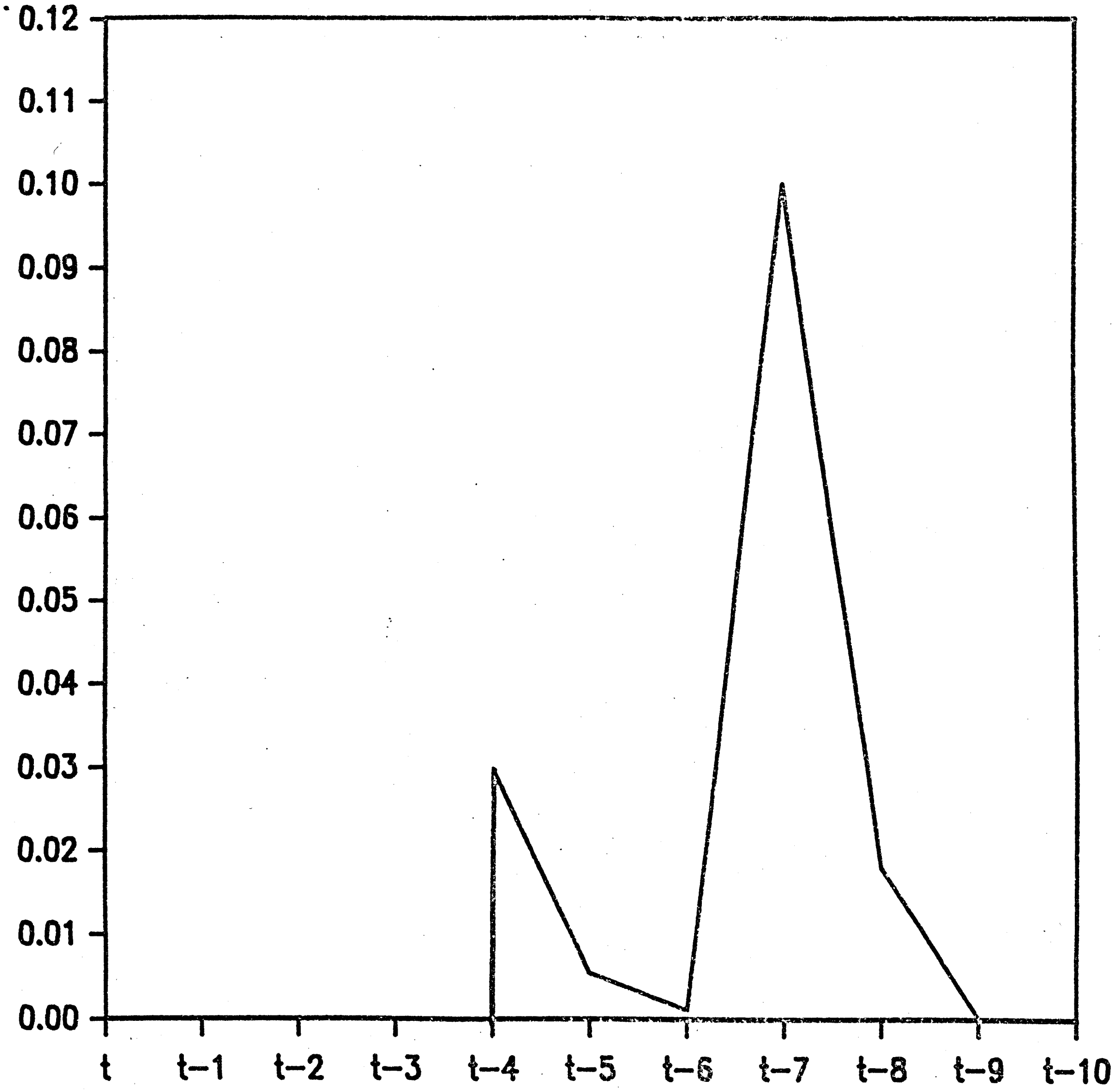
countries to producer price movements might explain the poor explanatory power of the production-weighted producer price in the total world production equation. The final equation shows that production responds to a change in cocoa market prices after a lag of seven years. There is also a response after four years but, though statistically significant, it is small. Full adjustment to a price change, as illustrated in Figure 20, takes eight years.

Cotton - The statistically-significant price variables in the production equation were those of cotton and soybeans, which entered the equation with a one and two year lag respectively, both measured in nominal terms. The response profile of cotton production to own price changes is demonstrated in Figure 21.

Two years, 1961 and 1984, were anomalies associated with Chinese government policies implemented in those years, for which binary variables were introduced. In 1961 political conditions in China caused serious disruptions in domestic production which, in turn, seriously affected global cotton output; in 1984 a Chinese government incentive program had a profound effect in encouraging domestic cotton production. In order to include the 1984 binary variable, it was necessary that the equation be estimated over a period that extended to 1984. As a result, the 1983-84 observations could not be used for ex-post validation of this equation.

Figure 20

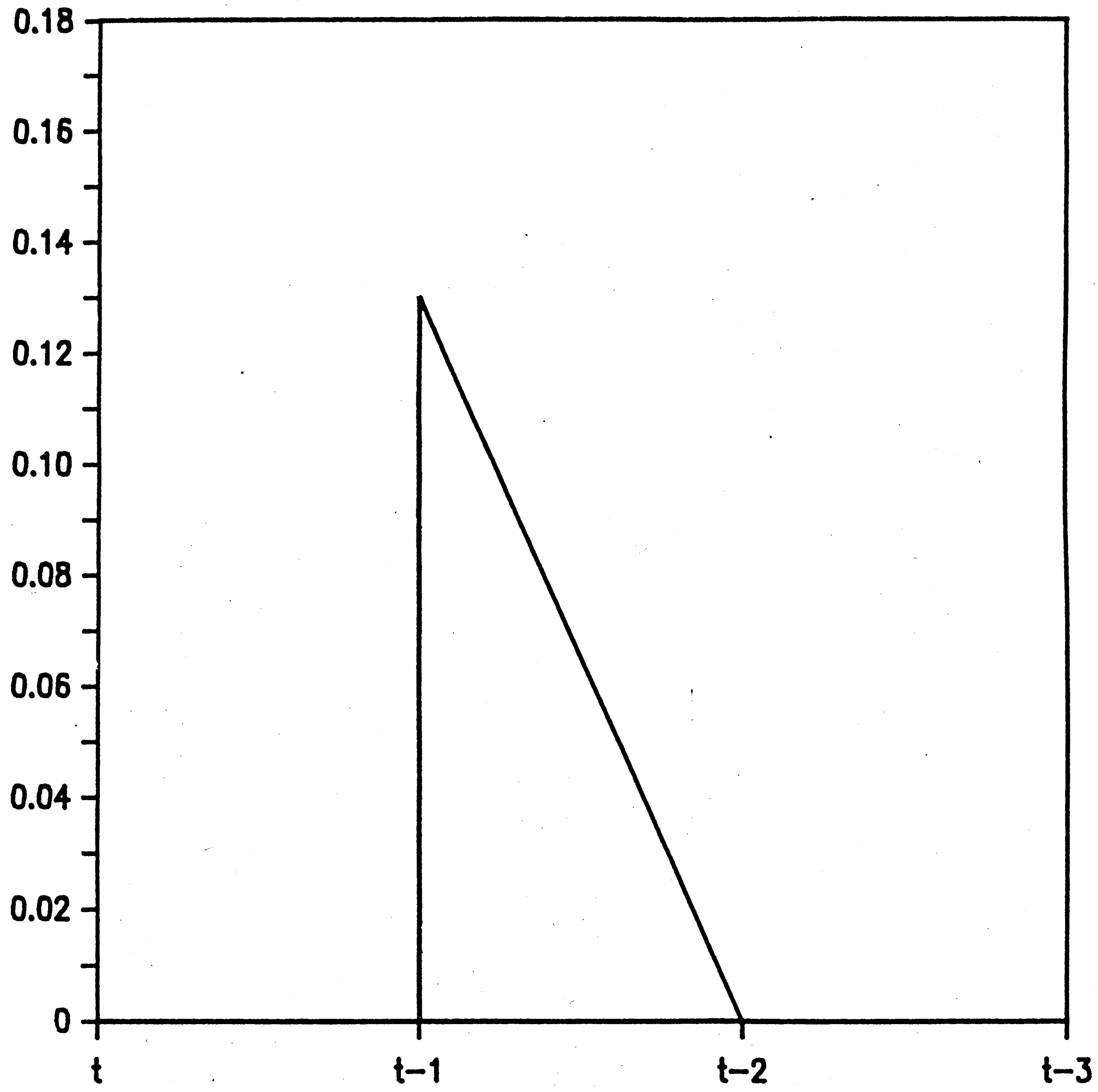
COCOA: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE



LAG	t-4	t-5	t-6	t-7	t-8	t-9
Lag Coefficient:	0.03	0.01	0.00	0.10	0.02	0.00
Normalized Lag Coefficient:	0.19	0.03	0.01	0.63	0.11	0.02
Cumulative Lag	0.03	0.04	0.04	0.14	0.15	0.16

Figure 21

COTTON: RESPONSE PROFILE OF SUPPLY TO MARKET PRICE CHANGE



LAG	t-1	t-2
Lag Coefficient:	0.13	0.00
Normalized Lag Coefficient:	0.98	0.02
Cumulative Effect	0.13	0.13

Chapter 16

RESULTS FOR STOCK DEMAND

The original specification of the demand for stocks equation imposed the restriction that a change in the level of consumption or production would induce a proportional response in the level of stocks demanded. However, a test of the proportionality restriction was performed when the specific stock demand equations for the sample of commodities in this study were estimated. Demand for stocks has had a more than proportional response to changes in production in two of the commodities modeled in their reduced form, implying that as output has increased over time the ratio of stocks to output has increased (see Table 6).

A proportional response to output or consumption changes was found to have prevailed in soybeans, copper, beef, maize, cocoa, and cotton. However, demand for stocks of sugar has responded to changes in output by rising three time more than the percent change that occurred in production; demand for coffee stocks has risen 5 times more than the percent increase in production.

Commodity-specific characteristics, other than those already discussed with respect to the stock-to-production or consumption ratio in steady-state growth, of the final form of the stock demand equation are as follows:

Table 6

STOCK DEMAND FUNCTION

	TRANSACTIONS DEMAND		SPECULATIVE DEMAND			
	Elasticity w.r.t. Output or Consumption		Interest Elast.		Price Elast.	
	Short Run	Long Run	Short Run	Long Run	Short Run	Long Run
COFFEE	0.86	5.1				
SOYBEANS	1.73	1.0				
COPPER	0.58 a/	1.0	-0.99	-1.00	0.73	
SUGAR	1.46	2.9			0.30 a/	0.49
BEEF	0.57 a/	1.0				
MAIZE	0.15	1.0				
COCOA	1.00	1.0				
COTTON	0.81	1.0				

a/ One-period lag.

Source: Appendix A: Table 3.

Coffee -- The final stock demand equation includes a binary variable to reflect the Brazilian government's policy towards its stocks. It contains values of one beginning in 1965 when the Brazilian government's policy to reduce national stocks was implemented; values of zero occur in prior years. The variable enters in multiplicative form with respect to a trend variable so as to reflect the additional effect on the trend of coffee stocks. As would be expected, the sign of the estimated coefficient is negative. Despite the Brazilian government's policy, the stock demand equation indicates that the ratio of stocks to production has increased as output has increased.

Two weather-related binary variables were included in the stock equation. They reflect the exceptional impact of frost damages on Brazilian coffee crops in 1973 and 1976 which caused the desired quantity of stock to fall below levels which would otherwise have occurred as a result of the decline in output.

Soybeans -- The estimated stock demand equation does not perform well which suggests that factors other than those considered here have had an important influence on demand for soybean stocks.

Copper -- Since the current market price of copper appeared in the final production equation, rather than the consumption equation, stock demand was related to consumption rather than production. The ratio of stocks to consumption of copper was found to be constant over the long run, a result which implies that a change in consumption will induce a proportional change in the demand for stocks in steady-state equilibrium.

The interest rate, which in part motivates the transactions demand for stocks and, in part, motivates speculative demand, was significant as a determinant of the amount of stocks demanded. As a transactions motive, interest rates affect the cost of stock-holding; as a speculative motive, interest rates induces investors to move between financial and commodity markets, particularly since the mid-seventies when investors moved between commodity markets to the Eurodollar market in response to interest rate variations. The general price level, which is associated with speculative demand for copper stocks, was also found to be an important determinant of the demand for stockholdings.

Sugar -- The stock demand equation includes a trend variable with a negative coefficient. This effect helped to offset the more-than-proportional response that stock demand has to changes in production. However, a second-degree polynomial in the trend variable suggests that the rate of change of stocks associated with changes in output has fallen over time. Demand for stocks is also affected by the general price level prevailing in the previous year.

Beef -- Since the stock series was constructed on the basis of incomplete information (see Chapter 8), the resulting stock demand equation may include data on production and consumption of some countries not considered elsewhere. The main result of the final form of the stock demand equation indicate that changes in the level of output have induced proportional increases in the level of stocks. However, a trend variable was found to be significant and had a positive-signed coefficient, suggesting that stocks have been increasing over and above whatever effect may have been brought on by changes in the level of production.

Chapter 17

THE PRICE EQUATION

The solution for the market price of a commodity is approximated through numerical methods when production and consumption concurrently respond to current price changes. However, the solution for market price can be estimated directly when either production or consumption has a non-contemporaneous response to a price change. Our empirical findings show that production in most commodities responds to price variations with a delay. These results apply to the eight commodities whose system of equations could be estimated in their structural form. Only copper production has a same-period response to price changes, whereas its consumption adjusts to price changes with a lag. Data which permit estimation of the system of equations in their structural form were unavailable for two commodities, iron ore and bananas, and consequently their price equations were calculated on the basis of limited information.

Table 7 summarizes the results of the estimated market price equations. It should be noted that the price equations were not estimated in reduced form for the eight commodities whose system of equations were estimated in their structural forms. Rather, they were estimated from the inverse consumption functions of all commodities except copper; that of copper was estimated from the inverse of the production function. As a result, the solution for price requires that solutions be obtained for the stock demand function and either the consumption function for copper or the production function for the other commodities.

Table 7

MARKET PRICE EQUATION

$$P = \left[\frac{Q_t - \Delta K_t}{e^{\alpha_{20}} Y_t^{\alpha_{21}} Y_{t-1}^{\alpha_{22}} D_t^{-\alpha_{23}} (P/D)_{t-1}^{\alpha_{24}} C_{t-1}^{\alpha_{25}}} \right]^{\frac{1}{\alpha_{23}^*}} \qquad \ldots(33b)$$

	α_{21}	α_{22}	α_{23}	α_{24}	α_{25}	α_{23}^*
COFFEE		0.55		0.18	0.09	-0.29
SOYBEANS		3.72				-1.05
SUGAR	0.40	0.76				-0.05
BEEF		0.45			0.74	-0.20
MAIZE	0.78		0.33			-0.33
COCOA	0.72					-0.12
COTTON	0.64		0.23			-0.36

$$P = \left[\frac{C_t + \Delta K_t}{e^{\alpha_{10}} Q_{t-1}^{\alpha_{11}} Q_{t-2}^{\alpha_{12}} D_t^{-\alpha_{13}} (P/D)_{t-n}^{\alpha_{14}} e^{\gamma_{15}T + \gamma_{16}W_t}} \right]^{\frac{1}{\alpha_{13}^*}} \qquad \ldots(33c)$$

	α_{14}	α_{13}^*
COPPER	0.22 (t-3)	0.57
	0.03 (t-7)	

$$\ln(P_t/P_{t-1}) = \alpha_{40} + \alpha_{41}\ln(D_t/D_{t-1}) + \beta_{42}\ln(P/D)_{t-1} + \beta_{43}\ln D_{t-1}$$
$$+ \alpha_{44}\ln(Y_t/Y_{t-1}) + \alpha_{45}\ln Y_{t-1} + \alpha_{46}T + \alpha_{47}W_t \qquad \ldots(33a)$$

	β_{42}	β_{43}	α_{45}	α_{46}
IRON ORE	-1.16	-0.72	1.00	-0.003
BANANAS	-0.65	-0.15		

Source: Appendix A: Table 4.

The sensitivity of commodity prices to changes in market conditions can be appreciated from the empirical results. In the price equation, the expression in bracket is raised to the power of the inverse of the short-term price elasticity of demand or, for copper, the short-term price elasticity of supply. The powers for the markets whose system of equations were estimated in their reduced form ranges from -20 (i.e. 1/(-0.05)) for sugar to -0.95 (i.e. 1/(-1.05)) for soybeans. (Note that negatively signed coefficientss in the power mean that the numerator and denominator in the bracketed term are inverted.) Any change in one of the variables in the bracketed term produces a multiplicative effect on the market price.

Some of the more important commodity-specific results of the estimated price equation are described in the remainder of this chapter.

Coffee - As with most other commodities, the market price equation for soybeans was estimated directly using non-linear estimation techniques with the coefficient values of the structural model used as the start-up values for the initial iteration. Direct non-linear estimation of the derived price equation did not result in the rejection of any variable from the consumption function estimated in its structural form. Nevertheless, there were some important changes in the magnitudes of the coefficient estimates of the inverse consumption function.

Soybeans - The result of the non-linear regression yield very high price and income elasticities for the inverse consuption function. The implied income elsticity is 3.7, which is twice as high as that obtained from a direct estimate, and the implied price elasticity is -1.1.

Copper - The price equation was derived from the solution of the system of structural equations for the current price of copper contained in the production equation. Direct non-linear estimation indicated that current and four and seven year lagged prices were the most signicant variables used from the originally estimated supply equation. The value of implied current price led to the rejection of two variables in the structural form of the production equation, one being production lagged one year, the other being the dummy variable used to account for the 1972 strike in the United States copper industry. The short-term price elasticity was nearly twice as high as in the structural form of the consumption equation, but the coefficient estimates for price lagged four and seven years were about the same as in the consumption equation.

Iron Ore - The major determinant of market price movements were found to be the general price level, economic activity lagged one period, and a trend variable. An error correction mechanism (ECM) specification driven by the general price level was used since the reduced form equation for prices of commodities in which stocks either do not exist or do not play an active role in the market suggests that prices should respond proportionately to changes in the general price level.

However, a test of the proportionality response indicated that this type of response has not been maintained in the case of iron ore prices. Moreover, the coefficient of the error correction term implied a dampened oscillatory path for price towards its intertemporal equilibrium. The oscillation arises because when the coefficients of the price terms in the equation are grouped together, the solved coefficient for price is negative and has an absolute value that is less than unity. Finally, the coefficient on economic activity was significant and had the expected positive sign. A change in economic activity produces a proportional effect on the price of iron ore. After the quantity of iron ore supplied and demanded have completely adjusted, the final response of price is 0.87 percent of the change in economic activity.

Sugar - Direct non-linear estimation of the derived price equation showed that all the predetermined variables in the standard specification of the model were statistically significant, except for consumption lagged one period. The estimated coefficients were not found to significantly differ from the coefficients obtained in the structural form of the model. The exception occurred in the coefficient of the lagged income term, whose value in the non-linear estimate was lower than in that of the structural form of the model.

Bananas - Movements in the market price of bananas were found to be closely related to changes in the general price level. A test was performed for proportionality between changes in banana prices and changes in the general price level. However, as expected, a less-than-proportional response existed over the sample period.

PART IV

MODEL SIMULATIONS

Chapter 18

EX-POST VALIDATION

Although the commodity market models might be internally consistent with the sample period employed to estimate the system of equations, it is important to determine how well they perform outside the sample. Hence their predictive ability has been tested. Observations for 1983-84 were used as the post-sample period.

The post-sample goodness of fit of the models was measured with the "root-mean-squared per cent error" (denoted RMSE%). It is defined for any endogenous market variable, Z, in the model over n periods as:

$$\text{RMSE\%} = \left[\frac{1}{n} \sum_{1}^{n} \left[\frac{\hat{Z}_t - Z_t}{Z_t} \right]^2 \right]^{1/2}$$

where $\hat{Z}$ denotes the simulated value of the variable and Z denotes its actual value. The post-sample predictive test was performed with "one-step- ahead" forecasts. One-step-ahead forecasts use past <u>actual</u> endogenous, as well as current and past exogenous, variables, rather than past <u>simulated</u> endogenous variables. The rationale for this approach is that agents always correct for their past errors. Were past simulated endogenous variables to be used, it would imply that agents did not correct for past errors and instead accumulated those errors over time. The results of the post-sample predictive test are presented in the last column of the tables in Appendix A.

Chapter 19

SENSITIVITY ANALYSIS

The dynamic properties of the commodity market models determine the response characteristics of the system. In particular, they determine whether the system is stable when subjected to a single alteration in one of the predetermined variables, what path is followed in the return to steady-state growth, and what is the degree of response to the external perturbation.

The dynamic nature of each commodity market is first examined in terms of its response to a one-time change in economic activity. Cycles would be expected in markets with long lags in their production response to price changes, whereas fairly smooth rates of expansion would be anticipated when production and consumption adjust fairly rapidly to changes in market conditions. Interactions among variables in the system of equations are likely to produce responses in supply and demand different from those which arose from direct estimates of single equations in the system. Secondary, or indirect, responses arise from feedback effects on market prices from other relationships in the system.

The effect of changes in economic activity on commodity markets has been measured by the difference between two solutions obtained from dynamic simulations of the commodity market models. The difference between the two simulations in their predetermined variables occurs in the values assumed by the economic activity variable. The first set of values for the economic activity variable generates the control solution. In the second simulation, the original values of the economic activity variable in the control solution are increased by one per cent. Comparison of the two solution paths then provides information about the short-term (impact) and long-term (dynamic) effects 1/.

The short-run elasticity is the same-period effect resulting from a change in economic activity. The response of production of many commodities to a change in price which is induced by a sustained change in economic activity tends to be slow, so the adjustment from the initial to the new solution is not fully realized within the same period. Convergence to the new steady-state growth path occurs only after several periods. Nonetheless, most of the response tends to occur in the first few periods following the change in economic activity, after which the new steady-state solution is approached asymptotically. The long-term elasticity measures the total effect from a change in economic activity. It is calculated from the response of the market variable to a sustained new level of economic activity, the sustained change being constant in its unit (U.S. dollar) amount.

1/ Multiplier analysis, which measures real value differences between base and alternative simulations, is often used to evaluate the response characteristics of econometric models. But multiplier analysis which compares changes in dollar magnitudes of market prices in a commodity with those of incomes in others is less meaningful than when multiplier analysis is used to compare changes among macroeconomic variables within a country. In commodity market models it is therefore more convenient to use elasticities, which are dimensionless measures, when performing multiplier analysis.

Figure 22 presents the results of a change in the rate of economic activity growth on market prices of commodities. It is evident that the one-period change impacts upon the markets over several years. Restoration of market prices to their stable growth rates take several years for most commodities. The time path followed by the market price variable of each commodity is closely associated with how rapidly production responds to price variations. Commodities in which production and consumption both respond within a short period of time to changes in macroeconomic conditions follow a smooth growth path. Commodities in which production responds to price changes with a significantly greater delay than consumption produce cycles at the beginning of the period which tend to dampen over time. Thus the systems are stable, but in most of them there is a dampened cyclical, rather than smooth, response to a change in economic activity.

The degree of response of prices to a change in economic activity is reported at the bottom of Figure 22. The short-term response tends to be higher than the long-term response. The reason for this occurrence is demonstrated in Figure 23. Initially, equilibrium is at quantity Q_o and price P_o. Higher income causes demand for a commodity to increase from D to D'. The price of the commodity rises to P_1. At this new price the quantity which producers are willing to supply expands. Additional output lowers price and eventually a new equilibrium is reached at Q_2 and P_2. The new equilibrium price P_2 is below the price, P_1, reached at the time demand for the commodity initially increased. However, the degree of response to a shift in

Figure 22

RESPONSE PATH OF MARKET PRICES TO ONE-TIME 1% INCREASE IN WORLD ECONOMIC ACTIVITY

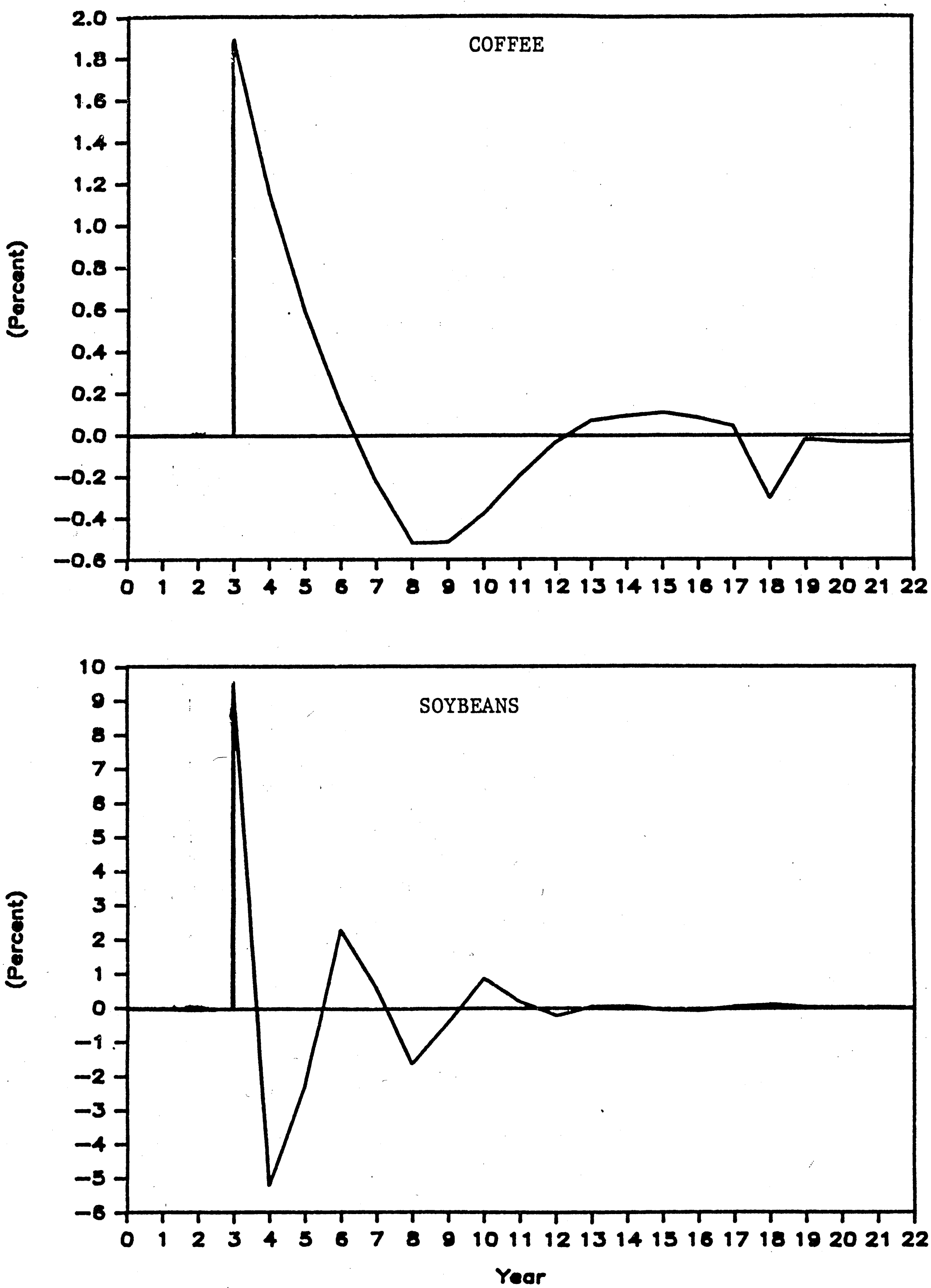
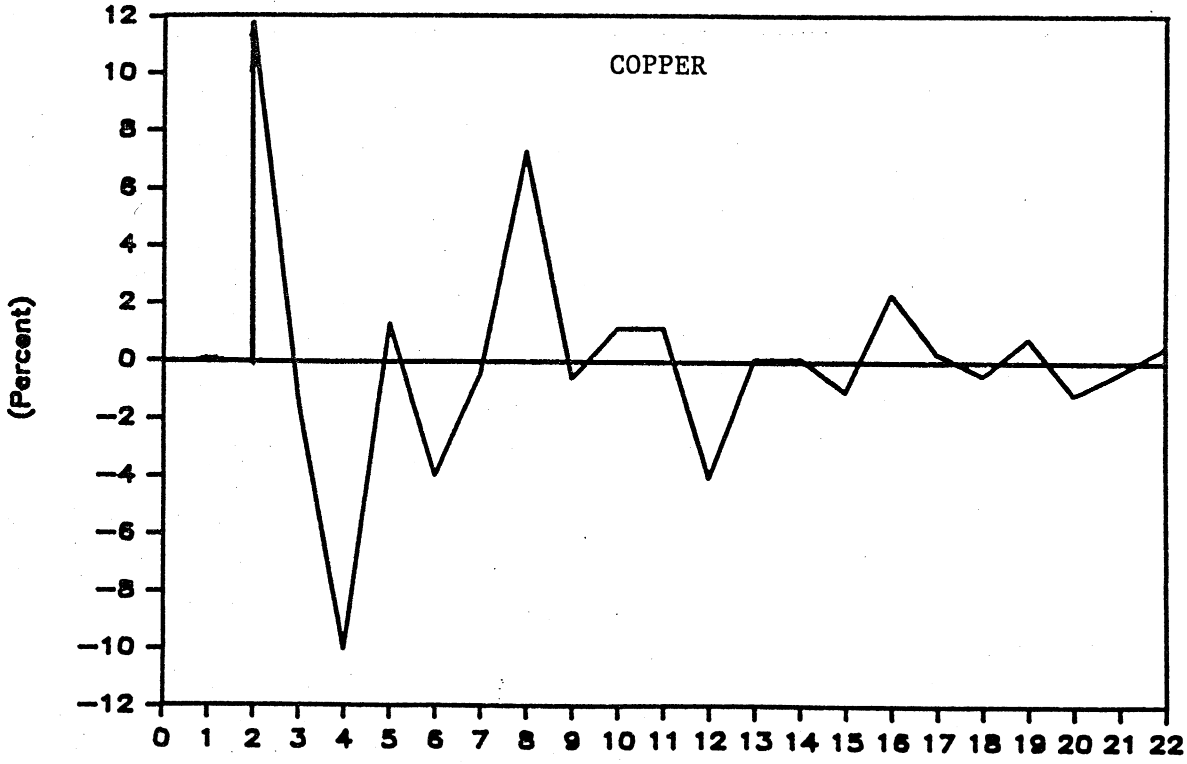
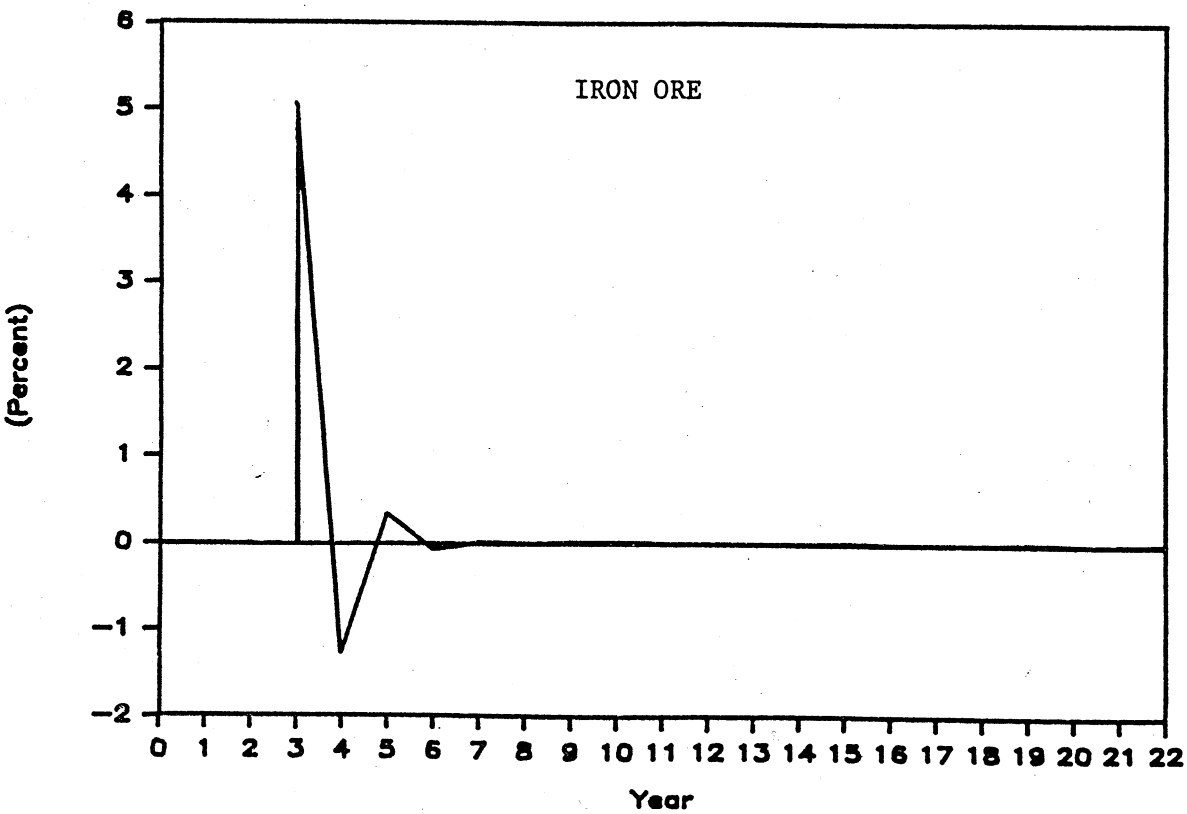


Figure 22 (cont'd)

RESPONSE PATH OF MARKET PRICES TO ONE-TIME 1% INCREASE IN WORLD ECONOMIC ACTIVITY





<u>Figure 22</u> (cont'd)

RESPONSE PATH OF MARKET PRICES TO ONE-TIME 1% INCREASE IN WORLD ECONOMIC ACTIVITY

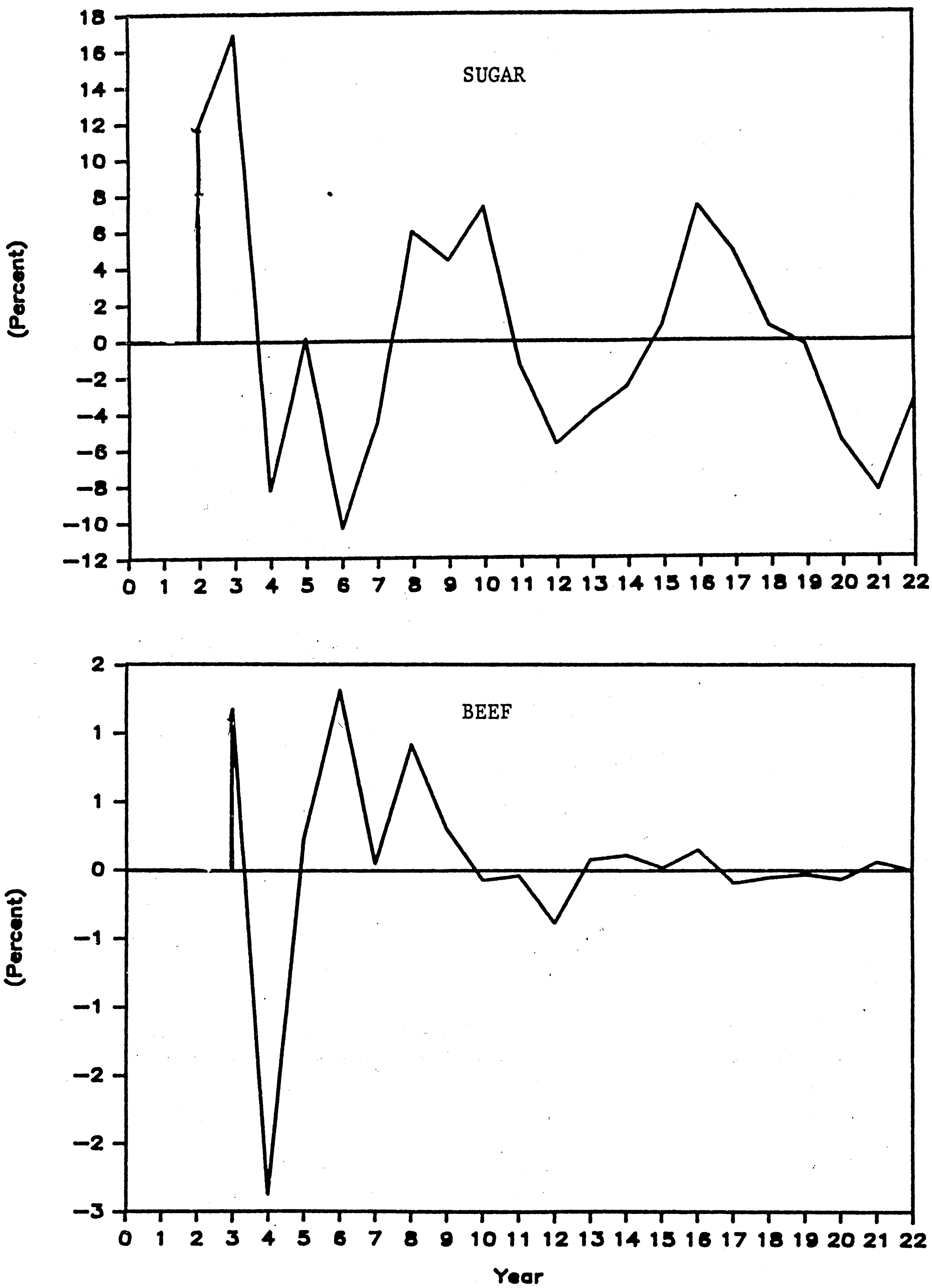
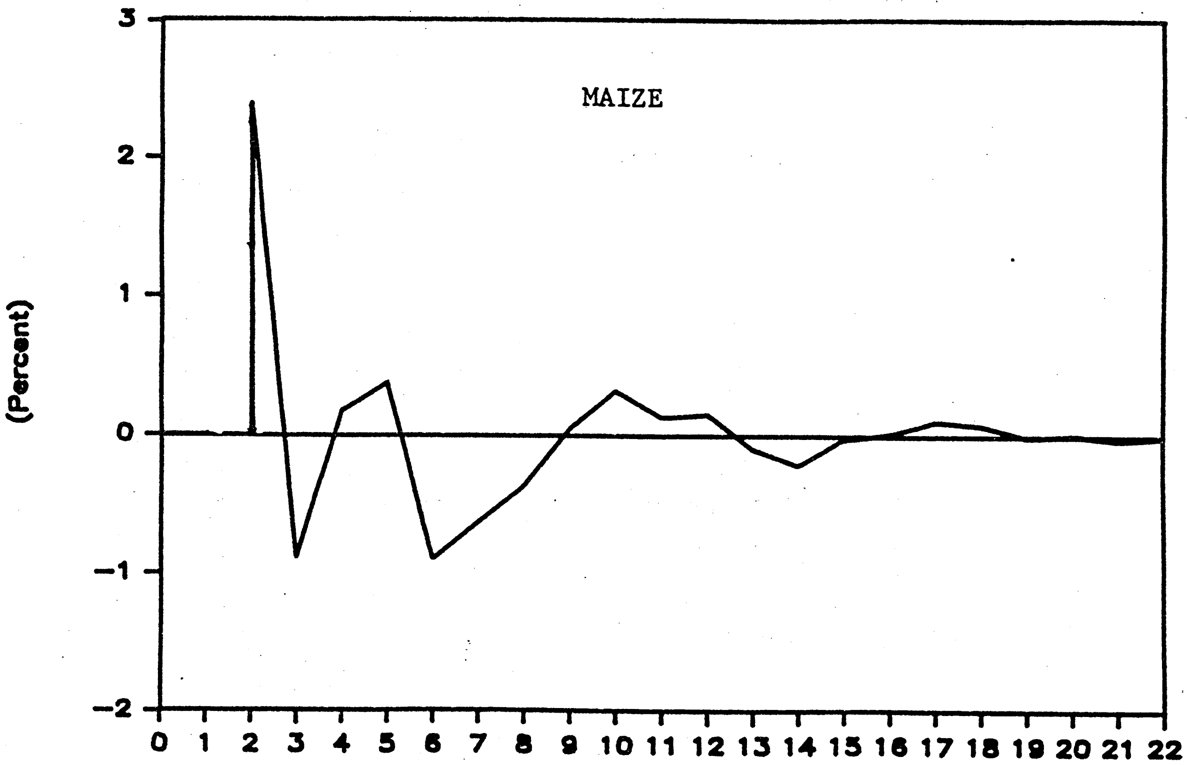


Figure 22 (cont'd)

RESPONSE PATH OF MARKET PRICES TO ONE-TIME 1% INCREASE IN WORLD ECONOMIC ACTIVITY



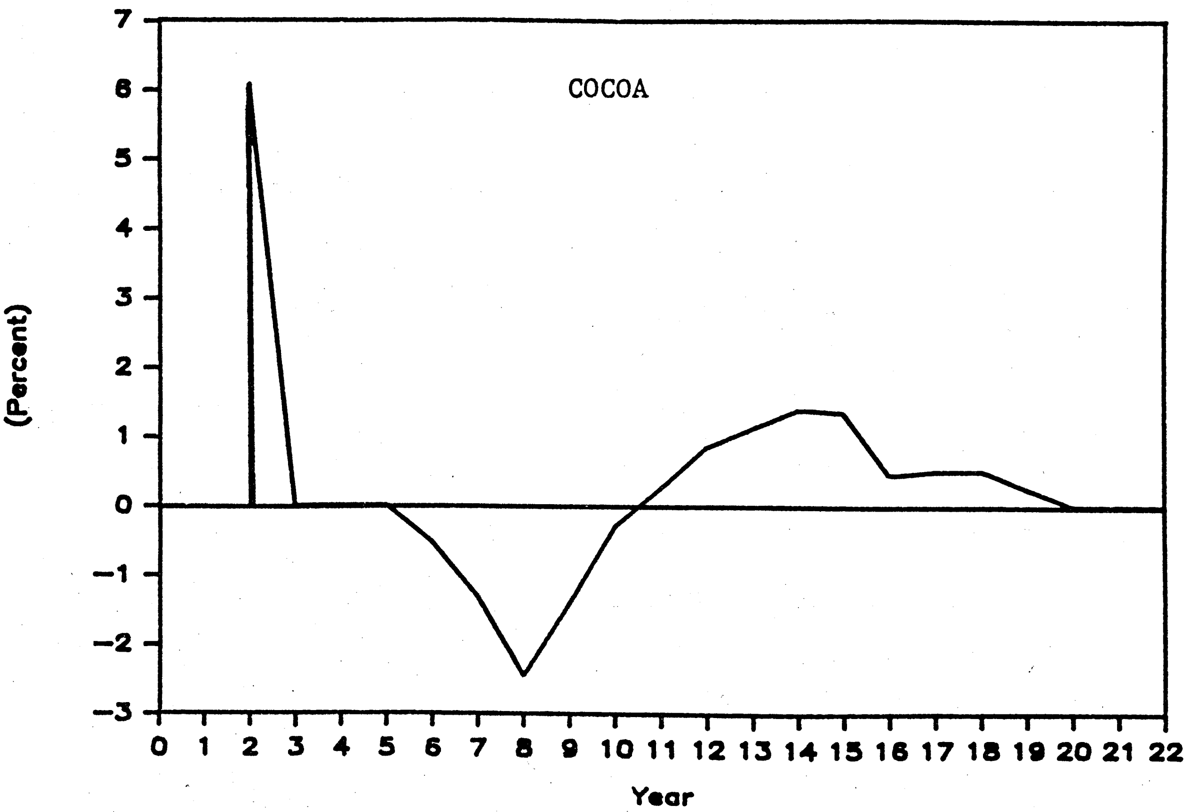
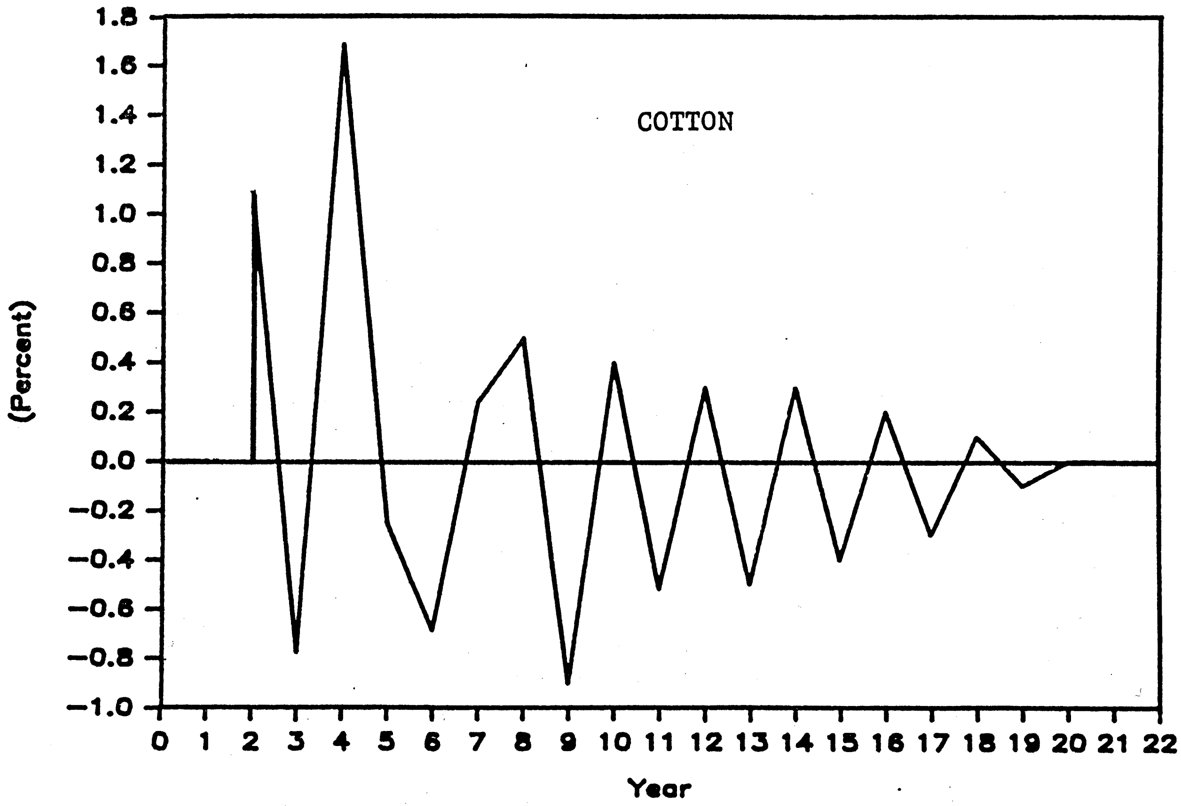


Figure 22 (cont'd)

RESPONSE PATH OF MARKET PRICES TO ONE-TIME 1% INCREASE IN WORLD ECONOMIC ACTIVITY

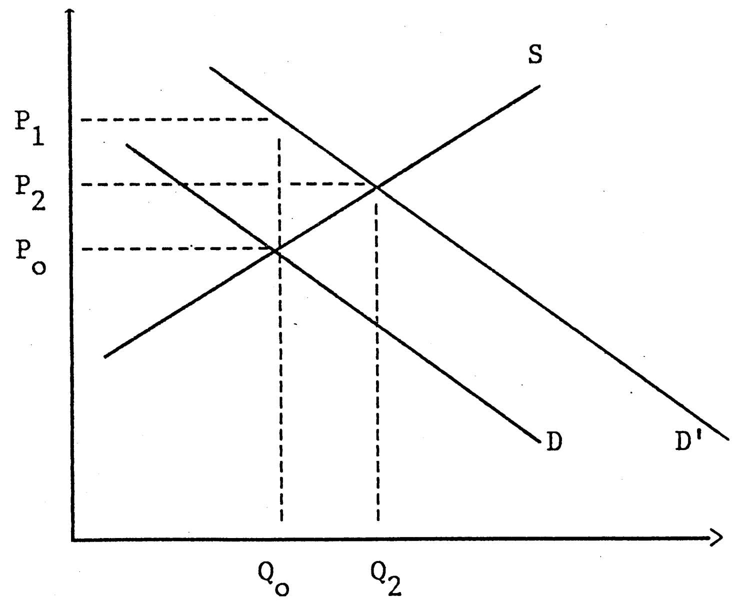


Change in Market Prices Due to One-Time Increase of 1.0% in Economic Activity

	Elasticity			Elasticity	
	Short Term	Long Term		Short Term	Long Term
Coffee	1.9	1.9	Beef	1.2	1.2
Soybeans	9.5	3.6	Maize	2.4	0.6
Copper	11.8	3.1	Cocoa	6.1	4.9
Iron Ore	5.1	4.0	Cotton	1.1	0.4
Sugar	11.7	6.0			

Figure 23

ILLUSTRATION OF MARKET PRICE RESPONSE TO CHANGE IN ECONOMIC ACTIVITY

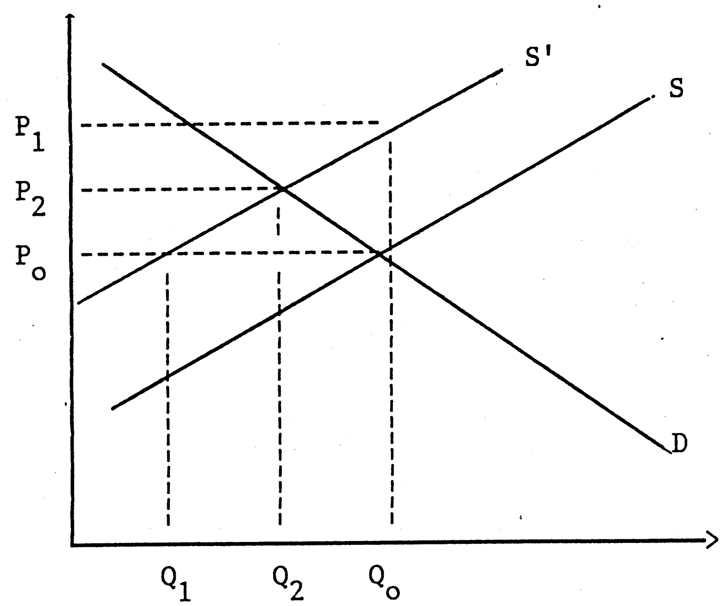


demand in the short run and the long run would be the same if supply is highly inelastic with respect to price. When supply is perfectly inelastic the price rise brought about by a shift in demand will cause the initial rise in price to remain unchanged.

The second most important influence on commodity markets is major disturbances from natural disasters and labor or political disruptions. Such disturbances usually shift the supply schedule from its long-run equilibrium level. Figure 24 illustrates the adjustment process. Initially, market price is P_o. A disturbance, such as originally occurred in coffee, shifts the supply curve to the left, causing price to rise to P_1. At the higher price, consumers lower the quantity of coffee demanded and producers increase output. The new long-run equilibrium is reached at P_2.

Figure 24

ILLUSTRATION OF MARKET PRICE RESPONSE TO MAJOR SUPPLY DISTURBANCE

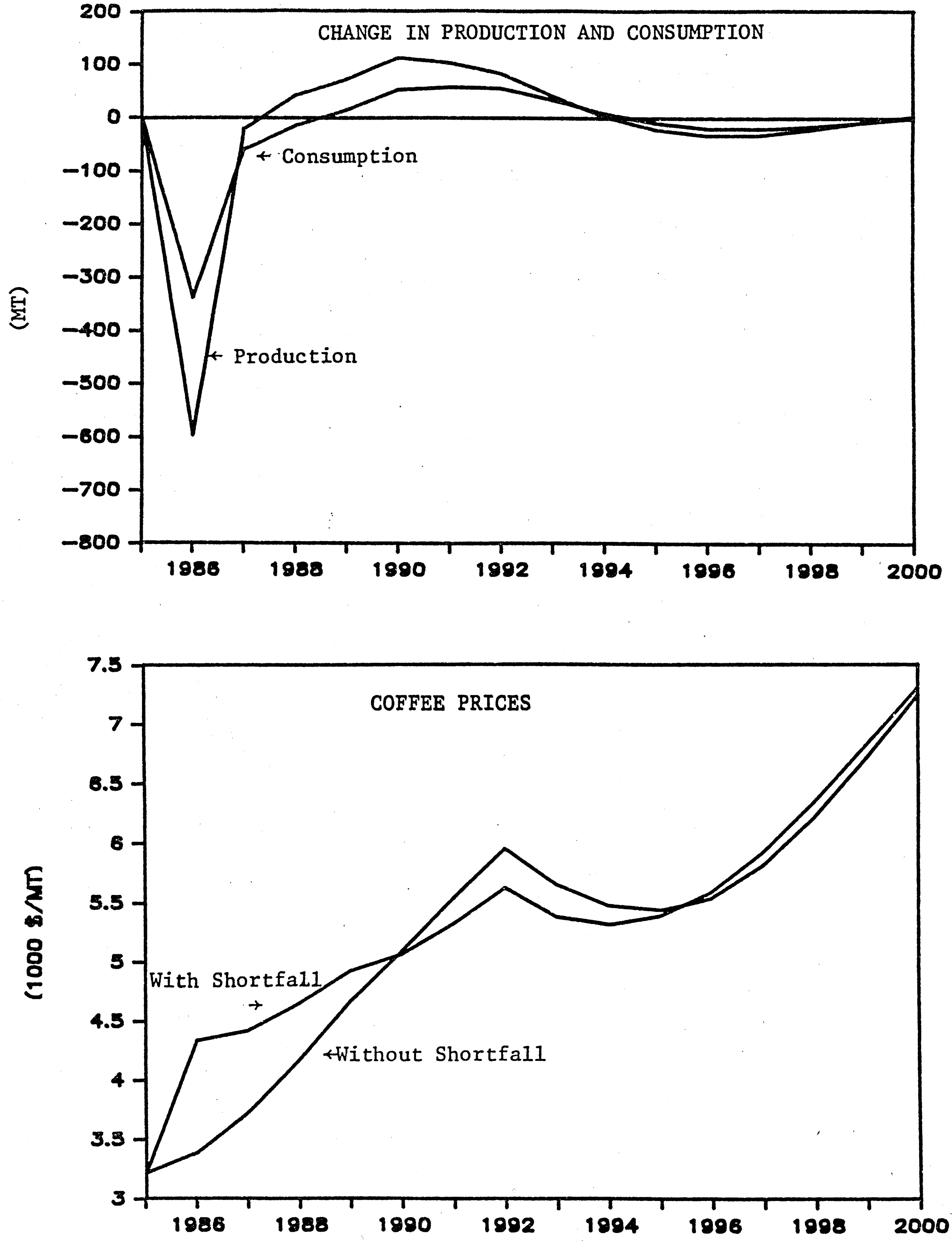


The dynamic properties of the the system of equations to an adjustment caused by a major disturbance can be analyzed on the basis of a recent incident. Towards the end of 1985 Brazil's coffee crop suffered from a drought which lowered 1986 production from an anticipated level of 1.62 million metric tons to less than 1.0 million tons. The simulation has been performed by adding a dummy variable in the production function of Brazil to lower production by 0.62 million tons in 1986.

The result of the disturbance on several of the more important variables in the coffee market is depicted in Figure 25. The upper-half of the figure depicts the amount of change that occurs in consumption and production; the lower-half shows the difference between predicted price variations with and without the shortfall.

Figure 25

RESPONSE OF COFFEE MARKET TO 1986 SHORTFALL IN BRAZILIAN PRODUCTION



Lowered production levels induce the price of coffee to move sharply above what it otherwise would have risen, thereby causing the quantity of coffee demanded to fall. Producers then respond to the higher prices after a delay associated with planting and harvesting. The increase in the amount of coffee supplies dampens the original price increase, and lower prices bring about an increase in the quantity of coffee demanded. The effect of a disturbance such as that which occurs as a result of a drought in Brazil is transitory. Eventually, production, consumption, and price converge back to their long-term equilibrium solutions.

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APPENDIX A

REGRESSION RESULTS OF MARKET MODEL EQUATIONS

A Note on Test Statistics

The following standard notations appear in the tables:

$\bar{R}^2$ Adjusted square of the multiple correlation coefficient.

dw Durbin-Watson statistic.

$\hat{\sigma}$ Coefficient of variation.

dof Degrees of freedom.

RMSE Root mean squared error.

The t-statistic is given below the coefficient estimate.

Appendix A: Table 1

REGRESSION RESULTS OF PRODUCTION EQUATION (2.26)

$$\Delta \ln Q_t = \alpha_{10} + \beta_{11} \ln Q_{t-1} + \alpha_{12} \ln Q_{t-2} + \sum_{k=0}^{n-1} \alpha_{13+k} \Delta \ln(P/D)_{t-k} + \beta_{14} \ln(P/D)_{t-k-1} + \beta_{15} \ln(P_o/D)_{t-m} + \gamma_{16} T + \gamma_{17} W_t + v_t$$

Product	$\ln Q_{t-1}$	$\ln Q_{t-2}$	$\Delta\ln(P/D)_{t-1}$	$\ln(P/D)_{t-2}$	$\Delta\ln(P/D)_{t-k}$	$\ln(P/D)_{t-k-1}$	$\ln(P_o/D)_{t-m}$	T	W(t)	Const.	Summary Statistics: Period	R^2	R^2 for levels a/	dw	$\hat{\sigma}$	dof	RMSE(%) 1983-84
COFFEE																	
Brazil	-0.97 (7.2)					0.19 b/c/ (1.5)			-0.69(70) (3.7) -0.88(76) (4.8)	5.69	1966-82	0.88	0.52	1.9	0.176	10	4.6
Rest-of World	-0.93 (5.7)					0.13 c/d/ (4.7)		0.01 (1.7)	0.07(72) (2.5) 0.08(74) (3.0)	-8.18	1967-82	0.75	0.96	2.2	0.026	10	4.1
SOYBEANS																	
World	-0.69 (5.4)		0.31 c/e/ (4.5)				0.22 c/f/ (2.1)		-0.16(75) (2.2) 0.12(80) (1.9)	4.24	1967-82	0.75	0.96	2.4	0.057	10	8.2
COPPER																	
World	-0.61 (3.9)		0.08c/e/g/ (2.1)	0.08c/h/ (2.0)		0.04c/i/ (1.1)				-10.72	1968-82	0.69	0.94	2.3	0.026	12	3.7
SUGAR j/																	
United States	-0.77 (4.1)		0.13 c/ (4.0)	0.18 c/ (3.8)				0.03 (3.0)	0.18(73) (4.1)	-47.82	1968-82	0.80	0.98	2.6	0.041	9	0.9 k/
Rest-of World	-0.64 (2.6)	-0.52 (2.4)			0.05 c/l/ (2.8)	0.03 c/h/ (1.7)		0.001 m/ (4.0)		12.41	1968-82	0.67	0.96	2.4	0.032	9	12.0
BEEF																	
World	0.22 (1.3)	-0.55 (3.9)				0.05 c/h/ (1.7)	0.05 c/n/ (3.1)			2.89	1965-82	0.68	0.98	2.3	0.016	13	0.7
MAIZE																	
World	-0.86 (6.1)				0.23 c/o/ (4.5)	0.25 c/l/ (5.5)	0.32 c/f/ (4.9)		0.10(71) (2.9)	-0.49	1963-82	0.71	0.98	2.8	0.032	14	14.1

(Cont'd.)

Appendix A: Table 1 (cont'd.)

REGRESSION RESULTS OF PRODUCTION EQUATION (2.26)

$$\Delta \ln Q_t = \alpha_{10} + \beta_{11}\ln Q_{t-1} + \alpha_{12}\ln Q_{t-2} + \sum_{k=0}^{n-1} \alpha_{13+k}\Delta\ln(P/D)_{t-k} + \beta_{14}\ln(P/D)_{t-k-1} + \beta_{15}\ln(P_o/D)_{t-m} + \gamma_{16}T + \gamma_{17}W_t + v_t$$

Product	$\ln Q_{t-1}$	$\ln Q_{t-2}$	$\Delta\ln(P/D)_{t-1}$	$\ln(P/D)_{t-2}$	$\Delta\ln(P/D)_{t-k}$	$\ln(P/D)_{t-k-1}$	$\ln(P_o/D)_{t-m}$	T	W(t)	Const.	Summary Statistics: Period	R^2	R^2 for levels a/	dw	$\hat{\sigma}$	dof	RMSE(%) 1983–84
COCOA																	
World	−0.82 (7.4)			0.03c/h/ (1.7)		0.10 c/h/ (3.8)			−0.13 p/ (7.4) 0.06 q/ (3.5)	5.12	1968–82	0:92	0.91	2.6	0.025	9	3.7
COTTON																	
World	−0.98 (5.2)		0.13 c/e/ (1.8)			−0.23 c/r/ (3.3)	0.02 (4.0)	0.18(84) (3.2)		9.23	1962–84	0.70	0.91	2.0	0.047	17	4.6

a/ Calculated from the fitted equation after all variables have been transformed to their original levels form.
b/ Three-year moving average around five-year lag.
c/ Nominal price.
d/ Three-year moving average around three-year lag.
e/ Variable expressed in levels form (as opposed to first difference).
f/ Current price of beef.
g/ Current price.
h/ Lagged 4 periods.
i/ Lagged 7 periods.
j/ Composed of sugar and high fructose corn syrup (HFCS).
k/ For 1983 only.
l/ Lagged 3 periods.
m/ Trend variable squared.
n/ Price of soybeans, lagged one period.
o/ Lagged 2 periods.
p/ Binary variable whose values are 1 in bad crop years; 0 otherwise.
q/ Binary variable whose values are 1 in good crop years; 0 otherwise.
r/ Soybean price, lagged two periods.
s/ Lagged 6 periods.

Note: See first page of appendix for explanation of test statistics.

Appendix A: Table 2

REGRESSION RESULTS OF CONSUMPTION EQUATION (2.29)

$$\Delta \ln C_t = \alpha_{20} + \alpha_{21}\Delta \ln Y_t + \beta_{22}\ln(C/Y)_{t-1} + \beta_{23}\ln Y_{t-1} + \beta_{24}\Delta \ln(P/D)_t + \beta_{25}\ln(P/D)_{t-1} + v_{2t}$$

Product	$\Delta \ln Y_t$	$\ln(C/Y)_{t-1}$	$\ln Y_{t-1}$	$\Delta \ln(P/D)_t$	$\ln(P/D)_{t-1}$	Const.	Summary Statistics: Period	R^2	R^2 for levels a/	dw	σ	dof	RMSE(%) 1983–84
COFFEE World		−0.98 (4.8)	−0.66 (4.4)	−0.08 b/ (1.8)	−0.03 b/ (0.7)	7.30	1966–82	0.81	0.79	2.1	0.032	11	1.3
SOYBEANS World		−0.96 (5.5)	0.83 (4.9)	−0.12 b/ (2.3)		2.30	1967–82	0.74	0.98	2.2	0.040	11	6.4
COPPER World	2.26 (6.5)	−0.58 (5.6)			−0.05 b/ (2.6)	2.89	1961–82	0.87	0.99	2.4	0.022	18	5.0
SUGAR c/ World d/	0.47 (2.2)	−0.81 (3.2)		−0.02 b/ (3.1)	−0.03 b/ (4.4)	5.46	1968–82	0.75	0.99	1.7	0.013	10	4.4 e/
BEEF World		−0.34 (1.8)		−0.10 b/ (3.8)	−0.10 b/ (3.8)	2.82	1962–82	0.56	0.98	1.2	0.019	17	1.1
MAIZE World	0.76 (2.0)	−0.71 (4.8)	−0.14 (3.4)	−0.21 f/ (4.7)		0.92	1961–82	0.58	0.99	2.6	0.028	17	8.7
COCOA World	0.59 (1.6)	−0.54 (2.6)	−0.19 (3.1)	−0.12 b/ (6.1)	−0.07 b/ (2.0)	2.79	1961–82	0.76	0.96	2.0	0.022	16	12.6
COTTON g/ World		−0.67 (3.2)	−0.35 (3.0)	−0.09 b/ (1.9)	−0.22 b/ (3.1)	6.57	1961–82	0.47	0.96	1.8	0.024	16	0.5

a/ Calculated from the final equation after all variables have been transformed to their original levels form.
b/ Nominal price.
c/ Composed of sugar and high fructose corn syrup (HFCS).
d/ Excluding the European Economic Community (EEC).
e/ For 1983 only.
f/ Expressed in levels form (as opposed to first difference).
g/ The equation included a seventh term: the natural logarithm of the current, nominal price of synthetic fibers. Its coefficient estimate was 0.18 and the corresponding t-statistic was 2.5.

Note: See first page of appendix for explanation of test statistics.

Appendix A: Table 3

REGRESSION RESULTS OF STOCK DEMAND EQUATION (2.31b) a/

$$\Delta \ln K^d_t = \alpha_{30} + \alpha_{31}\Delta \ln Q_t + \beta_{32}\ln(K^d/Q)_{t-1} + \beta_{33}\ln Q_{t-1} + \alpha_{34}\Delta \ln D_t + \beta_{35}\ln D_{t-1} + \alpha_{36}\Delta \ln I_t + \beta_{37}\ln I_{t-1} + \alpha_{38}\Delta Y_t + \beta_{39}Y_{t-1} + v_{3t}$$

Product	$\Delta \ln Q_t$	$\ln(K^d/Q)_{t-1}$	$\ln Q_{t-1}$	$\Delta \ln I_t$	$\ln I_{t-1}$	$\Delta \ln D_t$	$\ln D_{t-1}$	T	W(t)	Const.	Summary Statistics: Period	R^2	R^2 for levels b/	dw	δ	dof	RMSE(%) 1983-84
COFFEE World	0.86 (3.9)	-0.17 (1.6)	0.69 (2.2)						-0.02 c/ (2.4) -0.25(76) (2.1)	-5.67	1961-82	0.69	0.96	2.1	0.100	15	3.2
SOYBEANS World	1.73 (2.2)	-0.38 (1.8)								-0.86	1966-82	0.41	0.63	1.1	0.317	14	15.1
COPPER World		-0.58 d/ (3.6)		-0.99 (3.7)	-0.58 (1.8)	0.73 e/ (2.2)			-1.19(67) (5.9)	0.44	1961-82	0.69	0.93	1.6	0.185	16	16.1
SUGAR World	1.46 (8.6)	-0.61 (4.4)	1.16 (6.0)				0.30 (3.5)	-0.09 (5.2) 0.001 f/ (2.0)	-0.05(74) (2.3)	-12.11	1968-82	0.94	0.99	2.9	0.017	13	9.2
BEEF World		-0.57 (6.3)						0.09 (5.4)		-2.60	1961-82	0.73	0.99	2.0	0.081	19	1.7
MAIZE World	0.15 (3.0)	-0.04 (3.7)								0.02	1961-82	0.49	0.85	1.7	0.013	19	13.7
COCOA World	1.00	-0.15								-0.05	1964-82	0.65	0.80	1.7	0.128	16	24.2
COTTON World	0.81 (3.6)	-0.47 (3.1)							0.25(75) (3.7)	-0.45	1968-82	0.76	0.74	2.1	0.064	11	8.5

a/ Demand for stocks of all commodities except copper was estimated according to equation (2.31b); that of copper was estimated according to equation (2.31a).
b/ Calculated from the final equation after all variables have been transformed to their original levels form.
c/ Binary variable whose values are 0 in 1961-64 and 1 thereafter, multiplied by a trend variable.
d/ Coefficient of natural log for ratio of stock demand K^d to consumption C, rather than production Q.
e/ Expressed in levels form (as opposed to first difference).
f/ Trend variable squared.

Note: See first page of appendix for explanation of test statistics.

Appendix A: Table 4a

REGRESSION RESULTS OF MARKET PRICE EQUATION (2.33b)

$$P = \left[\frac{Q_t - \Delta K_t}{e^{\alpha_{20}} Y_t^{\alpha_{21}} Y_{t-1}^{\alpha_{22}} D_t^{-\alpha_{23}} (P/D)_{t-1}^{\alpha_{24}} C_{t-1}^{\alpha_{25}}} \right]^{\frac{1}{\alpha^*_{23}}}$$

Product	α_{20}	α_{21}	α_{22}	α_{23}	α_{24}	α_{25}	α^*_{23}	Summary Statistics				
								Period	R^2	Q statistic a/	$\hat{\sigma}$	RMSE(%) 1983-84
COFFEE	6.04		0.55 (1.6)		0.18b/ (2.2)	0.09 (0.3)	-0.29 (6.0)	1966-82	0.92	6.3(15,10)	439.7	17.8
SOYBEANS	-0.44		3.72 (1.4)				-1.05 (0.7)	1967-82	0.71	9.5(14,10)	48.1	16.5
SUGAR	6.08	0.40 (1.3)	0.76 (2.4)				-0.05 (3.7)	1968-82	0.82	4.4(13,9)	91.6	10.4
BEEF	2.22		0.45 (3.4)			0.74 (5.5)	-0.20 (4.2)	1965-82	0.92	13.8(16,12)	195.9	8.3
MAIZE	1.55	0.78 (18.2)		0.33 (8.8)			-0.33 (8.8)	1961-82	0.95	3.6(20,17)	7.9	20.4
COCOA	4.86	0.72 (20.8)					-0.12 (14.7)	1961-82	0.97	7.0(20,17)	179.4	22.1
COTTON	9.15	0.64 (3.8)		0.23 (2.0)			-0.36 (2.4)	1961-82	0.92	6.0(20,16)	150.7	23.4

a/ The first number in parenthesis refers to autocorrelations; the second refers to degrees of freedom.
b/ Nominal price.

Appendix A: Table 4b

REGRESSION RESULTS OF MARKET PRICE EQUATION (2.33c)

$$P_t = \left[\frac{C_t + \Delta K_t}{e^{\alpha_{10}} Q_{t-1}^{\alpha_{11}} Q_{t-2}^{\alpha_{12}} D_t^{-\alpha_{13}} (P/D)_{t-n}^{\alpha_{14}} e^{\gamma_{15} T} + \gamma_{16} W_t} \right]^{\frac{1}{\alpha^*_{13}}}$$

Product	α_{10}	α_{14}	α^*_{13}	Summary Statistics: Period	R^2	Q statistic a/	$\hat{\sigma}$	RMSE(%) 1983-84
COPPER	3.06	0.22 b/ (4.5) 0.03 c/ (1.5)	0.57 (7.6)	1962-82	0.61	7.0(19,15)	278.7	18.6

a/ The first number in parenthesis refers to autocorrelations; the second refers to degrees of freedom.
b/ Lagged 3 periods.
c/ Lagged 6 periods.

Appendix A: Table 4c

REGRESSION RESULTS OF MARKET PRICE EQUATION (2.33a)

$$\ln(P_t/P_{t-1}) = \alpha_{40} + \alpha_{41}\ln(D_t/D_{t-1}) + \beta_{42}\ln(P/D)_{t-1} + \beta_{43}\ln D_{t-1}$$
$$+ \alpha_{44}\ln(Y_t/Y_{t-1}) + \alpha_{45}\ln Y_{t-1} + \alpha_{46}T + \alpha_{47}W_t$$

Product	α_{40}	β_{42}	β_{43}	α_{45}	α_{46}	Summary Statistics: Period	R^2	R^2 for levels a/	dw	$\hat{\sigma}$	dof	RMSE(%) 1983-84
IRON ORE	0.36	-1.16 (4.0)	-0.72 (0.6)	1.00 (1.7)	-0.003b/ (2.47)	1967-82	0.60	0.90	2.2	0.090	11	4.3
BANANAS	3.83	-0.65 (4.9)	-0.15 (2.7)			1958-82	0.55	0.98	2.2	0.070	22	8.5

a/ Calculated from the fitted equation after all variables have been transformed to their original levels form.
b/ Trend variable squared.

Note: See first page of appendix for explanation of test statistics.

APPENDIX B

SOLVED COEFFICIENTS OF MARKET MODEL EQUATIONS

Appendix B: Table 1

SOLVED COEFFICIENTS FOR PRODUCTION EQUATION (2.26)

$$\ln Q_t = \alpha_{10} + (1+\beta_{11})\ln Q_{t-1} + \alpha_{12}\ln Q_{t-2} + \alpha_{13+k}\ln(P/D)_{t-k} + (\beta_{14}-\alpha_{13+k})\ln(P/D)_{t-k-1} + \beta_{15}(P_o/D)_{t-m}$$

	Production		OWN PRICE								OTHER PRICE		
Product	t-1	t-2	t	t-1	t-2	t-3	t-4	t-5	t-6	t-7	t	t-1	t-2
COFFEE													
Brazil	0.03							0.19a/b/					
Rest-of World	0.07					0.13a/b/							
SOYBEANS													
World	0.31			0.31a/							0.22a/c/		
COPPER													
World	0.39		0.08				0.08			0.04			
SUGAR d/													
United States	0.23			0.13a/	0.05a/								
Rest-of World	0.36	-0.52				0.05a/	-0.02a/						
BEEF													
World	1.22	-0.55					0.05a/					0.05a/e/	
MAIZE													
World	0.14				0.23a/	0.02a/					0.32a/c/		
COCOA													
World	0.18						0.03a/			0.10a/			
COTTON													
World	0.02			0.13a/									-0.23a/e/

a/ Nominal price.
b/ Three-year moving average.
c/ Price of beef.
d/ Composed of sugar and high fructose corn syrup (HFCS).
e/ Price of soybeans.

Note: See corresponding table number in Appendix A for estimated form of the equation.

Appendix B: Table 2

SOLVED COEFFICIENTS FOR CONSUMPTION EQUATION (2.29)

$$\ln C_t = \alpha_{20} + (1+\beta_{22})\ln C_{t-1} + \alpha_{21}\ln Y_t + (\beta_{23}-\alpha_{21}-\beta_{22})\ln Y_{t-1} + \beta_{24}\ln(P/D)_t + (\beta_{25}-\beta_{24})\ln(P/D)_{t-1}$$

		Coefficients		
Product	Period	lnC	lnY	ln(P/D)
COFFEE				
World	t			-0.08 a/
	t-1	0.02	0.32	0.05 a/
SOYBEANS				
World	t			-0.12 a/
	t-1	0.04	1.79	0.12
COPPER				
World	t		2.26	
	t-1	0.42	-1.68	-0.05 a/
SUGAR b/				
World c/	t		0.47	-0.02 a/
	t-1	0.19	0.34	-0.01 a/
BEEF				
World	t			-0.10 a/
	t-1	0.66	0.34	
MAIZE				
World	t		0.76	-0.21
	t-1	0.29	-0.19	
COCOA				
World	t		0.59	-0.12 a/
	t-1	0.46	-0.24	0.05 a/
COTTON				
World	t			-0.09 a/
	t-1	0.33	0.32	-0.13 a/

a/ Nominal price.
b/ Composed of sugar and high fructose corn syrup (HFCS).
c/ Excluding the European Economic Community (EEC).

Note: See the corresponding table number in Appendix A for estimated form of the equation.

Appendix B: Table 3

SOLVED COEFFICIENTS FOR STOCK DEMAND EQUATION (2.31b)

$$\ln K_t^d = \alpha_{30} + (1+\beta_{32})\ln K_{t-1}^d + \alpha_{31}\ln Q_t + (\beta_{33}-\alpha_{31}-\beta_{32})\ln Q_{t-1} + \alpha_{34}\ln D_t + (\beta_{35}-\alpha_{34})\ln D_{t-1} + \alpha_{36}\ln I_t + (\beta_{37}-\alpha_{36})\ln I_{t-1} + \alpha_{38}\ln Y_t + (\beta_{39}-\alpha_{38})\ln Y_{t-1}$$

		Coefficients			
Product	Period	$\ln K^d$	$\ln Q$	$\ln I$	$\ln D$
COFFEE					
World	t		0.86		
	t-1	0.83			
SOYBEANS					
World	t		1.73		
	t-1	0.62	-1.35		
COPPER					
World	t			-0.99	0.73
	t-1	0.42	0.58 b/	0.42	-0.73
SUGAR c/					
World d/	t		1.46		
	t-1	0.39	0.31		0.30
BEEF					
World	t				
	t-1	0.43			
MAIZE					
World	t		0.15		
	t-1	0.96	-0.11		
COCOA					
World	t		1.00		
	t-1	0.85	-0.85		
COTTON					
World	t		0.81		
	t-1	0.53	-0.34		

a/ Demand for stocks of all commodities except copper was estimated according to equation (2.31b); that of copper was estimated according to equation (2.31a).
b/ Coefficient on consumption, C, rather than production, Q.
c/ Composed of sugar and high fructose corn syrup (HFCS).
d/ Excluding the European Economic Community (EEC).

Note: See the corresponding table number in Appendix A for estimated form of the equation.

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WORLD MARKET DATA: COFFEE

YEAR	PRODUCTION: Brazil	PRODUCTION: Rest-of World	PRODUCTION: World	WORLD CONSUMPTION	WORLD END-OF-YEAR STOCKS	PRICE ($/mt)
	(1000 Metric Tons)					
1960	1788	2134	3922	3543	3907	924
1961	2376	2182	4558	4018	4448	895
1962	1734	2333	4067	3683	4832	833
1963	1392	2528	3920	4110	4642	805
1964	660	2499	3159	3508	4293	1010
1965	2262	2667	4929	4051	5171	1001
1966	1260	2543	3803	4073	4901	929
1967	1470	2799	4269	4399	4771	864
1968	1020	2777	3797	4380	4189	866
1969	1260	2918	4178	4424	3942	877
1970	660	2906	3566	4247	3261	1146
1971	1476	2923	4399	4621	3039	992
1972	1470	3162	4632	4701	2970	1109
1973	858	3086	3944	4745	2168	1373
1974	1650	3317	4967	4451	2684	1451
1975	1380	3007	4387	4707	2364	1442
1976	558	3096	3654	4475	1543	3146
1977	1050	3198	4248	4019	1772	5174
1978	1200	3534	4734	4999	1507	3589
1979	1320	3591	4911	4878	1540	3825
1980	1290	3890	5180	4786	1934	3400
1981	1980	3911	5891	5126	2699	2820
1982	1065	3902	4967	5088	2578	3086
1983	1800	3603	5403	5324	2657	2902
1984	1620	3801	5421	5539	2539	3180
1985	1980	3939	5919	5549	2909	3209

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Exogenous Variables....................... 213

WORLD MARKET DATA: COFFEE

YEAR	Brazil	Rest-of World	World	WORLD CONSUMPTION	WORLD END-OF-YEAR STOCKS	PRICE ($/mt)
	(PRODUCTION: 1000 Metric Tons				)	
1960	1788	2134	3922	3543	3907	924
1961	2376	2182	4558	4018	4448	895
1962	1734	2333	4067	3683	4832	833
1963	1392	2528	3920	4110	4642	805
1964	660	2499	3159	3508	4293	1010
1965	2262	2667	4929	4051	5171	1001
1966	1260	2543	3803	4073	4901	929
1967	1470	2799	4269	4399	4771	864
1968	1020	2777	3797	4380	4189	866
1969	1260	2918	4178	4424	3942	877
1970	660	2906	3566	4247	3261	1146
1971	1476	2923	4399	4621	3039	992
1972	1470	3162	4632	4701	2970	1109
1973	858	3086	3944	4745	2168	1373
1974	1650	3317	4967	4451	2684	1451
1975	1380	3007	4387	4707	2364	1442
1976	558	3096	3654	4475	1543	3146
1977	1050	3198	4248	4019	1772	5174
1978	1200	3534	4734	4999	1507	3589
1979	1320	3591	4911	4878	1540	3825
1980	1290	3890	5180	4786	1934	3400
1981	1980	3911	5891	5126	2699	2820
1982	1065	3902	4967	5088	2578	3086
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WORLD MARKET DATA: COFFEE

YEAR	PRODUCTION Brazil	PRODUCTION Rest-of World	PRODUCTION World	WORLD CONSUMPTION	WORLD END-OF-YEAR STOCKS	PRICE ($/mt)
	(1000 Metric Tons)					
1960	1788	2134	3922	3543	3907	924
1961	2376	2182	4558	4018	4448	895
1962	1734	2333	4067	3683	4832	833
1963	1392	2528	3920	4110	4642	805
1964	660	2499	3159	3508	4293	1010
1965	2262	2667	4929	4051	5171	1001
1966	1260	2543	3803	4073	4901	929
1967	1470	2799	4269	4399	4771	864
1968	1020	2777	3797	4380	4189	866
1969	1260	2918	4178	4424	3942	877
1970	660	2906	3566	4247	3261	1146
1971	1476	2923	4399	4621	3039	992
1972	1470	3162	4632	4701	2970	1109
1973	858	3086	3944	4745	2168	1373
1974	1650	3317	4967	4451	2684	1451
1975	1380	3007	4387	4707	2364	1442
1976	558	3096	3654	4475	1543	3146
1977	1050	3198	4248	4019	1772	5174
1978	1200	3534	4734	4999	1507	3589
1979	1320	3591	4911	4878	1540	3825
1980	1290	3890	5180	4786	1934	3400
1981	1980	3911	5891	5126	2699	2820
1982	1065	3902	4967	5088	2578	3086
1983	1800	3603	5403	5324	2657	2902
1984	1620	3801	5421	5539	2539	3180
1985	1980	3939	5919	5549	2909	3209

WORLD MARKET DATA: SOYBEANS

YEAR	PRODUCTION	CONSUMPTION	END-OF-YEAR STOCKS	PRICE ($/mt)
	(------------1000 Metric Tons	------------)		
1960	NA	NA	NA	92
1961	NA	NA	NA	111
1962	NA	NA	NA	100
1963	NA	NA	NA	110
1964	NA	NA	NA	110
1965	29239	NA	1652	117
1966	31701	31484	1869	126
1967	36469	34941	3397	112
1968	37774	35685	5486	106
1969	41699	37421	9764	103
1970	42479	44938	7305	117
1971	44278	47947	3636	126
1972	47201	47816	3021	140
1973	49189	49266	2944	290
1974	62395	59140	6199	277
1975	54641	53929	6911	220
1976	65614	62563	9962	231
1977	59458	63574	5846	280
1978	72214	70967	7093	268
1979	77497	76997	7593	298
1980	93514	87936	13171	296
1981	86120	84361	14930	288
1982	93560	91260	17230	245
1983	82800	86500	13530	282
1984	92280	88900	16910	282
1985	94080	90450	20540	224

WORLD MARKET DATA: REFINED COPPER

YEAR	PRODUCTION (---1000 Metric Tons---)	CONSUMPTION	END-OF-YEAR STOCK INDEX (1960=1000)	PRICE ($/mt)
1960	4998	4742	1000	677
1961	5128	5081	1047	633
1962	5297	5198	1146	644
1963	5400	5500	1045	646
1964	5739	6026	758	968
1965	6059	6217	599	1290
1966	6324	6489	434	1530
1967	6004	6240	197	1138
1968	6653	6536	314	1241
1969	7212	7141	385	1466
1970	7592	7261	715	1413
1971	7404	7290	828	1080
1972	8100	7946	982	1071
1973	8545	8753	774	1786
1974	8909	8399	1284	2059
1975	8355	7473	2166	1237
1976	8792	8537	2422	1401
1977	9065	9078	2408	1309
1978	9231	9513	2126	1365
1979	9367	9845	1648	1985
1980	9259	9389	1518	2183
1981	9567	9521	1563	1742
1982	9406	9062	1908	1480
1983	9651	9116	2443	1592
1984	9541	9810	2175	1377
1985	9631	9419	2387	1417

WORLD MARKET DATA: IRON ORE

YEAR	PRICE ($/MT)
1960	17.1
1961	17.8
1962	16.8
1963	15.7
1964	15.7
1965	15.7
1966	15.3
1967	13.5
1968	12.6
1969	11.8
1970	15.2
1971	13.5
1972	12.8
1973	17.1
1974	19.0
1975	22.6
1976	21.9
1977	21.6
1978	19.4
1979	23.3
1980	26.7
1981	24.3
1982	25.9
1983	24.0
1984	23.2
1985	22.6

WORLD MARKET DATA: SWEETENERS (SUGAR + HIGH FRUCTOSE CORN SYRUP)

	PRODUCTION			CONSUMPTION		
	USA	Rest-of World	World	EEC	Rest-of World	World
YEAR	(1000 Metric Tons)					
1960	2788	49511	52299	8733	40485	49218
1961	2880	51834	54714	8957	44291	53248
1962	2974	48648	51622	5765	47787	53552
1963	3419	49218	52637	5948	47401	53349
1964	3999	55320	59319	6069	48089	54158
1965	3767	60025	63792	6297	51667	57964
1966	3670	59073	62743	6528	53228	59756
1967	3722	61307	65029	9962	51643	61605
1968	3998	61426	65424	10544	54213	64757
1969	3939	64247	68186	10445	56448	66893
1970	4341	66879	71220	10692	59866	70558
1971	4245	67846	72091	10460	62113	72573
1972	4591	69291	73882	10474	63333	73807
1973	5930	70123	76053	11131	65463	76594
1974	5670	71103	76773	11733	65946	77679
1975	6439	73069	79508	9596	65504	75100
1976	7153	76231	83384	10826	69399	80225
1977	6704	84935	91639	10251	73630	83881
1978	6268	86117	92385	10966	76735	87701
1979	6885	84436	91321	10958	81034	91992
1980	7148	79896	87044	11140	79554	90694
1981	8208	87710	95918	10773	81029	91802
1982	8228	97140	105368	10880	84781	95661
1983	8480	92850	101330	10710	86374	97084
1984	9057	95268	104325	10893	90445	101338
1985	9888	95596	105484	10922	93233	104155

WORLD MARKET DATA: SUGAR

YEAR	PRODUCTION USA	PRODUCTION Rest-of World	PRODUCTION World	CONSUMPTION EEC	CONSUMPTION Rest-of World	CONSUMPTION World
	(1000 Metric Tons)					
1960	2788	49511	52299	8733	40485	49218
1961	2880	51834	54714	8957	44291	53248
1962	2974	48648	51622	5765	47787	53552
1963	3419	49218	52637	5948	47401	53349
1964	3999	55320	59319	6069	48089	54158
1965	3767	60023	63790	6297	51665	57962
1966	3670	59071	62741	6528	53226	59754
1967	3722	61304	65026	9962	51640	61602
1968	3988	61423	65411	10544	54200	64744
1969	3899	64241	68140	10445	56402	66847
1970	4273	66869	71142	10692	59788	70480
1971	4159	67816	71975	10460	61997	72457
1972	4479	69256	73735	10474	63186	73660
1973	5729	70060	75789	11116	65214	76330
1974	5399	70998	76397	11698	65605	77303
1975	5954	72892	78846	9541	64897	74438
1976	6438	75962	82400	10751	68490	79241
1977	5764	84586	90350	10164	72428	82592
1978	5133	85699	90832	10854	75294	86148
1979	5435	83892	89327	10813	79185	89998
1980	5313	79201	84514	10972	77192	88164
1981	5788	86734	92522	10593	77813	88406
1982	5418	96014	101432	10693	81032	91725
1983	5215	91600	96815	10533	82036	92569
1984	5342	93858	99200	10715	85498	96213
1985	5538	94001	99539	10742	87468	98210

WORLD MARKET DATA: SUGAR

YEAR	WORLD END-OF-YEAR SUGAR STOCKS (1000 MT)	WORLD PRICE ($/MT)	U.S. PRICE ($/MT)
1960	21713	69	118
1961	23179	59	118
1962	21249	61	123
1963	20537	184	160
1964	25698	127	132
1965	31526	44	128
1966	34513	40	133
1967	37937	42	139
1968	38604	42	144
1969	39897	71	149
1970	40559	81	178
1971	40077	99	188
1972	40152	160	200
1973	39611	208	227
1974	38705	654	650
1975	43113	449	496
1976	46272	255	293
1977	54030	179	243
1978	58714	172	244
1979	58043	213	343
1980	54393	632	664
1981	58509	374	435
1982	68216	186	439
1983	72462	187	486
1984	75449	115	479
1985	76778	90	479

WORLD MARKET DATA: HIGH FRUCTOSE CORN SYRUP (HFCS)

YEAR	PRODUCTION (1000 Metric Tons) USA	EEC	Rest-of World	World
1960	0	0	0	0
1961	0	0	0	0
1962	0	0	0	0
1963	0	0	0	0
1964	0	0	0	0
1965	0	0	0	2
1966	0	0	0	2
1967	0	0	0	3
1968	10	0	0	13
1969	40	0	0	46
1970	68	0	0	78
1971	86	0	0	116
1972	112	0	0	147
1973	201	15	48	264
1974	271	35	70	376
1975	485	55	122	662
1976	715	75	194	984
1977	940	87	262	1289
1978	1135	112	306	1553
1979	1450	145	399	1994
1980	1835	168	527	2530
1981	2420	180	796	3396
1982	2810	187	939	3936
1983	3265	177	1073	4515
1984	3715	178	1232	5125
1985	4350	180	1415	5945

WORLD MARKET DATA: BEEF

YEAR	PRODUCTION (----1000 Metric Tons---)	CONSUMPTION	END-OF-YEAR STOCK INDEX (1960=100)	PRICE ($/mt)
1960	23599	NA	100	737
1961	24470	24364	206	682
1962	25846	25816	236	714
1963	27436	27317	355	667
1964	27594	27388	561	841
1965	28067	27939	689	882
1966	29673	29694	668	1022
1967	31174	31041	801	1041
1968	32663	32522	942	1085
1969	33685	33426	1201	1223
1970	34044	33886	1359	1304
1971	33863	33609	1613	1346
1972	34282	34015	1880	1480
1973	34874	34721	2033	2011
1974	37487	37152	2368	1582
1975	39515	39012	2871	1327
1976	41411	40540	3742	1581
1977	42082	41498	4326	1506
1978	41917	41210	5033	2138
1979	40169	39607	5595	2884
1980	40451	39721	6325	2760
1981	40715	39803	7237	2475
1982	40822	39831	8228	2390
1983	41121	40202	9147	2440
1984	41923	40775	10295	2273
1985	42478	41589	11184	2154

WORLD MARKET DATA: BANANAS

YEAR	PRICE ($/mt)
1960	143
1961	139
1962	132
1963	168
1964	170
1965	159
1966	154
1967	159
1968	153
1969	159
1970	166
1971	140
1972	162
1973	165
1974	184
1975	247
1976	257
1977	275
1978	287
1979	326
1980	379
1981	401
1982	374
1983	429
1984	369
1985	389

WORLD MARKET DATA: MAIZE

YEAR	PRODUCTION	CONSUMPTION	END-OF-YEAR STOCKS	PRICE ($/mt)
	(-------------	1000 Metric Tons	-------------)	
1960	199000	193000	NA	44.0
1961	203000	210000	NA	46.7
1962	206000	213000	NA	52.2
1963	217000	213000	NA	55.6
1964	214000	223000	41717	56.7
1965	225142	233493	33366	55.9
1966	246707	242765	37308	60.4
1967	259577	252921	43964	50.7
1968	250647	255484	39127	49.9
1969	267400	270616	35911	54.8
1970	263500	270713	28698	59.4
1971	300590	289348	39940	59.4
1972	295234	306219	28955	56.9
1973	321949	323556	27348	99.6
1974	290390	292414	25324	134.2
1975	327962	325647	27639	121.6
1976	355709	339866	43482	114.2
1977	365423	360310	48595	96.9
1978	390900	389100	50395	102.3
1979	424200	414100	60495	117.4
1980	407200	415200	52495	127.4
1981	439500	415000	76995	132.9
1982	438500	418800	96695	111.1
1983	346100	409400	33395	136.0
1984	457300	436500	54195	135.9
1985	480900	423500	111595	112.2

WORLD MARKET DATA: COCOA

YEAR	PRODUCTION	CONSUMPTION	END-OF-YEAR STOCKS	PRICE
	(-----------------	-1000 Metric Tons-	-----------------)	($/mt)
1960	1177	1000	562	587
1961	1129	1095	596	485
1962	1164	1144	616	459
1963	1222	1184	654	553
1964	1493	1302	845	505
1965	1214	1374	685	366
1966	1337	1387	635	518
1967	1340	1403	572	597
1968	1230	1369	433	721
1969	1421	1354	500	904
1970	1484	1399	585	675
1971	1567	1536	616	538
1972	1383	1583	416	644
1973	1433	1512	337	1131
1974	1534	1452	419	1561
1975	1499	1523	395	1246
1976	1328	1442	281	2046
1977	1490	1399	372	3790
1978	1480	1459	393	3404
1979	1610	1489	514	3293
1980	1642	1589	567	2604
1981	1706	1602	671	2079
1982	1519	1623	567	1736
1983	1494	1706	355	2120
1984	1822	1727	450	2396
1985	1765	1690	503	2254

WORLD MARKET DATA: COTTON

YEAR	PRODUCTION (-----	CONSUMPTION 1000 Metric Tons-----	END-OF-YEAR STOCKS -----)	PRICE ($/mt)
1949	NA	NA	3696	NA
1950	6609	7642	2663	993
1951	8381	7664	3380	1376
1952	8687	8034	4033	938
1953	9020	8450	4603	818
1954	8896	8664	4835	845
1955	9471	8967	5339	802
1956	9135	9385	5089	726
1957	9011	9300	4800	724
1958	9691	9941	4550	692
1959	10245	10424	4371	626
1960	10281	10244	4408	650
1961	9855	9941	4322	671
1962	10455	9721	5056	657
1963	10936	10282	5710	640
1964	11600	11110	6200	642
1965	11970	11340	6830	626
1966	10990	11720	6100	606
1967	10810	11780	5130	650
1968	11950	11760	5320	672
1969	11430	11980	4770	608
1970	11790	11960	4600	632
1971	12950	12810	4740	741
1972	13730	13240	5230	793
1973	13800	13360	5670	1355
1974	14040	12590	7120	1415
1975	11720	13220	5620	1161
1976	12460	13160	4920	1691
1977	13900	13120	5700	1554
1978	12950	13670	4980	1572
1979	14140	14210	4910	1689
1980	14040	14270	4680	2047
1981	15370	14340	5710	1845
1982	14750	14640	5820	1597
1983	14710	14840	5690	1854
1984	19140	15060	9770	1785
1985	16790	15850	10710	1318

EXOGENOUS VARIABLES

YEAR	INTERNATIONAL INFLATION Index (1979=100)	INTERNATIONAL INFLATION Percent Change	INTEREST RATE Rate	INTEREST RATE Percent Change	WORLD GDP Index (1975=100)	WORLD GDP Percent Change
1955	29.1		1.7		44.4	
1956	30.0	3.4	2.7	56.9	46.7	5.2
1957	30.7	2.2	3.3	19.4	48.1	3.0
1958	31.3	1.8	1.8	-43.6	48.5	0.8
1959	30.8	-1.4	3.4	85.9	51.5	6.2
1960	31.5	2.1	2.9	-14.0	53.6	4.1
1961	32.0	1.7	2.4	-19.0	55.8	4.1
1962	32.6	1.7	2.8	16.8	58.8	5.3
1963	32.0	-1.7	3.2	13.7	61.5	4.7
1964	32.7	2.1	3.6	12.3	65.3	6.1
1965	32.9	0.7	3.9	11.3	68.8	5.4
1966	34.1	3.7	4.9	23.5	72.5	5.4
1967	34.4	1.0	4.3	-11.3	75.3	3.8
1968	34.2	-0.7	5.4	23.6	79.4	5.4
1969	36.0	5.2	6.7	25.0	83.4	5.1
1970	38.3	6.4	6.4	-3.7	86.0	3.1
1971	40.4	5.4	4.3	-32.6	89.2	3.7
1972	43.9	8.7	4.1	-6.2	94.0	5.4
1973	50.9	16.0	7.0	72.7	99.8	6.2
1974	62.0	21.8	7.9	11.9	100.3	0.5
1975	68.9	11.2	5.8	-26.0	100.0	-0.3
1976	69.8	1.4	5.0	-14.3	104.8	4.8
1977	76.8	9.9	5.3	5.6	109.0	4.0
1978	88.3	15.0	7.2	37.0	113.4	4.0
1979	100.0	13.3	10.0	39.1	117.1	3.3
1980	109.6	9.6	11.6	15.7	118.4	1.1
1981	110.2	0.5	14.1	21.2	121.1	2.3
1982	108.7	-1.4	10.7	-23.9	120.1	-0.8
1983	105.8	-2.6	8.6	-19.6	122.9	2.3
1984	103.9	-1.8	9.6	11.0	128.9	4.9
1985	105.3	1.3	7.5	-21.6	132.5	2.8

APPENDIX D

DATA SOURCES

APPENDIX D

DATA SOURCES

COMMODITY	Component	Period	Source
COFFEE			
	World Production	1960-85	United States Department of Agriculture (USDA), World Coffee Situation. January 1986.
	Brazilian Production	1960-80	USDA, World Coffee Situation. September 1984.
		1981-84	USDA, World Coffee Situation. January 1986.
	World Stocks	1960-85	USDA, World Coffee Situation. January 1986.
	World Price	1960-83	International Bank for Reconstruction and Development (I D), Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Notes:
1. The coffee marketing year varies among producers, beginning either in April, July or October. Since most of the harvest occurs during the first part of the marketing year, the first year is used when the marketing year is converted to a calendar year basis. Thus, for example, data for the 1985 calendar year are associated with the 1985/86 marketing year.
2. Coffee consumption data have been derived from production and stock data.
3. The market price used for coffee is that of the International Coffee Organization indicator price (arithmetic average of Salvadoran central, standard, Guatemalan and Mexican prime washed) ex-dock New York for prompt shipment.

COMMODITY	Component	Period	Source
SOYBEANS			
	World Production	1960-80	USDA, Oilseeds and Products. Various issues.
		1981-85	USDA, Oilseeds and Products. April 1986.
	World Stocks	1960-80	USDA, Oilseeds and Products. Various issues.
		1981-85	USDA, Oilseeds and Products. April 1986.
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Notes:
1. Soybean consumption data have been derived from production and stock data.
2. The market price used for soybeans is the United States market price, No. 2., bulk, c.i.f. Rotterdam.

APPENDIX D (cont'd)

DATA SOURCES

COMMODITY	Component	Period	Source
COPPER			
	World Production	1960-84	World Bureau of Metal Statistics, Metal Statistics. 1985 edition.
		1985	Commodities Research Unit (CRU), CRU Metal Monitor: Copper. April 1986.
	World Consumption	1960-84	World Bureau of Metal Statistics, Metal Statistics. 1985 edition.
		1985	CRU, CRU Metal Monitor: Copper. April 1986.
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD,"Commodity Price Data. May 20, 1986.

Note:
1. Copper stock data have been derived from production and consumption data.
2. The market price used for copper is the London Metal Exchange, high grade cathodes, settlement price.

COMMODITY	Component	Period	Source
IRON ORE			
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Notes: The market price used for iron ore is that of Brazilian, 65 percent, c.i.f. North Sea Ports.

COMMODITY	Component	Period	Source
SUGAR			
	United States Production	1960-83	International Sugar Organization (ISO), Sugar Yearbook. Various issues.
		1984-85	Landell Mills Commodities Studies, Ltd. (LMC), Sugar Quarterly. First Quarter, 1986.
	EEC Production	1960-83	ISO, Sugar Yearbook. Various issues.
		1984-85	LMC, Sugar Quarterly. First Quarter, 1986.
	World Production	1960-83	ISO, Sugar Yearbook. Various issues.
		1984-85	LMC, Sugar Quarterly. First Quarter, 1986.
	World Consumption	1960-83	ISO, Sugar Yearbook. Various issues.
		1984-85	LMC, Sugar Quarterly. First Quarter, 1986.

APPENDIX D (cont'd)

DATA SOURCES

COMMODITY	Component	Period	Source
SUGAR (cont'd)			
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Notes:
1. Sugar stock data have been calculated from production and consumption data.
2. The world price used for sugar is the ISA daily price, f.o.b. and stowed Caribbean ports.
3. The United States prices used for sugar is the New York domestic contract, based on c.i.f. duty/fee paid. Quotation for 1960 refers to No. 6 contract; for period 1961-66, No. 7 contract; from 1967-74, No. 10 contract; from 1975-84, No. 12 contract.

COMMODITY	Component	Period	Source
HIGH FRUCTOSE CORN SYRUP (HFCS)			
	World Production	1960-79	LMC, Sugar Quarterly. Third Quarter, 1985.
		1980-85	LMC, Sugar Quarterly. First Quarter, 1986.
	United States Production	1960-79	LMC, Sugar Quarterly. Third Quarter, 1985.
		1980-85	LMC, Sugar Quarterly. First quarter, 1986.
	EEC Production	1960-79	LMC, Sugar Quarterly. Third Quarter, 1985.
		1980-85	LMC, Sugar Quarterly. First quarter, 1986.
BEEF			
	World Production	1960-85	USDA, Livestock and Poultry Situation. Various issues.
	World Consumption	1960-85	USDA, Livestock and Poultry Situation. Various issues.
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Notes:
1. Beef production and consumption data include cattle, buffalo and veal. Data are expressed in terms of dressed carcass weight, excluding offal and slaughter fats.
2. Beef stock data have been calculated from production and consumption data.
3. The market price used for beef is that of United States, imported frozen, boneless, 85% visible lean cow meat, f.o.b. port of entry.

APPENDIX D (cont'd)

DATA SOURCES

COMMODITY	Component	Period	Source
BANANAS			
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Note: The market price used for bananas is that of first class green stems from Central America and Ecuador, importer to jobber or processor, f.o.b. port of entry.

COMMODITY	Component	Period	Source
MAIZE			
	World Production	1960-77	USDA, Grains. Various issues.
		1978-85	USDA, Grains. April 1986 issue.
	World Consumption	1960-77	USDA, Grains. Various issues.
		1978-85	USDA, Grains. April 1986 issue.
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Notes:
1. Maize stock data are calculated from production and consumption data.
2. The market price used for maize is United States market price, No. 2, f.o.b. Gulf ports.

COMMODITY	Component	Period	Source
COCOA			
	World Production	1960-84	Gill & Duffus Group, Ltd., Cocoa Market Report. No. 319, August 1985.
	World Stocks	1960-84	Gill & Duffus Group, Ltd., Cocoa Market Report. No. 319, August 1985.
	World Price	1960-83	IBRD, Commodity Trade & Price Trends. 1985 edition.
		1984-85	IBRD, Commodity Price Data. May 20, 1986.

Notes:
1. The cocoa marketing year is October-September. Since most of the harvest occurs during the first part of the marketing year, the first year is used when the marketing year is converted to a calendar year basis. Thus, for example, data for the 1985 calendar year was associated with the 1985/86 marketing year.
2. Coffee consumption data have been derived from production and stock data.
3. The market price used for cocoa is the International Cocoa Organization (ICCO) average daily price, nearest three future months.

APPENDIX D (cont'd)

DATA SOURCES

COMMODITY	Component	Period	Source
COTTON			
	World Production	1949-85	International Cotton Advisory Committee (ICAC), Cotton: World Statistics. Various issues.
	World Stocks	1949-85	International Cotton Advisory Committee (ICAC), Cotton: World Statistics. Various issues.
	World Price	1960-83 1984-85	IBRD, Commodity Trade & Price Trends. 1985 edition. IBRD, Commodity Price Data. May 20, 1986.

Notes:
1. Data on production and stocks in 1985 are preliminary.
2. Cotton consumption data have been derived from production and stock data.
3. The market price used for cotton is that of "A" Cotton Outlook Index, middling, 1-3/32 inch, c.i.f. North Europe.

	Component	Period	Source
	International Inflation Index	1960-85	IBRD, Economic Analysis & Projections Department.
	Interest Rate	1960-85	IMF, International Financial Statistics. Various issues.

Note: The quotation used for the interest rate is that of the United States Treasury Bill rate.

	Component	Period	Source
	GDP	1960-85	IMF, International Financial Statistics. Various issues.

Note: The GDP is expressed as an index (1975=100).