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AN ECONOMETRIC SIMULATION STUDY OF THE EFFECT OF EXCHANGE RATE OVERVALUATION ON BRAZILIAN AGRICULTURE

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Doraci Heloisa Crocomo

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Stanley R. Thompson
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AN ECONOMETRIC SIMULATION STUDY OF THE EFFECT OF EXCHANGE RATE OVERVALUATION ON BRAZILIAN AGRICULTURE

By

Doraci Heloisa Crocomo

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ABSTRACT

AN ECONOMETRIC SIMULATION STUDY OF THE EFFECT OF EXCHANGE RATE OVERVALUATION ON BRAZILIAN AGRICULTURE

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Doraci Heloisa Crocomo

Previous studies have suggested that overvaluation of the exchange rate has discriminated against Brazilian agriculture. This study was an attempt to measure the effect of this overvaluation on several important agricultural commodities.

An econometric simulation model was constructed, where simultaneous interactions between the consumer and farm levels of the market channels were possible. The econometric model linked supply, demand, trade, and government policy for the major agricultural commodity markets. The model was then simulated to quantify the effects of the overvaluation of the domestic currency on Brazilian agriculture.

The products considered include corn, rice, wheat, soybeans, soymeal, soyoil, beef, hogs, and chickens. For each commodity, functional relationships were specified, based on annual time-series data covering the 1961-80 period, for production, domestic disappearance, and stocks. Trade was considered the residual in all cases. The conceptual model focused on the effect of government intervention on domestic producer prices. A set of price relationships was estimated to explain the government intervention, based on economic variables.

To analyze the impact of overvalued exchange rates on the considered commodities, the model was simulated under two different sets of assumptions. In the first, the model generated a base forecast using the actual exchange rates for the 1971-80 period. In the second simulation, "equilibrium" instead of official exchange rates were used. The changes in the endogenous variables were attributed to the removal of the overvaluation, which averaged 27 percent a year for the simulated period (1971-80).

The results showed strong evidence of government intervention in domestic agricultural prices by the maintenance of overvalued exchange rates for corn and soyoil. Some indications of this kind of intervention were found for soybeans and wheat, and no evidence of such intervention was found for soymeal, rice, or beef. However, because of the interdependence between commodities, a removal of the price intervention on corn, wheat, soyoil, and soybeans would affect all Brazilian agricultural commodities.

To my mother, Luiza.

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CHAPTER I

INTRODUCTION

Background

The crisis that was started in 1973 by OPEC's decision to raise international petroleum prices brought a variety of consequences for the oil-importing countries. In the Brazilian case, the decision was particularly harmful because the country produces only about 20 percent of its petroleum needs. The value of total imports more than doubled in 1974 in comparison to the previous year. In the same period, exports that had been experiencing a steady increase, mainly due to the government's effort to promote expansion and diversification, grew only 12.8 percent--that is, from US$6,199 million to US$7,951 million, as shown in Table 1.1.

The situation has not changed much since 1974, despite the country's effort to curtail imports and to increase exports. The share of petroleum imports in relation to the total import bill has increased over time; it now constitutes almost one-half of the total (Table 1.1). The main problem is that means of transportation depend almost exclusively on petroleum, and the dependency is not expected to decrease in the near future. The second largest item on the import list is wheat, and again Brazil depends heavily on imports to supply its internal demand. Furthermore, the importing of capital goods cannot be cut severely without harming the development process.

Because not much can be done to curtail imports, the best way to improve the balance of trade is by increasing exports.

Table 1.1.--Brazil's total exports, total imports, and the import of petroleum as a share of total imports (US$ million FOB).

Year	Exports (1)	Imports (2)	Petroleum Imports (3)	Share (%) (3/2)
1970	2,740	2,508	236	9
1971	2,904	3,245	327	10
1972	3,991	4,235	409	10
1973	6,199	6,192	711	11
1974	7,951	12,642	2,840	24
1975	8,670	12,211	2,875	24
1976	10,128	12,347	3,613	29
1977	12,120	12,023	3,814	32
1978	12,659	13,639	4,196	31
1979	15,244	17,961	6,403	36
1980	20,132	22,960	9,405	41

SOURCE: Conjuntura Econômica, various issues.

The balance-of-payments problem faced by Brazil is accompanied by a very high internal rate of inflation with consequent deterioration of the income distribution in a country in which the annual rate of population growth is still around 2.5 percent.

It an attempt to alleviate these problems, the government that came to power in 1979 has selected the agricultural sector as its top priority. For the first time in Brazil's history, a change in policy in favor of this sector is believed to be underway. After

World War II, Brazil experienced a very high rate of growth as a result of the import-substitution industrialization policy that was adopted. This policy was guided by the common belief that this was the only way under-developed countries could achieve economic development (Prebisch, 1949). By 1963, policies to promote the expansion and diversification of exports as a source of economic growth were adopted, and the manufacturing sector was the one chosen to benefit from such policies.

The demand placed on the agricultural sector now is expected to be very heavy, due to the need for exports for foreign-exchange earnings and the needs of the domestic market. The supply of food for the domestic market will have to increase by more than the present expansion rate in order to have abundant and cheap food. Although the historical contribution of agricultural products to the export sector has been decreasing compared to that of manufactured products, it is still responsible for a large share of the export market, as shown in Table 1.2.

Agriculture is believed to be the best way to increase exports because of certain characteristics of the sector. First, the world demand for agricultural products is expected to continue to grow at least at the same rate as the population will grow. Second, most of the oil-importing countries are experiencing various degrees of recession, making it hard for the developing nations to sell their manufactured products. Finally, Brazil is only a marginal exporter for the majority of its agricultural products, so the increase in exports can be achieved without influencing international prices. Therefore, no other sector has the opportunity for advancement like the agricultural sector does.

Table 1.2.--Value of Brazilian exports and share of the major sectors (US$ million FOB).

Year	Total Exports	Agriculture[a]		Manufactured		Semi-Manufactured	
		Total	%	Total	%	Total	%
1970	2,740	2,050	75	420	15	250	9
1971	2,904	1,990	69	580	20	240	8
1972	3,991	2,720	68	910	23	310	8
1973	6,199	4,100	66	1,470	24	480	8
1974	7,951	4,810	60	2,330	29	630	8
1975	8,670	5,030	58	2,580	30	850	10
1976	10,128	6,130	61	2,770	27	840	8
1977	12,120	6,930	57	3,840	32	1,040	9
1978	12,659	5,980	47	5,080	40	1,420	11
1979	15,244	6,510	43	6,680	44	1,890	12
1980	20,132	8,488	42	9,028	45	2,349	12

SOURCE: Conjuntura Econômica, various issues.

NOTE: During the 1960s, the participation of the agricultural sector remained around 80% (Miller Paiva, p. 47).

[a]The contribution of agricultural products is undervalued because the participation of agricultural raw materials in the semi-manufactured sector is not shown.

To increase the supply of agricultural products to both the internal and the external markets, it is necessary to create favorable conditions for increasing supply. The agricultural sector is known for its ability to respond very quickly to price incentives, so small price increases can induce positive response in production. However, this response must come mainly through an increase in yields. Such an increase is possible, though, because technology is already available for some important crops and depends only on the right incentives to be profitable.

Until recently, it has been argued that one of the few governmental actions that benefited the agricultural export sector, as well as other sectors, was the mini-devaluation policy ("floating-peg") adopted in 1968 (Zockun et al., 1976, p. 44). This policy helped to decrease the instability of the export activity by reducing the speculation associated with the previous devaluation policy. The mini-devaluation policy coincided with a period of favorable international prices for some agricultural products and had positive effects on the export sector.

The Problem

Although the agricultural sector has typically been the sector responsible for assisting the development process through the transfer of its surpluses, only recently has the Brazilian government decided to select this sector as the one to receive top priority in its development strategy. Historically, the agricultural sector has been discriminated against by economic policies aimed at protecting other forms of development, such as the industrialization for import substitution or the export promotion of manufactured goods. A series of restrictive policies such as export quotas, multiple exchange rates, overvalued exchange rates, and even more complicated methods of licensing and deposit were some of the ways governmental policies penalized the agricultural sector. At the same time, the industrial sector received different forms of subsidies such as preferential treatment concerning the import of capital goods, raw materials, and other inputs; preferential exchange rates; and tax exemption, followed by massive public investment to stimulate the sector.[1]

Besides the economic measures directed toward the export market, agriculture also suffered from domestic intervention such as controlled or fixed prices, retention of stocks, etc. These policies had effects similar to the measures directed to the external market in the sense that their main objective was to discourage exports until the domestic market had been "perfectly" supplied.[2]

The consequences of these restrictive policies directed toward either the external or the internal markets or both were to drive resources out of the agricultural sector. This resulted in fewer exports and less foreign-exchange-revenue earnings. Valdes (1973) found a similar situation in Chile in a study of the effects of restrictive agricultural policies. Much of the "trade gap" in

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[1]Several exhaustive studies have been conducted concerning the measures adopted by the government during the post-World War II period. They clearly demonstrated that the agricultural sector was being penalized. Among them are Veiga (1974), Bergsman (1970), Zockum et al. (1976), and Lopes and Schuh (1979).

[2]Leff (1967, 1969) claimed that during most of the post-World War II period and up to 1967, Brazil followed an "exportable surplus" approach to trade, by which a country exports the "surplus" that is "left over" after the domestic market has been "adequately" supplied, even if internal prices are lower than the world-market prices.

agricultural products in that country in the post-World War II period was a result of the international commercial policies followed by the Chilean government.

Of all the Brazilian policies adopted, the most persistent was the maintenance of an overvalued exchange rate. This measure constituted an implicit export tax on the agricultural sector. There seem to have been several reasons for maintaining this policy, as suggested by Thompson and Schuh (1977): (a) to exploit the country's dominant position in the world coffee market, where it was possible to shift the tax onto the foreign consumer; (b) to keep the domestic price of export products below their opportunity costs, as a way to control domestic inflation; and finally (c) to keep the price of imported goods low to encourage industrialization. Bergsman (1970) stated that during the 1947-67 period "the overvalued exchange rate probably owed its existence at least as much to a desire to keep food prices down as to a desire to industrialize" (p. 152).

Several researchers have shown the persistence of the overvaluation in the last three decades. Bergsman (1970) and Bergsman and Malan (1970) estimated the magnitude of this implicit taxation during the 1954-66 period as being between 23 and 27 percent. Bacha et al. (1971) estimated that during the first years of the 1960s the exchange rate was about 20 to 25 percent overvalued. Schuh (1976) pointed out that after being close to equilibrium in 1970, the exchange rate was overvalued again by 25 percent by 1976. By the end of 1979, the government decided to devalue the Brazilian currency (cruzeiro) by 30 percent, leading it to an equilibrium position and breaking the rule adopted in 1968 to devalue constantly and by small amounts (mini-devaluations). However, after a couple of months the currency again became overvalued because the mini-devaluation policy was not able to compensate for the inflation differential between Brazil and the United States.

In a classic paper, Schuh (1974) argued that

> an important variable in understanding the agricultural problems faced by the United States during the 1950s was the exchange rate and its role in trade, in the valuation of resources within the U.S. economy, in the distribution of benefits of economic progress between consumers and producers within an economy, and in the way the benefits of technical change are shared between the domestic population and the world at large. (p. 1)

In the same paper, Schuh explained why overvaluation tends to have detrimental effects on the agriculture of low-income countries, in which new production technologies are not available. In this situation the effect of overvaluation can be so strong that countries can move from being net exporters to being net importers of agricultural exports.

Several studies of the effects of overvaluation and other restrictive trade policies over particular agricultural and livestock commodities were conducted for the Brazilian case. Thompson and Schuh (1977) concluded that during the 1947-70 period, Brazil, which had been only a marginal exporter of corn, could have exported an average of 1.26 million metric tons more of corn each year if the cruzeiro had been devaluated by 20 percent. In effect, the increase in export earnings from corn would have been 475 percent if the exchange rate had been kept near an equilibrium level. Ayer and Schuh (1971) found that for each cruzeiro in consumer suplus gained in the cotton market through export restrictions, the country paid over 2.5 cruzeiros in foregone export earnings. Studying the beef sector in Brazil, Lattimore (1974) concluded that because of the intervention policy, each .45 cruzeiro saved by the Brazilian consumer caused the producer to be taxed one cruzeiro.

Based on the evidence that restrictive trade policies have discriminated against the agricultural sector, it appears that if a less-restrictive set of economic policies and, more specifically, a policy of more-near-equilibrium exchange rate had been adopted throughout the years, Brazil could now be a steady exporter of several agricultural products. The present study is an attempt to measure the effect of these restrictions over a system of several important commodities, in which simultaneous interactions between the consumer and farm levels of the market channels are possible.

Objectives of the Study

The specific objectives of this study are:

1. To build an econometric model that links the supply, demand, trade, and government sectors in Brazil for the major agricultural commodity markets.

2. To integrate this econometric model into a model system that can be used for prediction and policy-analysis simulation, i.e., for testing the operation of stabilization schemes under alternative assumed conditions.

3. To quantify the effects of overvaluation of the domestic currency on Brazilian agriculture.

The general objective of this study was to increase the understanding of the markets for the agricultural products considered and to provide instruments for their analysis. More specifically, it was attempted to explain the historical discrimination against the agricultural sector through a persistent overvaluation of the Brazilian currency.

The products considered in this study included corn, rice, wheat, soybeans, soymeal, soyoil, beef, hogs, and chickens. These products were chosen mainly because of their importance in the domestic economy and because they are interrelated, competing for the same area and/or as substitutes in terms of consumption. No mention is made of other important agricultural products, such as coffee and sugar cane, in order to keep the model manageable and because the interest was mainly concentrated in the grain-livestock sector.

Organization of the Dissertation

The remainder of the dissertation is organized as follows. Chapter II contains the theoretical considerations used to demonstrate the effects of changes in trade policy. Chapter III includes an overview of the modelling approach. The results of the estimation of the parameters and validation of the estimated model are presented in Chapters IV through VI. Production is discussed in Chapter IV, demand in Chapter V, and net trade and price and stock relationships

in Chapter VI. Chapter VII demonstrates the use of the model for policy analysis. The final chapter contains a summary, conclusions, and suggestions for further research. Supporting materials are contained in the appendices.

CHAPTER II

THEORETICAL CONSIDERATIONS

One of the objectives of this study was to quantify the effects of the overvaluation of the domestic currency on Brazilian agriculture. These effects can be shown graphically with the help of a partial-equilibrium framework. The use of partial-equilibrium analysis, although subject to several criticisms, can be very useful for "rough and ready" analyses of the effects of changes in trade policy (Thompson, 1977). The partial-equilibrium approach considers only one commodity in isolation and does not include other markets in the analyses. But, to link the agricultural sector with the other sectors of the economy and still have a comprehensive system, simplifying assumptions are required.

To illustrate the effects of an overvalued exchange rate in a one-commodity, two-country model, a set of two-dimensional graphs can be used. The more general case, whereby the exporting country has a sufficiently large world-market share to influence the world-market equilibrium price by changing the quantity it exports, will be presented first. Because Brazil can still be considered a small country in world markets for most of its agricultural products, the small-country case will be presented following the more general case.

Large-Country Case[1]

Figure 2.1, panel (a) represents the domestic demand and supply curves of a certain homogeneous commodity of an exporting country. When there is no international trade, the equilibrium price and quantity are determined by the intersection of the domestic supply and demand curves. However, if there is free trade, the domestic price at the port of the exporting country is equal to the FOB (free on board) price. Panel (c) of the same figure shows the "domestic" supply and demand curves for the importing country, considered here as the rest of the world (ROW).[2] The intersection of the domestic demand and supply curves gives the "domestic" equilibrium price and quantity for the ROW[3] before trade begins. The prices are expressed in domestic currency for the exporting country and in dollars for the ROW. It was assumed that the exchange rate was in equilibrium and that transportation costs could be ignored for simplicity.

Panels (b) and (b') represent the world-market conditions in the exporting country's domestic currency and in dollars, respectively. An excess-supply curve (ES) can be drawn, panel (b), on the assumption that at any price above OP_1 the quantity supplied domestically is

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[1]This section is heavily based on Thompson and Schuh (1977).

[2]The aggregation of all other trading countries into the "rest of the world" constitutes another important limitation of this partial-equilibrium graphical approach. See Thompson (1977, p. 10).

[3]The curves were drawn on the assumption that before trade, the domestic price in the exporting country is lower than the equilibrium price in the ROW, the only reason why a country can be an exporter.

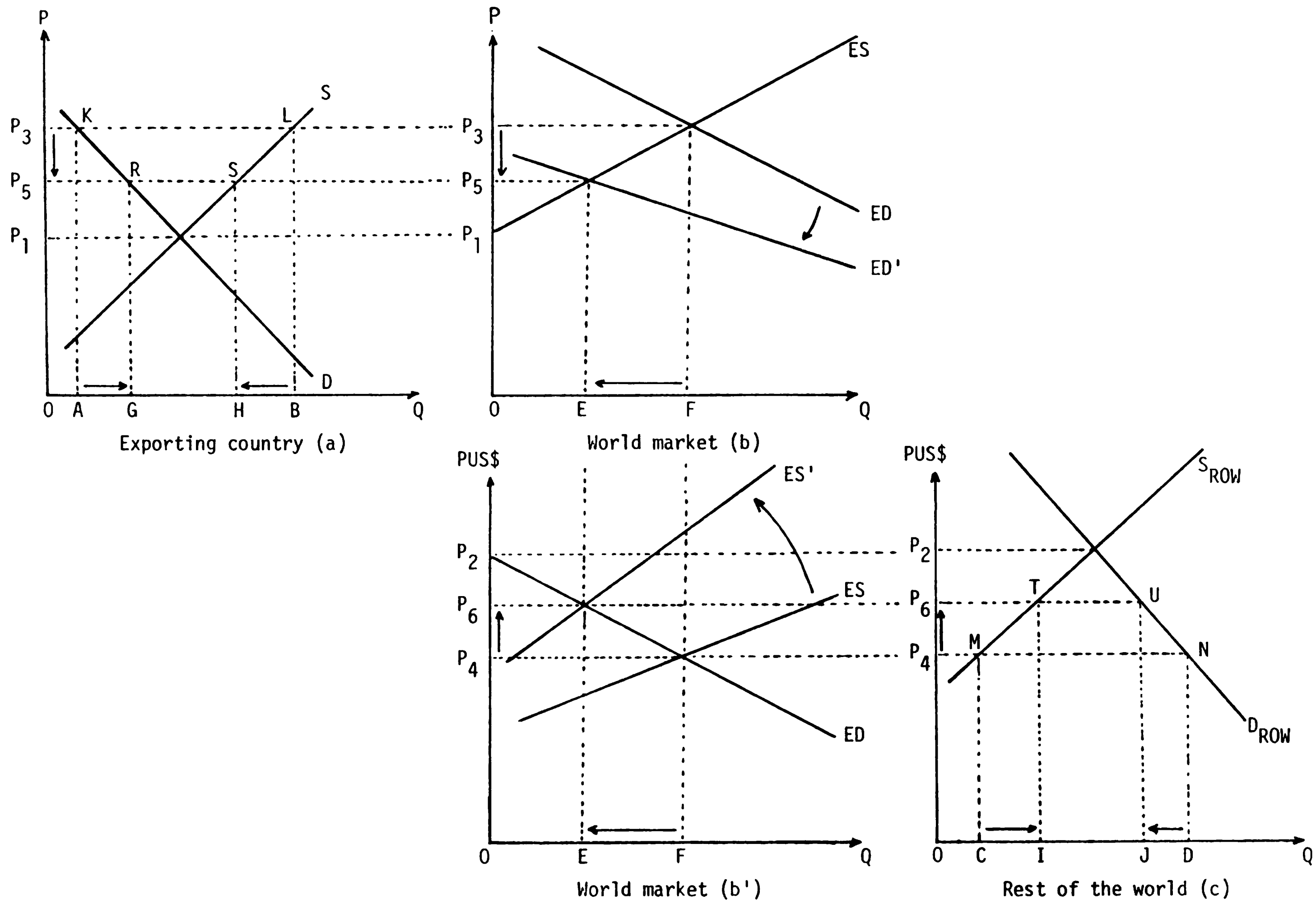

Figure 2.1.--Effect of overvaluation on exportable products, large-country case.

greater than the quantity demanded. Then ES is obtained by measuring horizontally the differences between domestic supply and demand curves at prices above the equilibrium price and shows the quantities a country will export at various prices. The slope of ES is the combined slope of the domestic supply and demand curves of panel (a). The excess-demand curve (ED) for the rest of the world can be obtained in a similar manner. At prices below the "domestic" equilibrium price OP_2 in panel (c), more is demanded and less is supplied, assuming that "domestic" supply and demand curves are normally shaped. ED is then obtained by measuring horizontally the differences between the "domestic" supply and demand curves for the ROW at any price below the equilibrium price and shows the quantities the ROW is willing to import from the exporting country at various prices. The derivation of this curve is not as straightforward as the ES curve because it has to be considered as the difference between total imports of all countries less the quantities imported from other exporting countries, so it is in fact a net excess-demand curve. The slope of ED is the combined slope of the "domestic" supply and demand curves of all countries aggregated in panel (c).

If it is assumed there are no trade restrictions, that the exchange rate is in equilibrium, and that transportation costs can be ignored, a new world-equilibrium price can be obtained at the intersection of ES and ED in panels (b) and (b'). This free-trade price will be equal to the domestic equilibrium prices at the ports--OP_3 in the exporting country and OP_4 in the ROW. At this price, the

exporting country will produce OB and OA will be domestically demanded, leaving AB = OF to be exported. At the same time, the ROW is producing OC at the price OP_4, consuming OD, and importing CD = OF. The exporting country's foreign revenue from this scale is equal to CMND, which in turn is equal to AKLB.

Up to this point, perfect competition was assumed to exist among the markets, and free trade was allowed. Now assume that the exporting country decides to peg its exchange rate to the dollar at a level that overvalues its currency. This shifts the ED curve of the ROW down to ED' in terms of the exporting country currency. The exporting country ES curve shifts up to ES' from the viewpoint of the ROW, in terms of dollars. These shifts are not parallel but percentage shifts. The immediate effect of this policy decision is to lower the price of the commodity to OP_5 in terms of the exporting country currency or to increase it to OP_6 in terms of dollars. This means that less will be produced and more consumed domestically, leaving less to be exported. On the other hand, in the ROW more will be produced and less consumed because the prices now are higher in terms of dollars. The quantity traded now is GH = OE = IJ, which is smaller than before the overvaluation, meaning that less foreign-exchange revenue will be earned by the exporting country (ITUJ).

One way to measure the average effect of a price change as a result of a trade intervention such as an overvaluation is by using the elasticities of ES and ED. These elasticities, in turn, depend

directly on the domestic-price elasticities of supply and demand of the respective countries involved.[1]

Thompson and Schuh (1977, p. 9) showed that an overvaluation of t percent, <u>ceteris paribus</u>, will lower the domestic price in the exporting country by

$$\frac{d\ P}{P} = \left(\frac{\varepsilon}{\varepsilon - \eta}\right)\ t = \left(\frac{1}{1 - \frac{\eta}{\varepsilon}}\right)\ t \text{ percent}$$

and will raise the domestic price in the ROW by

$$\frac{d\ P_{US\$}}{P_{US\$}} = \left(\frac{\eta}{\eta - \varepsilon}\right) t = \left(\frac{1}{1 - \frac{\varepsilon}{\eta}}\right)\ t \text{ percent}$$

where:

η = the price elasticity of excess supply of the exporting country

ε = the price elasticity of excess demand of the ROW

$(\eta > 0 > \varepsilon)$

The effectiveness of such a policy will depend on the power of the country to influence the international market price. If the exporting country is large enough and overvalues its currency or imposes any other kind of trade restriction, it can transfer income from the ROW to the exporting country by increasing the world-market price (in dollars). The magnitude of these changes in prices greatly depends on the elasticities of excess demand faced by the exporting country for each different exportable product. The more inelastic the excess-demand curve of the ROW is for the product considered,

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[1]For derivation of the ES and ED elasticities, see Kreinin (1975), Appendix III, p. 428.

the more the exporting country stands to gain from such a restrictive trade policy.

Small-Country Case

This is a particular situation of the more general case, whereby the exporting country faces a horizontal excess-demand curve for its product ($\varepsilon = -\infty$). The above formulas will then be reduced to:

$$\lim_{\varepsilon \to -\infty} \frac{d\,P}{P} = t \text{ percent}$$

and

$$\lim_{\varepsilon \to -\infty} \frac{d\,P_{US\$}}{P_{US\$}} = 0$$

This means that a t percent overvaluation, ceteris paribus, will translate into a similar amount of decrease in the exporting country domestic price with no influence at all in the world-market equilibrium price.

The effects of an overvalued exchange rate in a small-country case are shown graphically in Figure 2.2. The analysis is similar to the large-country case. Panel (a) illustrates the exporting country's domestic supply and demand curves for a certain homogeneous commodity. Panel (b) represents the world-market conditions faced by the exporting country. ES is the excess-supply curve for prices above the domestic equilibrium level P_1. ED is the ROW's excess-demand curve, when the exchange rate is in equilibrium. The intersection of these two curves in panel (b) gives the domestic free trade price P_2. At this price, the exporting country produces OB and demands OA

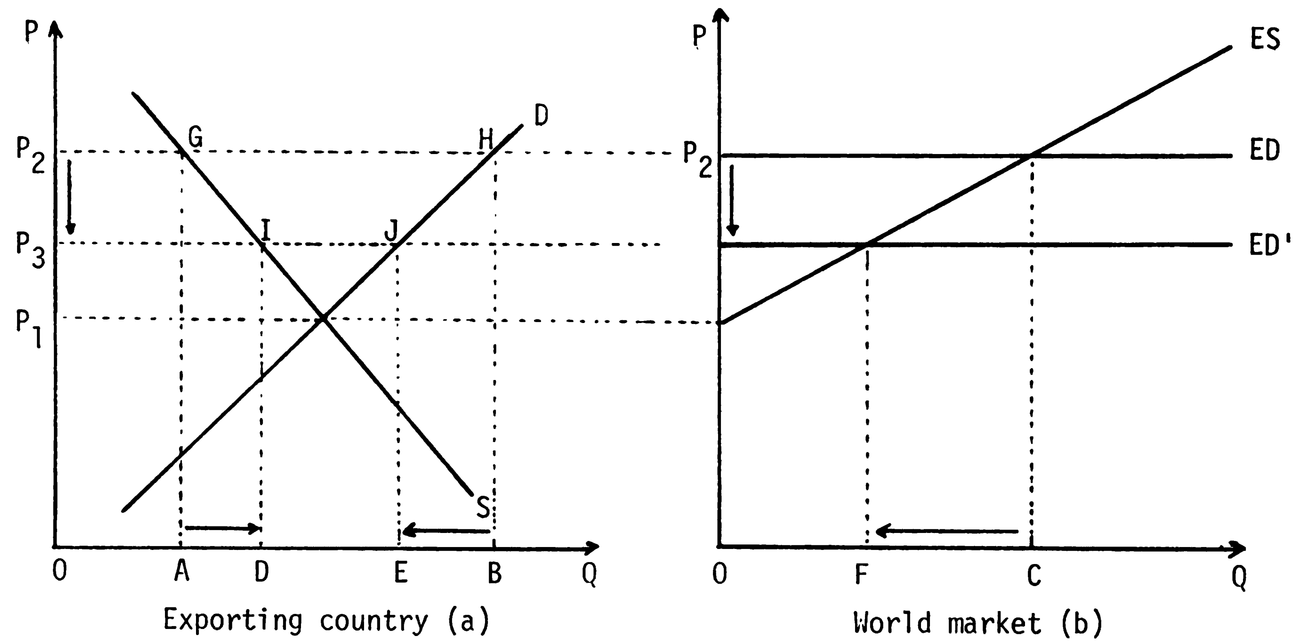

Figure 2.2.--Effect of overvaluation on exportable products, small-country case.

domestically, leaving AB = OC to be exported. The revenue of this sale is AGHB.

If the exporting country overvalues its exchange rate, the ED curve shifts down to ED'. The new domestic equilibrium price will be $OP_3 < OP_2$. At this lower price, OE < OB will be produced and OD > OA will be demanded domestically, leaving DE = OF < OC to be exported. This means that a lower revenue DIJE will be earned.

If a country has no power to influence world-market prices, the effects of the overvaluation tend to stay within the domestic economy. Consumers will gain in the short run because the prices in domestic currency will fall. Lower prices will result in undervaluation of the agricultural resources, which in time will leave the sector to find better alternative uses. Also, if prices are lower domestically, more will be consumed internally and less produced. The amount available for trade will decrease, with a consequent decrease in foreign-exchange earnings. Imports will also be cheaper in terms of domestic currency, and the government may have to impose restrictive measures to control imports. The country's capacity to import the capital goods and other inputs necessary to its developmental process may also be affected. How much foreign exchange will be lost depends on the elasticities and the amount of the overvaluation.

CHAPTER III

OVERVIEW OF THE MODELING APPROACH

Introduction

In recent years a variety of complete econometric models have been built, having different objectives and using a series of estimation techniques. These models usually provide ways for better understanding the structure and parameters of the behavioral relationships underlying commodity markets as well as the relationships between the various markets and the producer and consumer economies (Adams & Behrman, 1976, p. 2). They have been used for purposes of forecasting and for simulation under different policy alternatives. Labys (1973, 1975) has an extensive inventory of studies related to commodity-model building.

The objective of this study was to build an econometric model for the grain and livestock sectors to be used for prediction and policy simulation. The model includes production components (acreage, yields, slaughtered animals), domestic-demand equations, feed-demand equations derived from the livestock component for soymeal and corn, soybeans crush demand, a system of price-linkage equations relating domestic to world prices, stock equations where applicable, and a set of identities and "technical" relationships. In all cases, trade was considered the residual after considering domestic availability and domestic disappearance.

A simulation approach was chosen because this procedure allows the major agricultural products to be analyzed simultaneously. This enables important cross-price effects among commodities to be considered. The simulation analysis has some advantages over the alternative multiplier analysis to evaluate effects of policy changes (Labys, 1973, p. 199). It permits one to consider, among other things, varying rates of change in an exogenous variable or varying levels of several exogenous variables at once. It was hoped that this procedure would show more accurately the total effects of a change in the exogenous variables than would the use of simple elasticities computed from the structural form.

To model commodity markets, it is necessary to know the characteristics of each commodity. This means that different conditions of production, transport, and marketing, as well as government intervention, must be taken into consideration (Adams & Behrman, 1976, p. 3). To use this kind of detailed information when building large econometric models is not always feasible because of data and resource limitations.

Bearing in mind the limitations in constructing any econometric model, it was hoped that useful conclusions could be reached with a relatively simple econometric model built from data available mainly in agricultural balance sheets. A complete description of the model is presented in subsequent chapters.

Simulation Model

The basic conceptual approach to the model for each commodity was similar. Functional relationships were estimated for domestic disappearance (including food and industrial use, feed, and seed), carryover stocks, production, and domestic-price determination. The demand for exports was considered as a residual. The role of government intervention in determining domestic agricultural prices was included as a set of price relationships relating domestic to world prices and exchange rate. These price relationships also included other economic variables assumed to influence the government's decision to intervene in domestic prices.

Following a study by Reynolds, Heady, and Mitchell (1975), a simplified diagram was developed in which the most relevant interrelationships among the different components of the model are presented. (See Figure 3.1.) The most important components of the economic model of the Brazilian grain-livestock subsystem are producers, domestic consumers, the government, and foreign consumers. Because of the recursive and simultaneous nature of the system, a change in one of the submodels can affect the whole system. An increase in beef-cattle price, for example, will affect the other livestock products and will even show effects beyond the sector. Direct and indirect effects will be observed in the hog, poultry, corn, and soybean submodels. A change in the price of beef cattle affects the soybean acreage through changes in the area devoted to grazing. A change in the price of soybeans affects the demand for Brazilian soybeans. The domestic soymeal demand is mainly determined

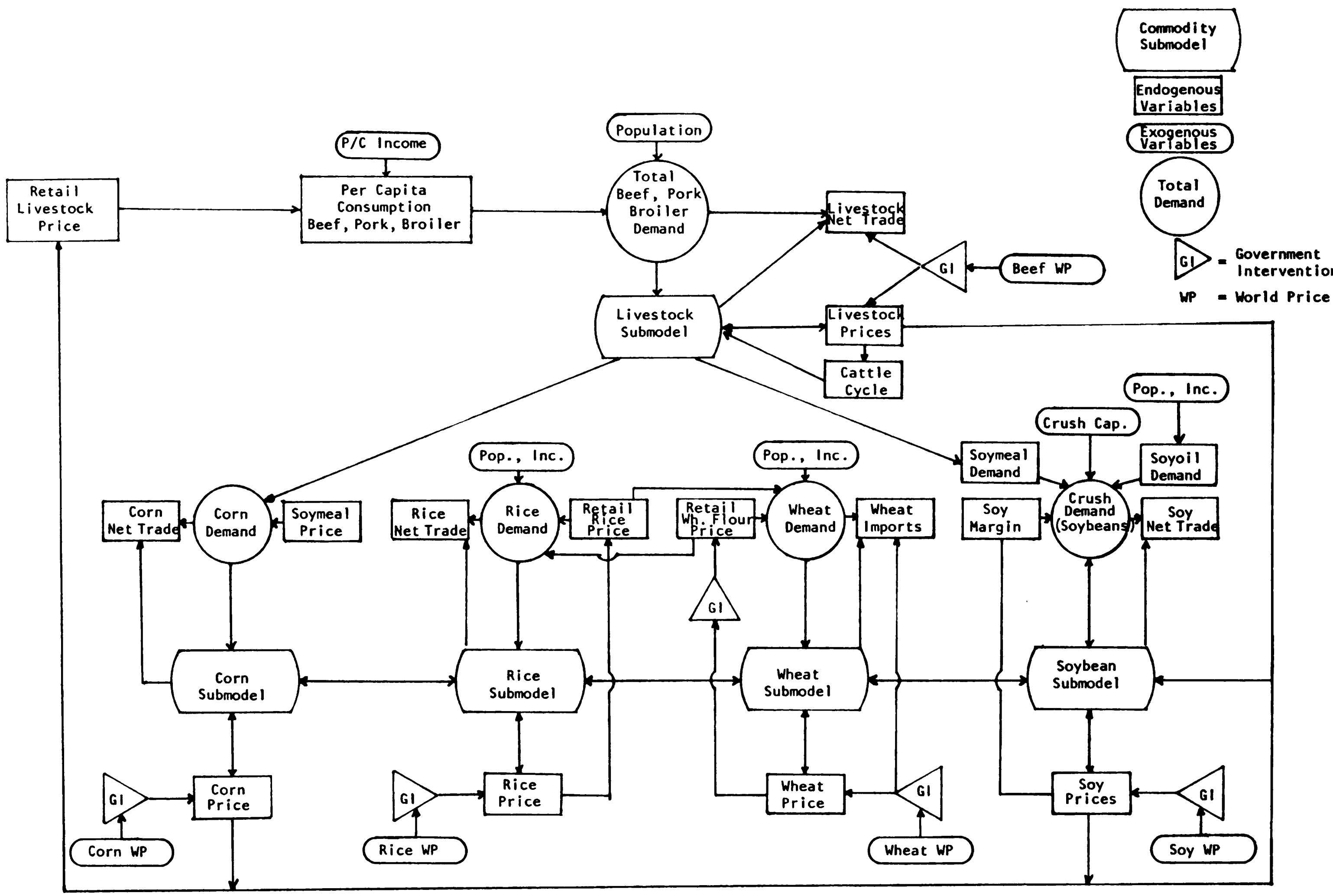

Figure 3.1.--Aggregate simulation model of the Brazilian agricultural sector.

by the demand for broiler feed, and demand for soyoil is largely determined by the demand for cooking oil. The volume of soybeans and products to be exported is determined mainly by the difference between the respective supply and demand. The same soybean price determines the relative profitability of soybeans, which in turn affects the decision to cultivate soybeans and competitive crops the following year, when interaction of the total demand and supply of soybeans and government intervention produces a new market price.

The submodels for the other commodities follow a similar pattern. Additional interactions are generated in the system as the continuous effects of changes in other sectors are performed. The interaction and feedback effects among the products considered (corn, rice, wheat, soybeans, soymeal, soyoil, beef, hog meat, and broilers) are represented by the underlying recursive and simultaneous equations of the model.

The preceding submodels were simulated simultaneously over the period 1971-80. Actual lagged values were used to force the model to correct itself. Interactions among the submodels were thus permitted. Model evaluation over the historical period was analyzed by performance measures, which are presented at the end of this chapter. These measures relate to the model's predictive ability. The performance results are presented in the next three chapters, after a discussion of the estimated equations.

Next, the model is simulated over the historical period under two different scenarios. A baseline forecast was obtained by letting

the model feed itself, using estimated lagged values instead of actual values. The predictions from this scenario are then compared with those from an alternative scenario designed to allow analysis of the effect of a change in the level of government intervention by using "equilibrium" exchange rate. The results of those simulations are presented in Chapter VII.

The simulations described in this study were carried out using the GSIM[1] program developed in the Agricultural Economics Department at Michigan State University. GSIM uses the Gauss-Seidel straightforward numerical method to obtain the solution of simultaneous systems of equations.

The full model consists of 48 equations, 37 of which are structural equations. The remaining 11 equations are technical relationships and identities. Estimation of the econometric equations was based on yearly time series data covering the period from 1961 through 1980. It was felt that this was the most representative period to reflect the current structure of production, consumption, and trade in Brazil. All of the monetary variables used in the analysis were deflated by the respective price index with base 1977 = 100. For a detailed description of the variables entering the equations and data sources, see Appendix A.

Estimation Procedures

The choice of an estimation procedure depends on the characteristics of the model under analysis. Using practical considerations

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[1]Based on the General Analytical Simulation Solution Program (GASSP) developed originally at the USDA.

of estimating and applying commodity models, Labys (1973, p. 135) established the choice of criteria based on theoretical and computational complexity, required sample size, equation or system approach, nature of consistency, and sensitivity to specification errors, identification, and multicollinearity. His comparison scheme is a useful device in making the tradeoff between computational ease and desirable properties of estimates.

Ideally, where there is simultaneity in a commodity model, one should apply specific methods for use with simultaneous systems. In this study, it was possible to order the supply (production) equations in a dynamic recursive system in such a way that the dependent variables were related to exogenous and predetermined variables. The ordinary-least-squares procedure is then suitable for estimating the parameters of the supply equations because it can provide estimates that are unbiased, consistent, and efficient, as well as giving the maximum likelihood for a recursive system of equations (Labys, 1973, p. 135).

The two-stage least-squares method seems to be adequate for estimating demand functions where the interdependence among demand and prices extends to supply. This method, however, fails when the number of observations is less than the number of predetermined variables. Most of the time, this was the case in the present study. It is impossible to estimate the reduced-form coefficients in the first stage of the process because the number of unknowns is greater

than the number of observations. Kloek and Mennes (1960) proposed a solution to handling this problem, using principal components of predetermined variables. One can replace the matrix of predetermined variables with one of a smaller number of principal components accounting for a large proportion of the total variance in the original variables. Although it has some merits, this method also includes several disadvantages. The linear combinations of the principal components have no meaningful economic interpretation. Also, the parameter estimates cannot be expected to be consistent as in the case of original two-stage least-squares procedures (Labys, 1973, p. 142). Another disadvantage is the arbitrariness caused by (a) the fact that the computation of principal components needs a certain normalization rule on the variables (such as a unit mean square) and (b) the number of principal components to be used and whether these components should pertain only to the variables excluded from the equation to be estimated or to the set of all predetermined variables of the system (Theil, 1971). Besides, as Maddala (1977, p. 194) pointed out, the principal-components method is only a statistical device and of very limited use, and it can easily be misused in econometric work.

According to Theil (1971), there are no obvious solutions in a case of an undersized sample. He presented two other approaches but cautioned that further research is needed before the merits of such procedures can be assessed. The number of predetermined variables entering each reduced-form equation is very large for considerably or even moderately sized models, so that methods specifically designed

for use with simultaneous systems such as two- or three-stage least-squares procedures are almost never employed in practice (Brundy & Jorgenson, 1971).

It is common to assert that identification does not constitute a serious problem with agricultural-commodity models because most of these models are overidentified. Usually, the only rule used for identification is the order (necessary) condition. The rank (necessary and sufficient) condition is normally neglected because it requires a profound knowledge of certain aspects of matrix algebra. The subject should not be ignored, however, because the parameters of an equation sometimes are not identifiable even when their number does not exceed that of the exogenous variables (Theil, 1971, p. 449). Besides the difficulties described above, it is not worthwhile to pursue a solution for the simultaneity problem when one does not know whether the system of equations is identified or not.

Based on the preceding considerations, it was decided to estimate most equations by the ordinary-least-squares (OLS) method. Exceptions were made in the case of beef production, in which a polynomial-distributed-lag model was used; and when serially correlated errors were detected, the generalized-least-squares method was used. The decision to use the OLS method may lead to simultaneous equation bias in the coefficients. Given the relatively small number of observations for the present study, and, more specifically, the limited number of years for some of the products considered, such as broilers and soyoil, that were relevant in Brazil, it cannot be assured that the use of a more consistent method of estimation (if possible) would result in a significant change in the coefficients. According to Labys (1973),

> It should be kept in mind that OLS results in biased parameters estimates where simultaneity is present, but the same is true of estimates from other methods unless the given sample size is relatively large and the model specification is fairly exact. Thus, one must weigh resulting bias against the fact that OLS estimates typically have lower variance than estimates obtained from other methods. (p. 138)

Given the preceding discussion, it was expected that the use of OLS may still provide meaningful results. It was decided that it was more profitable to improve the model in terms of specification than in terms of methods of estimation, which can be left for later research in which refinements in the data could be obtained, together with a larger number of observations.

Validation

Once the model equations are estimated, the full-model evaluation over the historical period is analyzed by different performance measures. They are related to the mean square simulation error. The first is Theil's inequality coefficient, defined as

$$U_1 = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s)^2} + \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^a)^2}}$$

where

Y_t^s = simulated or predicted value of Y_t

Y_t^a = actual value

T = number of periods in the simulation

The numerator of U_1 is the root of the mean square error (MSE). This statistic lies between zero and one. If it is zero, the model predicts perfectly for the historical period. According to Maddala (1977, p. 346), U_1 does not provide a good ranking of forecasts; thus a second measure, Theil's U_2 statistic, is preferred. It is defined as

$$U_2 = \frac{\sqrt{MSE}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^a)^2}}$$

The value for U_2 ranges from zero to infinity; again, this measure is zero in the case of perfect forecasts.

The mean square error can be decomposed into either one of two sets of components: (1) bias, variance, and covariance and (2) bias, regression, and residual proportions.[1] Maddala pointed out that the latter decomposition should be used; it is defined as:

$$UM = \frac{(\bar{s} - \bar{a})}{MSE} = \text{bias proportion}$$

$$UR = \frac{(Ss - r.Sa)^2}{MSE} = \text{regression proportion}$$

$$UD = \frac{(1 - r^2)S_a^2}{MSE} = \text{disturbance proportion}$$

where

$\bar{s}$, $\bar{a}$ = the means of s_t and a_t defined as

$s_t = (Y_t^s - Y_{t-1}^a)/Y_{t-1}^a$

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[1]For a detailed discussion of this decomposition, see Maddala (1977, p. 344) and Pindych and Rubinfeld (1981, p. 365).

$a_t = (Y^a_t - Y^a_{t-1})/Y^a_{t-1}$

Ss = the variance of the predictions

Sa = the variance of the actual values

r = the correlation between s and a

If one considers the regression of actual values on predicted values

$$Y^a_t = \alpha + \beta\, Y^s_t$$

UM will be equal to zero if the parameter α is zero, and UR will be zero if β equals one. The bias proportion UM gives an indication of the systematic error--that is, the extent to which average predicted change deviates from average actual change. Note that UM + UR + UD = 1. The ideal distribution of these proportions is UM = UR = 0, and UD = 1.

The above criteria were used to validate the model. The results are presented in the next three chapters, together with the structure and estimation of the model components.

CHAPTER IV

SUPPLY

Introduction

This chapter focuses on the production side of the model. To situate geographically the distribution of production within Brazil, a brief idea of the land use is given below. The succeeding sections are devoted to specification, estimation, and validation of the structural relations of the underlying supplies for each product considered.

The extension of the Brazilian territory is 851.2 million hectares (8,511,965 km^2). Of this area, approximately 322.6 million hectares (38.2 percent) was occupied by agricultural establishments in 1975, of which only about 70 percent or 227.8 million hectares was under full exploration, distributed as follows: 38.8 million hectares in arable land and permanent crops, 164.9 million hectares in permanent pasture, and 24.0 million hectares in extractive exploration (Mesquita, 1981). After discounting the urban areas and other facilities, Brazil still has more than 50 percent of its territory that is not being explored economically. Naturally, a large percentage of the unexplored area is not suitable for agricultural activity for a number of reasons not to be discussed here. Mainly because of this availability of land, most of the increase in agricultural production has been achieved through area expansion. This pattern is bound to change in the near

future for the simple reason that most of the suitable land close to the urban centers has already been brought into exploration. Further occupation of land will be possible only with increased costs in transportation and infrastructure.

As can be seen in Table 4.1, the land devoted to agricultural exploration is very irregularly distributed among the regions. Figures 4.1 and 4.2 give an idea of the geographical position of the states and their distribution within the respective regions.

Table 4.1.--Brazilian land distribution among the regions and agricultural land use.

Region	Area (million ha) (1)	% of Total Area (2)	Agricultural Use (million ha) (3)	% Agricultural Use (3)/(1)
North	358.1	42.1	29.8	8.4
Northeast	154.9	18.2	79.8	51.7
West-Central	187.9	22.2	93.7	49.8
Southeast	92.5	10.8	72.8	79.3
South	57.8	6.8	46.5	82.8
Total	851.2	100.0	322.6	38.2

Sources: Mesquita (1981) and Fundação IBGE.

The southeastern and southern regions have about 80 percent of their areas already under cultivation, and very little expansion can be expected in the future. The west-central region is the area that can be expanded, at least in the short run. It has the advantage of already having most of the basic infrastructure and of being close to urban centers. But its exploration cannot be accomplished without

Figure 4.1.--Map of Brazil: Geographical distribution of the states. (From Anuário Estatístico do Brazil, Fundaçao IBGE, 1980.)

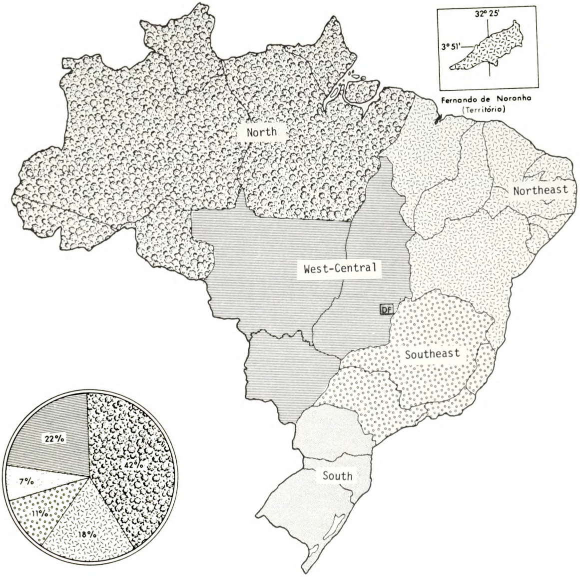

Figure 4.2.--Map of Brazil: Geographical distribution of the regions. (From Anuário Estatístico do Brasil, Fundação IBGE, 1980.)

heavy investment in fertilizer and lime to correct soil problems, which are common to a large percentage of its area, particularly the Cerrado region. The northern region is the largest in the country, occupying 42.1 percent of the total territory, most of which is covered by the dense vegetation of the Amazon Forest. This region has the disadvantage of being too far from the consumption centers. On the other hand, the controversy raised about the devastation of its natural resources, along with problems of soil and climate inadequate for crop cultivation, have prevented a rational exploration of the area. These problems make the region a difficult alternative of frontier expansion, at least in the short run. The northeastern region, covering 18.2 percent of the territorial land, is one of the poorest in the country for agricultural exploration. The main problem is related to the unavailability of water. More than half of its area receives only from 250 to 800 mm of rainfall, distributed irregularly during four to six months of the year (Alves, 1981). There is a possibility of expanding agriculture, but only with special irrigation techniques and research in crop varieties well adapted to the dry climate of the region.

What emerges is mainly the fact that an increase in agricultural production can still be achieved through an expansion of cultivated area, although with increased production costs. But further growth in production must be attained through an increase in the productivity of agricultural commodities as well. This is the main task of the agricultural research coordinated by EMBRAPA, the Brazilian Agriculture Research Corporation; the positive results already obtained by this

institution indicate that Brazil has a great potential for further expansion of agricultural production. The agricultural products considered in this study are largely concentrated in the southern, southeastern, and west-central regions.

Crop and Meat Production

A perfectly competitive market was assumed in this study in both input and output markets. The farmers try to maximize expected profits when making decisions about the amount of land to devote to various crops. To estimate agricultural supply, the Nerlove model, hypothesizing farmers' reactions in terms of price expectations and partial area adjustments, was adopted. Planted area was chosen as an indicator of intended supply instead of quantity produced because it was believed the latter is subject to variations outside the farmers' control, such as weather, pests, and diseases. For a review of arguments favoring the approach adopted in this research, i.e., that area shows intended supply better than does quantity, see Nerlove (1958) and Gemmil (1978). The latter showed that this approach is superior in terms of efficiency of forecasting quantity.

It was hypothesized that farmers respond to expected crop yield as well as to expected prices (Spriggs, 1981). A linear-trend yield was used to represent expected yield. The explanatory price variable was then represented by a new variable called "expected return per hectare." This expected return was given by the multiplication of the lagged price by the expected crop yield. The prices from the preceding year were considered as proxies for the expected prices because the announcements of minimum prices during the period under consideration were made too late each year to affect the planting decisions. For this reason and because they had usually been set below prevailing market prices, the minimum prices were not considered as affecting the planting decisions. In the case of wheat, the established support price was used because the government is the only buyer of the entire crop, and this support price is set in advance of planting time. It is generally believed that this is a more correct way of representing the factors determining planting decisions, and these factors are vitally important to farm-policy decision makers.

The expected returns of the major crops that compete for area with the considered crop were included in the hectarage-response function. Another explanatory variable was the lagged-crop hectarage. It was assumed, therefore, that farmers do not react immediately to changes in the factors that affect planting decisions because of the cost of change and inertia or because of the asset-fixity problem. It seemed reasonable to believe that farmers would not change their activities in the short run. All of the four crops considered here occupied large areas in which there were few alternatives; the assumption, therefore, was that a large proportion of the hectarage devoted to these crops would be continued over the next year.

A linear trend was introduced to account for changes in technology. It was expected that this variable would pick up the influence of omitted variables that were highly correlated with time and then eliminate at least part of the bias to which the coefficient of

adjustment derived from the coefficient of the lagged dependent variable is susceptible (Thompson & Schuh, 1977).

Four types of equations were used to forecast crop production:

$$YIELD = F_1\ (TREND)$$

$$ERETURN = LPRICE * YIELD$$

$$AREA = F_2\ (LAREA,\ ERETURN,\ TREND)$$

$$PRODUCTION = AREA * YIELD$$

where the letters L and E at the beginning of the words stand for lagged and expected values, respectively. Obviously, there were expected return variables for the crop under consideration and for the major competing crop(s). However, because of the aggregate nature of the model, only the major competing crops were considered in each case.

The use of a lagged dependent variable on the right-hand side of the equations raised the possibility of serial correlation. The use of the Durbin-Watson statistic in this specification is known to be inappropriate. This test is biased toward 2.0 and therefore favors accepting the null hypothesis that there is no serial correlation. Maddala (1977, p. 372) stated that the test can be used only when it leads to the rejection of the null hypothesis. An alternative test, the statistic h, developed by Durbin (1970) was used. A great advantage of using this statistic is that it can be computed from the ordinary-least-squares residuals and then tested as a standard normal deviate; thus if $h > 1.645$, one would reject the hypothesis that there is no serial correlation at the 5 percent level (Johnston, 1972, p. 313).

In the following sections, the results of the estimated equations for each product are presented and discussed. The values in parentheses are the standard error of the estimates.[1] Unless otherwise specified, the period covered in the analysis was 1961-1980. Crops like soybeans experienced a very rapid rate of growth during this period, even more significantly after 1970. This unusual growth, together with other reasons, completely changed the broiler industry in the last decade. Hog production also suffered profound modifications in this period, mainly because of the African Swine Fever problem. The development of the mixed-feed industry is closely related to the growth of these two livestock products. But the hog industry is not as efficient as the broiler industry, one reason being its low 4:1 conversion rate compared to 2.5:1 for the broiler industry.

Crop Production

Corn.--Corn production takes place largely on small- and medium-size farms. Corn is the most widely planted crop in Brazil, accounting for about 25 percent of the total area cropped. Although corn is grown throughout Brazil, production is mainly concentrated in the southern and southeastern regions. There has been a rapid expansion in corn production in recent years. The 44 percent increase in total production in the decade from 1971 to 1980 was achieved through a significant expansion in area cropped (8.4 percent); yields have increased

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[1]The t-ratio is defined here as the absolute value of the estimated coefficient considered, divided by its standard error. The t-ratio is then compared with the student's t-statistic. One asterisk over the parameter indicates that it is statistically significant at the 10 percent level, two asterisks at the 5 percent level, and three asterisks at the 1 percent level.

from 1.4 to 1.7 MT/ha. (In the 1960s, the average productivity was around 1.3 MT/ha.) The increased yield in this period was a result of the adoption of hybrid varieties and of fertilization in southern Brazil. Despite these low figures, mainly as compared with the United States, Brazil is the world's third largest corn producer, coming after the United States and the People's Republic of China. It appears that Brazil has a potential to become a major force in the world corn trade (Thompson & Garcia, 1978). One of the objectives of the Brazilian Agricultural Research Corporation (EMBRAPA) is to generate yield-increasing technological change, and corn is one of the products studied through the National Center for Corn and Sorghum Research. The impressive yield increases attained by this Center indicate that, in fact, Brazil has the potential for expanding its corn production.

In an aggregate view, the principal crop that competes with corn in Brazil is rice. Therefore, the expected return per hectare of rice was expected to have a negative sign. The equations used to forecast corn production are presented below with the R^2, Durbin-Watson statistic, and h-statistic from the ordinary-least-squares estimates. The values in parentheses are the standard errors of the estimated coefficients.

$$AC = 842069 + \underset{(.2644)}{.7443^{**}}\ LAC + \underset{(334.54)}{461.24}\ ERC - \underset{(58.95)}{16.15}\ ERR + \underset{(72297.6)}{37246.6}\ TREND$$

$R^2 = .95$ D.W. $= 2.41$

$$AC = 322337 + \underset{(.0564)}{.8772^{***}}\ LAC + \underset{(249.82)}{572.34^{**}}\ ERC - \underset{(55.78)}{23.69}\ ERR$$

$R^2 = .95$ D.W. = 2.49 h = -1.37

$$YC = 280.59 + \underset{(4.39)}{16.00^{***}}\ TREND$$

$R^2 = .42$ D.W. = 2.05

$$TPC = AC * YC$$

where:

AC = corn hectarage (hectares)

LAC = AC lagged one year

ERC = expected return of corn per hectare (Cr$1,000/ha)

ERR = expected return of rice per hectare (Cr$1,000/ha)

TREND = equals 61 for 1961 and increases by one each year

YC = yield for corn (kg/ha)

TPC = total corn production (MT)

In the initial estimation, the area function provided a good fit of the data with high R^2 and the expected signs. However, only the lagged dependent variable showed a coefficient significantly different from zero. A possible explanation for these results can be found in the high correlation between LAC and TREND (.96). Although high correlation is only a necessary condition for the presence of multicollinearity, it implies a potential problem. If this is the case, the precision of estimation falls so that it becomes very difficult, if not impossible, to determine the relative influence of the various independent variables (Johnston, 1972, p. 160). Deleting TREND from the area equation improved the results, which appear in the second equation. The R^2 remained the same, and all the coefficients had higher t-ratios. The result of the h-statistics computed from the least-squares residuals led to the rejection of the hypothesis that there is serial correlation in the estimated equation.

The yield equation is a linear trend, and total production of corn is the product of corn hectarage and yield.

Rice.--Rice is a staple food that typically provides about 25 percent of the caloric and 15 percent of the protein intake for the Brazilian population. The traditional rice-growing areas have been the states of Rio Grande do Sul, Parana, Minas Gerais, Goias, and São Paulo. In recent years there has been a rapid expansion of the areas in the West-Central region. The increase in total production in the last decade (30 percent) has been primarily a result of a notable area expansion; yields have remained around 1.45 MT/ha. Irrigated rice cultivation is concentrated in the state of Rio Grande do Sul; the yield has been about 3.8 MT/ha compared to 1.3 MT/ha obtained in the upper-land rice. The ideal would be to have irrigated and dry-land hectarage and yield equations. Unfortunately, this was not possible because of the unavailability of data. However, only about 10 percent of the area under rice cultivation is irrigated. Total rice production is dominated by dry-land production, so it was hoped that the equilibrium model would not be severely affected by the fact that only aggregate functions were estimated to forecast rice production.

At the aggregate level, soybean was considered the major crop competing with rice, and then the expected return of soybean per hectare was included as an explanatory variable. The results of the equations used to forecast rice production are as follows:

$$AR = \underset{}{4720390} + \underset{(.2169)}{.5042^{**}}\ LAR + \underset{(60.32)}{176.67^{**}}\ ERR - \underset{(134.97)}{86.61}\ ERSB + \underset{(36692.1)}{92228.5^{**}}\ TREND$$

$R^2 = .89$ D.W. = 2.06 h = -.53

$$YR = 2206.92 - \underset{(3.15)}{10.03^{***}}\ TREND$$

$R^2 = .36$ D.W. = 2.00

TPR = AR * YR

where:

AR = rice hectarage (hectares)

LAR = AR lagged one year

ERR = expected return of rice per hectare (Cr$1,000/ha)

ERSB = expected return of soybean per hectare (Cr$1,000/ha)

TREND = equals 61 for 1961 and increases by one each year

YR = yield for rice (kg/ha)

TPR = total rice production (MT)

The equation for rice hectarage provided a relatively good fit of the data. All signs were as expected, and all of the coefficients with the exception of the one for ERSB had relatively high t-ratios. The h-statistic showed a low value, leading to the conclusion that there was no serial correlation.

In the yield equation, a negative sign for trend may appear unacceptable, but in this case it can be explained. Rice production has been diverted from the more fertile soils of the southern states to the Cerrado region. It is usually used as the first crop in the opening of new areas where the less-fertile soils and unstable climatic conditions have been negatively influencing the yields. This is compensated for, in part, by the expressive increase in irrigated rice yields over the time period, although the irrigated area under cultivation has remained almost constant. On the aggregate level, these two opposite effects result in a nearly insignificant decrease in rice yield.

Soybeans.--Soybean production increased sharply in the 1960s and 1970s. Both area and yield contributed to this phenomenon. The planted area increased fivefold from 1971 to 1980. In the same period, the average yield rose 43 percent, from 1.2 MT/ha to 1.7 MT/ha, allowing total production to increase more than sevenfold. Brazil produced 2.1 million metric tons of soybeans in 1971 and 15.2 million metric tons in 1980. There was, therefore, unforeseen growth in the production, use, and export of soybeans, soymeal, and soyoil in the last decade.

Several factors contributed to this dramatic growth in soybean production (Williams, 1977). Initially in the South, more precisely in Rio Grande do Sul, the relatively high support price for wheat and subsidies for purchasing machinery and fertilizer increased the wheat hectarage and consequently that of soybeans because of the practice of double-cropping wheat and soybeans in the state. Besides, the same machinery could be used for both wheat and soybeans, and there was no necessity to use fertilizer in the case of soybeans, which depend only on the carryover effects of the fertilizer used in the wheat crop. By the end of the 1960s, soybean cultivation spread throughout several other states and continued to expand during the 1970s as a single crop. The factors responsible for this rapid growth were the infrastructure provided by the government, relatively favorable prices, and availability of credit. Also, soybeans are relatively cheap to cultivate because they are nitrogen-fixing legumes; this is very important because Brazil produces only a small fraction of its nitrogen fertilizer.

At the same time soybean production increased in Brazil, the country also experienced a very rapid growth in the production of broilers. Because soybean meal is the major protein meal used in compound feeds in the broiler industry, this was another factor that contributed to the expansion of soybean production.

Brazil is now the second largest producer and crusher of soybeans in the world. It shares with the United States the leading position in terms of exports of soymeal and soyoil.

The potential exists for further expansion of soybean production. This has become more evident because of the positive results achieved by the National Center for Soybean Research in terms of developing varieties that are better adapted for the low latitudes farther north. The West-Central region, where the soil is less fertile, recently has shown a tendency to expand soybean production. Although these soils require heavy initial amounts of fertilizers, the yields have been above the country's average. This fact, together with the relatively low cost of land, has helped offset at least part of the increased cost due to the heavier application of fertilizer and to transportation because the West-Central states are farther from export ports and crushing facilities.

The expansion of area devoted to soybean production has come about not only through the opening of new land, but also at the expense of other crops and pasture. For this aggregate model, wheat and pasture were considered the major competitors for area. It is common to see studies in which price of wheat is expected to be positively related to the supply of soybeans because of the possibility of double-cropping between soybeans and wheat. In this study, there were two main reasons to expect a negative sign. First, as pointed out above, double-cropping with wheat was more common when soybeans got their start in the South. Although no figures have been reported, it is known that the double-cropping system has declined relative to total production in Rio Grande do Sul. In the rest of the country, soybean is grown as a single crop. Second, agricultural researchers common believe that a significant negative interaction may exist between double-cropping and soybean yield. Because of weather conditions, frequent delays in wheat harvesting and consequently in soybean planting can reduce soybean yield up to 25 percent (Thompson, 1979).

The price of beef was chosen as a proxy for the return of the product of pastureland. In Brazil, practically all cattle are grass

fed, and an increase in the price of beef would lead farmers to increase the number of animals and consequently the area devoted to pasture (Williams, 1977). For this reason, the price paid to farmers for beef cattle was expected to be negatively related to soybean hectarage. The estimated equations are presented below (standard errors in parentheses).

$$\begin{aligned} ASB = {} & -205625 + \underset{(.0380)}{.9689^{***}}\ LASB + \underset{(81.431)}{409.059^{***}}\ ERSB \\ & - \underset{(107.220)}{363.596^{***}}\ ERW - \underset{(19.703)}{25.414}\ LPB + \underset{(21458.9)}{10394.8}\ TREND \end{aligned}$$

$$R^2 = .99 \qquad D.W. = 1.80$$

$$\begin{aligned} ASB = {} & 41962.2 + \underset{(.0121)}{.9997^{***}}\ LASB + \underset{(44.890)}{427.635^{***}}\ ERSB \\ & - \underset{(65.284)}{276.294^{***}}\ ERW - \underset{(11.891)}{29.167^{**}}\ LPB + \underset{(117978)}{550451^{***}}\ D_{72} \end{aligned}$$

$$R^2 = .99 \qquad D.W. = 1.67 \qquad h = .74$$

$$YSB = -1125.33 + \underset{(7.5200)}{34.1579^{***}}\ TREND$$

$$R^2 = .53 \qquad D.W. = 1.32$$

$$TPSB = ASB * YSB$$

where:

ASB = soybean hectarage (hectares)

LASB = ASB lagged one year

ERSB = expected return of soybeans per hectare (Cr$1,000/ha)

ERW = expected return of wheat per hectare (Cr$1,000/ha)

LPB = price paid to farmers for beef cattle lagged one year (Cr$/MT)

TREND = equals 61 for 1961 and increases by one each year

D_{72} = dummy variable equals 1 for 1972, otherwise zero

YSB = yield for soybeans (kg/ha)

TPSB = total soybean production (MT)

In the initial estimation, all the variables had the expected signs, and the coefficient of determination was very high (.99). The LPB variable had a coefficient greater than the standard errors, and the coefficient of the TREND variable was not significantly different from zero. All other variables had relatively high t-ratios. As in the case of corn, the TREND and LASB variables were highly correlated (.94). For this reason and because of the low t-ratio, TREND was deleted. There was controversial information about the observed data for 1972. The data used in the analysis were based on the USDA revised calculations. However, the new-soybean-area information was about 30 percent higher than the older data, and for this reason a dummy variable for that year was added to the final equation. The resulting equation showed the same goodness of fit and had increased t-ratios. The low value for the h-statistics indicated the absence of serial correlation.

Supplies of soymeal and soyoil.--The supplies of soymeal and soyoil are directly related to the domestic crush of soybeans. The rates of extraction varied during the study period because of the adoption of modern technologies. Then the observed yields were used. In recent years, however, yields became stabilized at about .776 for meal and .185 for oil. This means that for every metric ton of soybeans crushed, 776 kilos of meal and 185 kilos of oil are produced. The remainder is moisture loss. The supplies of soymeal and soyoil are then expressed as:

TPSM = YSM * DSB

TPSO = YSO * DSB

where:

TPSM = total production of soymeal (MT)

TPSO = total production of soyoil (MT)

YSM = extraction rate for soymeal (percent)

YSO = extraction rate for soyoil (percent)

DSB = domestic crush demand for soybeans (MT)

Wheat.--Brazil imports about two-thirds of its total wheat consumption. A long-term objective of the government has been self-sufficiency in wheat production. To help achieve this goal, the government tried to stimulate production through making credit available at substantially negative real rates of interest for acquisition of machinery and other inputs such as fertilizer and seeds, and by announcing price supports before planting time, always above world-market levels. The real differences between domestic and international prices, because of persistent overvaluation of the exchange rate, are really smaller than they might appear.

The Marketing Department for National Wheat (CITRIN) is the sole buyer for domestic wheat and the sole importer. CITRIN buys the entire crop at the established support price and sells the imported and domestic wheat to the mills at a uniform price that is higher than

the import price but lower than the support price. This is done in such a way that revenues and costs are equalized, eliminating the necessity of direct government resources to cover possible differences.

Wheat production increased during the 1970s, reaching a peak in 1976 (3.2 million metric tons). The wheat yield has been very low, averaging only .85 MT/ha in the last decade. The excellent prices for soybeans have contributed to the expansion of wheat production. It seems that soybean production is now leading wheat production rather than the contrary, as occurred in the 1960s (Williams, 1977).

Soybeans are considered a complementary crop to wheat because of the double-dropping system. The expected return of soybeans per hectare is expected to have a positive sign. The production of wheat is concentrated in the South, and most of the area traditionally devoted to its cultivation can be used on a double-cropping basis with soybeans because of climatic conditions.

Wheat is planted in May or June, cultivated during the Brazilian winter, and harvest begins in September. Soybean is planted from October to December, grown during the Brazilian summer, and the harvest begins in March. The expected return of wheat per hectare is expressed as the product of wheat support price (the only price) and the expected yield. The results of the estimated equations are presented below.

$$AW = -6389230 + \underset{(.2070)}{.5006^{**}}\ LAW + \underset{(231.501)}{228.075}\ ERW$$

$$+ \underset{(143.659)}{152.427}\ ERSB + \underset{(40214.5)}{86329.5^{**}}\ TREND$$

$R^2 = .91$ D.W. = 2.32 h = -1.91

$$AW = -6110110 + \underset{(.1655)}{.5795^{***}}\ LAW + \underset{(175.192)}{220.225}\ ERW$$

$$+ \underset{(114.982)}{136.256}\ ERSB + \underset{(34059.4)}{81527.5^{**}}\ TREND$$

$$R^2 = .96 \qquad D.W. = 2.07 \qquad \rho = \underset{(.21)}{-.40^{*}}$$

$$YW = 299.471 + \underset{(3.76)}{7.46^{**}}\ TREND$$

$$R^2 = .49 \qquad D.W. = 2.66$$

$$TPW = AW * YW$$

where:

AW = wheat hectarage (hectares)

LAW = AW lagged one year

ERW = expected return of wheat per hectare defined as wheat support price * expected yield (Cr$1,000/ha)

ERSB = expected return of soybeans per hectare (Cr$1,000/ha)

TREND = equals 61 for 1961 and increases by one per year

YW = yield for wheat (kg/ha)

TPW = total wheat production (MT)

As discussed before, the use of a lagged dependent variable as a regressor raises the possibility of serial correlation. The first equation presents an estimate for the h-statistic that is high enough to detect the presence of serial correlation. That equation was re-estimated using the Hildreth-Lu estimation procedure because it is the appropriate method for equations with lagged dependent variables (Maddala, 1977, p. 282). The new results appear in the following equation. The estimate of ρ was -.40 with a t-ratio of 1.9, indicating that the value of this parameter was significantly different from zero. According to the Rao and Griliches rule of thumb, there is an indication of some gain in efficiency by using estimation procedures that take serial correlation into account when the absolute value for the estimate of ρ is greater than .3 (Maddala, 1977, p. 283). This study assumed that the true residuals were first-order autoregressive. The R^2 increased from .91 to .96 in the second equation, and all of the estimated coefficients were more robust than in the first one.

Supply elasticities of cereal grains.--The results presented in Table 4.2 show the hectarage response elasticities derived directly from the estimated crop hectarage equations and evaluated at the average expected return and hectarage values. Not only changes in prices but also changes in yields were taken into consideration. These elasticity estimates must be interpreted with caution because the underlying *ceteris paribus* conditions usually do not hold for simultaneous systems of equations.

Although no direct comparisons among this and other studies can be made because of the approach adopted here, in which farmers were considered to respond to expected crop yield as well as to expected price, some confidence can be placed in these elasticity estimates because they were found to have about the same order of magnitude as those expected and empirically obtained in other studies

(Williams, 1977; Vilas, 1975; Thompson & Schuh, 1977), using the traditional approach.

Table 4.2.--Elasticities of hectarage response.[a]

Crop	Expected Return Per Hectare				
	Corn	Rice	Soybeans	Wheat	Beef Cattle[b]
Corn	.1247	-.0136	..	..	..
Rice	..	.2076	-.0683	..	..
Soybeans	..	..	.5267	-.2696	-.1428
Wheat	..	..	.2767	.3599	..

[a]The formula for the elasticity computed at the means is $\frac{\partial A}{\partial R} \cdot \frac{\bar{R}}{\bar{A}}$, where A represents area (hectarage) and R the relevant expected return per hectare as defined in the text.

[b]In the case of beef cattle, price received by farmers was used instead of return per hectare.

Soybean supply (hectarage) was found to be more responsive than the other crops. Although the direct elasticity of corn was rather inelastic, it still implied that price policy and research efforts could contribute to expanding its production.

In terms of cross-price elasticities, only the results in the soybean and wheat equations seemed to be relevant. The cross-price effects between soybeans and wheat had opposite directions, but both had a significant effect on the hectarage equations. A change in the price of beef cattle implied some effect on the soybean hectarage through the changes in the area devoted to grazing.

Meat Production

The livestock subsector was included in the model because of its interactions with the feed-grain market. Although beef cattle are almost exclusively grass fed, they were included in the model because the interrelationships between beef and other meats in the consumer-demand side influence the demand for corn and soymeal as feed input, and because of the competition for area between pasture (grazing) and crops, especially soybeans.

The economic model used to represent the structure of the meat sector was based on the assumptions that producers, as in the case of crops, try to maximize their profits when deciding the amount to be produced; that their product is considered to be homogeneous; and that individually they do not influence product or input prices--that is, perfect competition is assumed.

Beef production.--The cattle industry presents a particular characteristic when compared with other enterprises. Its product is, at the same time, both an investment and a consumption good. Ideally, one should have a set of equations including investment and slaughter functions for both males and females. However, this refinement was limited by the availability of data. In Brazil, the official data on the stock of cattle on farms are not considered to be reliable. Because of these data problems, a single equation was postulated to explain the production of beef in Brazil. For this purpose, annual data of cattle slaughtered under federal inspection were used.

As in the case of crops, it was assumed that, in the short run, a beef-cattle farmer was likely to remain in the same enterprise, adjusting the size of his herd in response to changes in economic conditions. In this way, beef production is determined by the previous year's output as well as price. Therefore, it was assumed that the beef-cattle farmer would move in the direction of the optimum by an amount proportional to the difference between the optimum and the present position.

The model should also specify a period long enough to account for the time that elapses between the moment a farmer decides to increase production and the moment the product is ready to go to the market. In the case of beef production in Brazil, this period was believed to be about four years.

According to Nerlove (1956), farmers react not only to the current price but also to the price they expect to receive in the future. He suggested that the expectation concerning future prices can be formulated based on past prices. Therefore, in the supply of beef there is a delayed adjustment to changes in price. Following Coirolo (1979), a polynomial-lag model was chosen to estimate the supply function. In this distributed-lag model, the parameters of the lagged variable are allowed first to increase and then to decrease and vice versa. These a priori restrictions on the parameters reduce the problem with degrees of freedom. Another advantage of this technique is that it deals indirectly with the problem of multicollinearity, which certainly would be present if the function were estimated as in an ordinary multiple-regression equation because the lagged variables would probably be highly correlated (Kmenta, 1971, p. 473).

Several lagged structures in terms of degree of polynomial, lag length, and constrained or unconstrained lag parameters were attempted. The best equation was achieved with a second-degree polynomial approximation of the farmer's beef price lagged for five years, with the last lagged parameter constrained to be zero. One additional variable should be the price of feed (pasture), but this was not possible because of the difficulty of constructing such a variable representing the opportunity cost of land for pasture. The results for the estimated equation are given in Table 4.3.

Table 4.3.--Parameter estimates for constrained second-degree polynomial lag model. Dependent variable: TPB.

Independent Variable	Estimated Coefficient	Standard Error	t-Ratio
Constant	21207.2	138934	.15
TPB (t-1)	.7660***	.0721	10.63
PB (t)	-17.04***	4.82	-3.53
PB (t-1)	2.61	2.89	.90
PB (t-2)	14.14***	3.01	4.70
PB (t-3)	17.55***	3.08	5.69
PB (t-4)	12.83***	2.15	5.96
R^2	.95		
N	20		
D.W.	1.52		
h	1.13		

where:

TPB = total production of beef (MT e.c.w.)
PB = price of beef cattle received by farmers (Cr$/MT e.c.w.)
t = current year
e.c.w. = equivalent carcass weight

In evaluating the results of this equation, it should be noted that the statistical significance of the individual coefficients was relatively good. The R^2 was quite high for this equation, and all of the coefficients had the expected signs. The value of h led to the rejection of the hypothesis that there was serial correlation in the equation. Based on these results, it can be concluded that the value of the total slaughtered beef at any given time depends on a weighted sum of the present and past values of the independent variables.

The effect of beef prices on the total slaughtered animals is negative in the short run. Given an increase in price, the beef-cattle producer expecting the price to increase more will withhold animals from slaughter in order to increase future production. In the long run, the opposite is expected; that is, the effect of a change in price is positive--as the stock of animals increases, the number of animals ready to be slaughtered becomes higher than previous levels.

The elasticities presented in Table 4.4 illustrate these results. The short-run price elasticity of slaughter was -.15, and the long-run elasticity was .23. Three to four years would be necessary to reach again the level of slaughter supply occurring at the moment of the price increase.

To gain some confidence, it is interesting to compare the single and cumulative elasticities of slaughter derived in this study with those obtained in other studies. (See Table 4.5.) Although none of these studies used exactly the same approach or considered the same period, the values of the elasticities were of the same order of magnitude.

Table 4.4.--Simple and cumulative price elasticities of beef slaughter.

Time Period	Simple Price Elasticity	Cumulative Price Elasticity
t	-.15	-.15
t-1	.02	-.13
t-2	.12	-.01
t-3	.14	.13
t-4	.10	.23

Table 4.5.--Comparison of cumulative elasticities of beef supply in three studies.

Time Period	Brazil (Total)[a]	Brazil (Male)[b]	Uruguay (Total)[c]
t	-.15	-.11	-.26
t-1	-.13	-.04	-.30
t-2	-.01	.04	-.19
t-3	.13	.11	.00
t-4	.23	.17	.19

[a]Present study, period: 1961-1980.

[b]Lattimore (1974), period: 1941-1971.

[c]Coirolo (1979), period: 1956-1975.

Hog production.--Only recently has the swine industry started to expand, as a result of improved management techniques and the use of specialized breeds. The supply of hog meat can be derived in a manner similar to that used for the supply of beef. The assumption that at least part of the live animals may be kept on farms as inventory carryovers when

producers expect higher future prices can also be applied here. However, the length of time within the weight range at which the slaughtered hogs are marketed is shorter than in the situation with cattle (Myers & Havlicek, 1975). In some cases it is possible to have two pig crops per year, and some pigs born in one year are not slaughtered until the next. Ideally, empirical analysis of the hog-meat supply should focus on a time period shorter than one year--a quarter or at least a semester--to capture the changes that might occur within a year. The use of annual observations in a more sophisticated approach could lead to erroneous conclusions. However, economic data for hogs in Brazil for the study period were available only on a yearly basis, and, as in the case of cattle, the only data considered reliable were the observations of hogs slaughtered under federal inspection.

Because of these data problems, it was decided to specify the hog-meat supply as a simple function in which the total meat supplied was a function of the hog price received by farmers lagged one year and the price of the principal input, corn in this case, also lagged one year. A negative sign for the price of hogs was obtained in several specifications where the hog price appeared as an independent explanatory variable, and because no apparent reason was found for that, it was decided to work with a ratio of the two prices instead of two independent variables. A great number of animals were eliminated, mainly during the 1971-75 period, because of the problem with the African Swine Fever. In the absence of data reporting the number

of animals discharged, a dummy variable was added to the explanatory variables. The results are presented below.

$$TPH = 15437.1 + \underset{(.0927)}{.9416^{***}} LTP + \underset{(3421.24)}{5164.83} LPH/CORN$$

$$- \underset{(16394.0)}{83244.8^{***}} D_{7175}$$

$R^2 = .87$ N = 20 D.W. = 2.09 h = -.24

where:

TPH = total production of hog meat (MT e.c.w.)

LTPH = TPH lagged one year

LPH/CORN = ratio between the hog price received by farmers (Cr$/MT e.c.w.) and the price of corn (Cr$/MT), lagged one year

D_{7175} = dummy variable equals 1 for years 197-75, otherwise zero

The R^2 seemed reasonable for this kind of specification. All of the coefficients had the correct sign and were greater than the respective standard error. The variable that expressed the ratio between the prices of hogs and corn was the least robust, with a t-ratio of 1.5. The coefficient of the dummy variable that was used in an attempt to take care of the discharge of animals because of the African Swine Fever appeared to indicate that the supply of hog meat in the period 1971-75 was significantly less than in the other years. The h-statistic was small enough to reject the null hypothesis concerning the existence of serial correlation.

Although the "price" elasticity of hog slaughter (.0849) was rather inelastic, it should be remembered that it reflected the change

in supply of hog meat to changes in variables with effects operating in opposite directions.

Poultry production.--The rapid expansion of the poultry-meat industry in Brazil occurred in the last decade and resulted mainly from the use of modern, intensive systems of production based on new imported technologies. In 1961, Brazil produced 7,700 metric tons (MT) of poultry meat. The 1980 production was about 864,000 MT. This should be viewed as an unusual circumstance and not as indicative of a new trend. Another factor that contributed to the rapid transformation of the poultry sector was the expansion of the mixed-feed industry. Corn and soymeal are used extensively in the production of feed rations. Improvement in the quality of these rations has helped the new poultry breeds to convert feed more efficiently. In the case of broilers, for example, conversion is about 2.5:1 (Nogueira & Criscuolo, 1979). This indicates the high-technology level of the Brazilian poultry industry.

This rapid expansion of the poultry sector allowed the country to begin exporting poultry meat in 1975 (3,500 MT). Including the Middle East among the importing countries, in addition to the factors described above, made it possible for Brazil to export about 169,000 MT of poultry meat in 1980 and approximately 275,000 MT in 1981.

It is difficult to model a sector with such rapid technological change. Also, the same data problems as those described in the section on hog production existed here.

In addition to the difficulties described above, real prices for meat declined more throughout the study period than did the cost of feed, mainly soymeal--the principal component of the rations used in the poultry industry. Regressions based on these variables always resulted in wrong signs, notably negative coefficients for the real prices of chicken received by the farmers. Several attempts were made to obtain theoretically reasonable estimates but did not improve the results. Examples of alternative forms are nominal rather than real prices and supply and demand based on two-stage least-squares estimation.

The choice of the final model used here was based on the study by Peterson (1981). According to concepts drawn from the theory of the firm, this writer concluded it was reasonable to assume that relatively new sectors, like the poultry industry in Brazil, are still moving toward equilibrium. Over the historical period, this sector has had declining profits, but the writer believes it is still positive. Only in the long run would equilibrium be reached, with economic profits for all industries equalized at zero.

It was hypothesized that the poultry sector will continue to increase as long as profits are greater than those of the hog industry, which is considered the alternative investment possibility because of the vertical integration of those sectors with the feed industry.

Ideally, one should construct return measures based on the gross margin for poultry relative to the gross margin for pork. Because of data unavailability, a ratio between the prices received for chickens and hogs was used as a proxy for the relative return measure. Therefore, the total-meat-production (MT of slaughtered

animals) equation has as arguments the chicken-hog price ratio; the price of soymeal, considered the main element in the compounded feed ration; and a trend to represent the technological change of the sector. Only observations beginning in 1970 were used in the estimation of this equation because of the dramatic change Brazil experienced in this sector during the last decade. The results are presented below.

$$TPCH = -5033320 + \underset{(162214)}{193417}\ PCH/HOG - \underset{(44.793)}{111.236^{**}}\ WPSM + \underset{(6928.5)}{73813.1^{***}}\ TREND$$

$$R^2 = .97 \qquad D.W. = 1.33$$

where:

TPCH = total production of poultry meat (MT e.c.w.)

PCH/HOG = ratio between the price of chicken received by farmers (Cr$/MT e.c.w.) and the price of hogs received by farmers (Cr$/MT e.c.w.)

WPSM = wholesale price of soymeal (Cr$/MT)

TREND = equals 70 for 1970 and increases by one each year

The explanatory variables seemed to explain relatively well the variation in total meat production. All of the coefficients were greater than the respective standard errors and had the correct signs. The Durbin-Watson test was inconclusive regarding the existence of serial correlation. The estimation of the same equation using the Cochrane-Orcutt procedure did not improve the results. In fact, the residuals did not show evidence of serial correlation.

Although the equation used in this model seemed to account very well for the rapid growth of the broiler industry, a more realistic formulation is needed to take care of the long-run equilibrium.

Validation

To validate the model, the period 1971-80 was simulated, based on the estimated equations, and compared with the actual values of the variables. To make the model self-corrective at each iteration, actual lagged values were used rather than those estimated by the equations. The results related to the area and total-production equations are presented in Figures 4.3 to 4.6. The accuracies of forecasts are given by Theil's U-statistics presented in Tables 4.6 and 4.7, which include the correlation coefficients for actual levels (R_1). This measure is based on the regression of actual and predicted values ($Y_t^a = \alpha + \beta Y_t^s$) presented in Chapter III. As discussed before, UM, UR, and UD should add up to one, since they are error proportions of the mean square error, but they may not do so because of rounding.

Actual yields and predicted acreages were used to forecast total production. The percentage errors between the actual and simulated values of area and total production were generally small. As can be seen in the figures, most of the turning points were caught. Following the criteria that UM and UR have to be close to zero and UD close to one for a perfect forecast, it can be said that the equations' performance was satisfactory. The U-statistics suggest that the rice equations were somewhat weaker than the others as

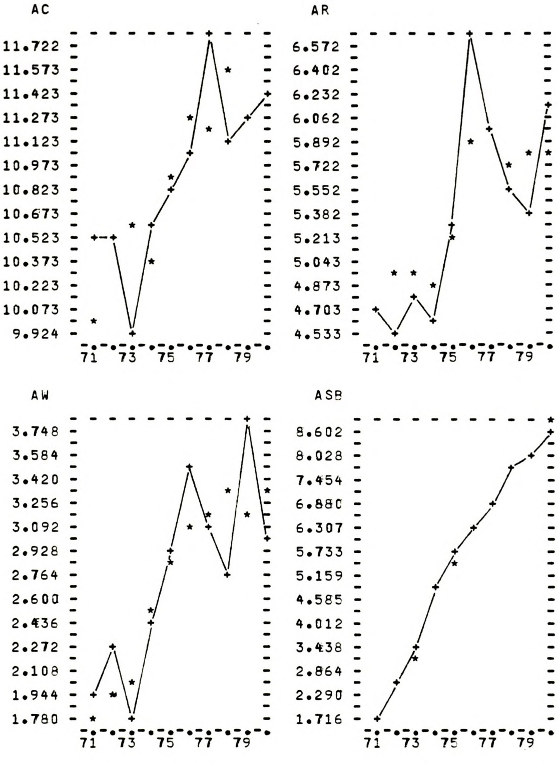

Figure 4.3.--Actual (+) and simulated (*) values for area: corn (AC), rice (AR), wheat (AW), and soybeans (ASB), in million ha, 1971-80.

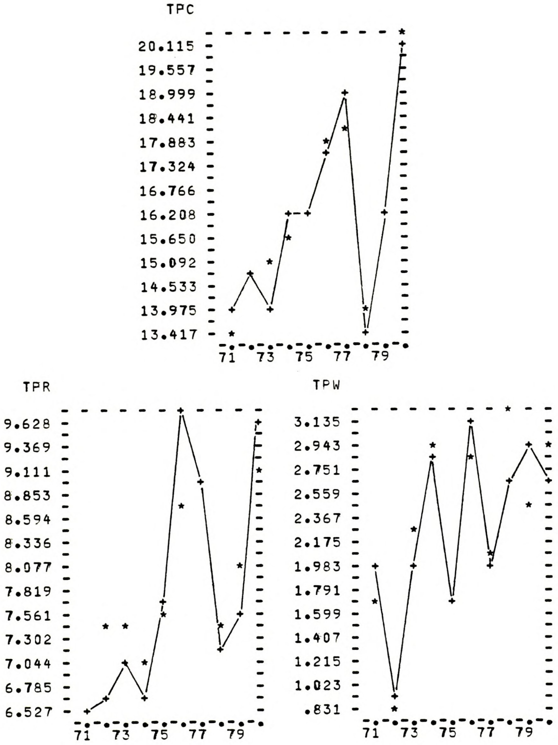

Figure 4.4.--Actual (+) and simulated (*) values for production: corn (TPC), rice (TPR), and wheat (TPW), in million MT, 1971-80.

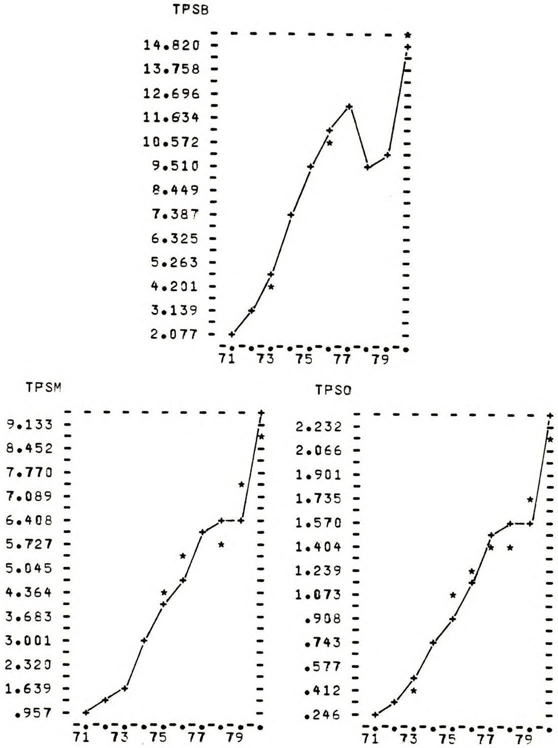

Figure 4.5.--Actual (+) and simulated (*) values for production: soybeans (TPSB), soymeal (TPSM), and soyoil (TPSO), in million MT, 1971-80.

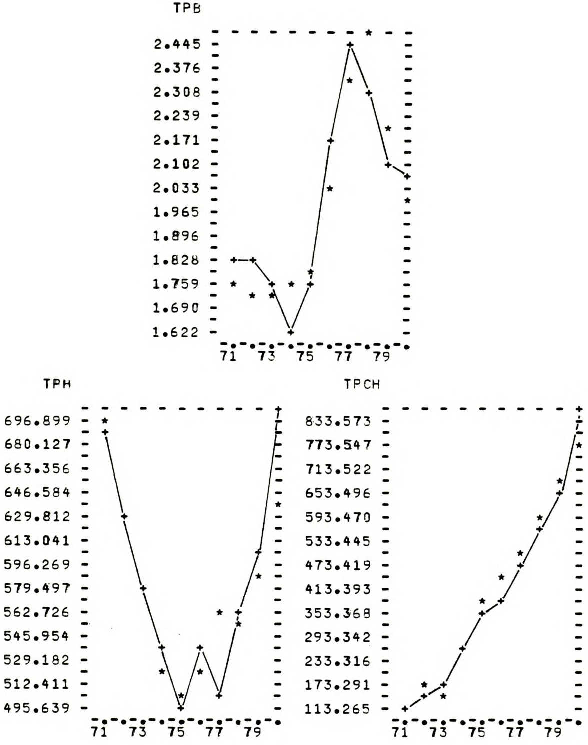

Figure 4.6.--Actual (+) and simulated (*) values for meat production: beef (TPS), in million MT, and hogs (TPS) and chickens (TPCH) in thousand MT, 1971-80.

forecasters. This is probably due to decreasing expected yields, which may have affected the decision to plant, represented by the expected revenue variable in the acreage equation. On the other hand, the wheat equations led to relatively large forecasting errors in certain years. One explanation for that could be the omission of a variable to represent credit in the acreage equation, since its availability is crucial to the planting decisions. The figures show that the soybean equations were the best forecasters.

Table 4.6.--U-statistics for area equations.

Equation	U_1	U_2	UM	UR	UD	R_1
Corn	.0171	.7864	.0002	.1185	.8813	.73
Rice	.0316	.5462	.0097	.1308	.8595	.88
Wheat	.0596	.5696	.0077	.0559	.9364	.84
Soybeans	.0080	.1164	.0239	.0877	.8884	.99

Table 4.7.--U-statistics for total-production equations.

Equation	U_1	U_2	UM	UR	UD	R_1
Corn	.0164	.1988	.0000	.0144	.9856	.97
Rice	.0319	.4126	.0069	.2110	.7820	.92
Wheat	.0600	.3101	.0002	.1564	.8434	.91
Soybeans	.0076	.0598	.0304	.0790	.8906	.99
Soymeal	.0422	.3694	.0008	.0048	.9945	.98
Soyoil	.0422	.3547	.0017	.0031	.9951	.98
Beef	.0247	.5133	.0028	.0795	.9177	.93
Hogs	.0245	.5286	.0280	.0154	.9566	.91
Chickens	.0352	.3573	.0043	.0998	.8958	.99

CHAPTER V

DEMAND

Introduction

Consumer-demand theory is, in fact, an allocation problem. The consumers are concerned with the amount of their incomes to be allocated to each particular good. Each time they make a decision, it must be based on the knowledge of the total amount of money available for spending and the prices of all goods. Therefore, consumer demand should not be analyzed on the basis of individual commodities, but as part of a complete system of demand equations. Recently, an increasing number of researchers have dealt with problems of specifying and estimating such systems (see Barten, 1968, 1977; Theil, 1975, 1976, 1978; Brown & Deaton, 1972). Working with systems of demand equations has the advantage of recognizing the interdependency of demand for the various goods while using the basic concepts of the utility function and budget constraint. The results are usually presented as a set of demand equations, which show demand as a function of income and price.

Without misplacing the importance of the relationship between the quantity demanded of all commodities within the budget, this study did not focus on a complete system of demand equations. One of the reasons for this decision was the unavailability of data for all commodities needed for this particular procedure.

Another was the fact that even if one has the proper data, it is almost always necessary to group the commodities to cope with the problem of degrees of freedom, and this researcher was interested in having coefficients for specific commodities and not for a group of them.

Individual demand equations were estimated for several commodities, based on the consumer-demand theory. This theory explains demand in terms of the maximization of consumer utility subject to an appropriate budgetary constraint. As Labys (1973, p. 9) pointed out, several important considerations surround demand equations. Among them are a set of assumptions and conditions under which the behavioral relationship between quantity demanded and prices must hold. These points have been fully explored in many studies (Theil, 1978; Barten, 1977; Labys, 1973) and are not repeated here.

Fulfillment of these conditions and assumptions was assumed in this study. For example, it was assumed that all consumers face an equivalent price, that individual responses to income changes can be approximated by the average quantity response to income changes among consumers, and that utility maximization is adopted by the consumers subject to their income or budgetary constraints.

To simplify the presentation and discussion of the several equations, they were categorized in three different groups: one for consumer demand (soyoil, meats, rice, and wheat), one for crush demand (soybeans), and another for feed use (soymeal and corn).

The consumer-demand theory suggests that the quantity demanded of a good depends on the price of the good, the prices of all other

related goods, and consumers' income. In the case of retail demands considered in this study, it was not feasible, according to the preceding discussion, to interact with all of the considered products in each equation. For the purpose of this study, only the most important food items were considered explicitly as connected products.

It was assumed that a doubling of price and income variables would have no apparent effect on consumption. Thus, postulating the absence of money illusion, prices and incomes were deflated by their respective price indexes.

The consumer-demand theory indicates a negative relationship between the quantity demanded of a particular food item and its price. The prices of the products considered as substitutes in consumption are directly related to the quantity demanded of the considered product. A similar direct relationship holds for income and population variables.

Initially, it was intended to use per-capita disposable income and population as distinct explanatory variables and to express the dependent variable as total (aggregate) consumption. Because of the high correlation between per-capita income and population, per-capita consumption was used as the dependent variable in all retail-demand equations, eliminating the population variable from the right-hand side among the independent variables.

A major problem in using this approach is that no data series exist for the volume of consumption for most of the agricultural products in Brazil. For this reason, series of apparent consumption had to be constructed for all the products studied. In general,

apparent consumption was calculated by subtracting from total production the uses as seed and industrial processing, net trade, and changes in stocks. Each case is considered in detail in a separate section of this chapter. Unfortunately, only data for stocks of soybeans and products were available. The calculated consumptions of the other items diverge from their true values to the degree that the assumption of no carryover stock is improper. This is crucial, mainly in the case of rice.

Another problem in using this approach is that exports, in general, are reported on a calendar-year basis for January through December, but most of the products are harvested by the end of the first quarter in the central and southern regions of Brazil. This means, in some cases, that exports realized at the beginning of the year are derived mainly from the previous year's production. These factors could prejudice the calculation of apparent consumption described above.

The results of the estimation of each demand equation are given in the following sections. Twenty observations covering the period 1961-80 were used in most of the cases, with the exception of broilers and pork, for which the 11 most recent observations were considered. The estimated standard error of each coefficient appears in parentheses beneath each of the coefficient values.

Consumer Demand

Soyoil

In the last two decades, as a result of rapid urbanization and increase in per-capita income, demand has shifted from lard to vegetable-origin oils, and per-capita consumption of edible oils has risen. At the same time that the production of soyoil increased dramatically, the production of both peanut and cotton oil declined in Brazil. As a result, soyoil now accounts for about 90 percent of the total domestic consumption of edible oils. In 1980, domestic demand for soyoil was about 1.5 million metric tons.

The demand for soybean oil was initially postulated to be a function of its own price, the price of a close substitute (lard), and real income. No satisfactory results were obtained with this formulation, mainly indicating an erroneous sign for the price of soyoil.

To help explain the rapid expansion of consumption of soy-oil in Brazil in recent years, variables such as lagged consumption and trend were tried, but because both were highly correlated with income, these formulations could not be carried on. The results of a final version of the equation are reported below, where availability of soyoil, which includes total production plus stocks at the beginning of the year, was included as one of the explanatory variables. It is believed that in the case of soyoil in Brazil, the dramatic increase in per-capita consumption was not only a result of urbanization and growth in per-capita income, but was mainly due to

availability as a consequence of the rapid growth of the soybean sector.

$$DSO = -1.415 - \underset{(.0657)}{.0614}\ PSO + \underset{(.0523)}{.0524}\ PLARD + \underset{(.0006)}{.0032^{***}}\ AVSO + \underset{(.1147)}{.2558^{**}}\ INCOME$$

$$R^2 = .99 \qquad D.W. = 1.92$$

where:

DSO = per-capita domestic demand for soyoil (kg)

PSO = retail price of soyoil (Cr$/kg)

PLARD = retail price of pork lard (Cr$/kg)

AVSO = availability of soyoil (MT)

INCOME = disposable income per capita (Cr$/inhabitant)

The explanatory variables had the expected signs. The less-significant coefficient was the price of soyoil. Its estimate had about the same size of standard error as reported below each of the coefficient values. The goodness of fit in the preceding equation can be attributed mostly to the income and availability variables. As expected, changes in per-capita consumption in the period considered can be attributed to changes in these two variables.

The own-price elasticity was -.26 at the observation means. The estimated cross-price elasticity of soyoil with respect to a change in the price of lard was .27 in this study. A previous study by Williams (1977) reported an own-price elasticity of -.15. However, no strict comparison could be made between these two results because they were based on different equation formulations and because the

latter was based on an even less significant coefficient. The income elasticity of soyoil was .8352.

Rice

In Brazil, rice is a staple food that usually provides about 25 percent of the caloric and 15 percent of the protein intake of the population. Because no data exist for the volume of rice consumed in the country, the apparent consumption was calculated based on an average milling rate of 68 percent. The following formula was used: Disappearance = .68 (total production - seed [76 kg/ha] - waste [10 percent of total production]) - exports + imports. The absence of data related to the stocks of rice affects greatly the apparent-consumption measure. It is believed that significant amounts of rice have been held by processors, producers, and wholesalers in addition to the government in most recent years, but accounting systems seldom report inventory data.

Per-capita consumption is more or less constant in most regions of Brazil, with the exception of the Northeast, where per-capita consumption is about half of the average for the rest of the country. The major reason for this is the fact that the northeastern region does not produce rice, and transportation costs to ship the product from the southern and central regions are very high, considerably increasing the price to the consumers. In this region, manioc flour is the main substitute for rice, whereas wheat flour is the natural substitute for the rest of the country.

Bearing in mind the data limitations, the demand for rice was postulated to be a function of its own price, per-capita income, and

the price of two possible substitutes--wheat flour and manioc flour. The statistical results of the estimated equation were as follows:

$$DR = 36.1603 - \underset{(1.1977)}{1.9966}\ RPR + \underset{(2.0071)}{.8866}\ RPWFL + \underset{(1.4220)}{3.6019^{**}}\ RPMFL$$

$$- \underset{(.7476)}{.0435}\ INCOME$$

$$R^2 = .43 \qquad D.W. = 2.15$$

where:

DR = per capita apparent consumption of rice (kg)

RPR = retail price of rice (Cr$/kg)

RPWFL = retail price of wheat flour (Cr$/kg)

RPMFL = retail price of manioc flour (Cr$/kg)

INCOME = disposable income (Cr$/inhabitant)

The multiple-correlation level was considered very low, but this equation was kept because it was the best that could be obtained with the information available. The price variables presented the expected signs, and the results showed that manioc flour can be considered a relevant rice substitute. The coefficient for the wheat-flour price had a low t-ratio; this meant that the coefficient was not statistically different from zero. A possible explanation for this unacceptable result could be related either to the data problem discussed before or to the fact that wheat consumption during the sample period was heavily subsidized, disguising the true effect of wheat-flour price on the consumption of rice. The negative sign accompanying the income variable was not expected, but its parameter was not statistically different from zero.

The own-price elasticity was -.325 at the observation means, and the cross-price elasticities were .112 for wheat flour and .374 for manioc flour. According to these results, it appears that changes in price of wheat flour did not affect the consumption of rice, whereas the opposite was more likely in the case of manioc flour, in which the estimated elasticity was greater in absolute value than the rice-price elasticity. The insignificant and negative income elasticity (-.014) was less worrisome because consumption of rice remained practically constant over the sample period.

Several attempts were made to improve the results of the rice-demand equation, but no success was obtained. According to Labys (1973), the commodity-demand behavior in several situations is more appropriately described dynamically. Consumers spread their response over some period of time when income or prices change. The introduction of consumption in the previous period as an additional explanatory variable altered significantly the results of the equation, increasing not only the goodness-of-fit measure but also the significance of all independent variables. However, the sign for the coefficient of the lagged endogenous variable (consumption) turned out negative, implying a coefficient of adjustment greater than one, which was not easy to interpret and suggested overaction by market participants. As a result, this modified equation was not considered in the final version of the model.

Wheat

Wheat is an important element in Brazilian nourishment. Because of the rapid growth in subsidized domestic consumption, imports have been increasing, despite a doubling in wheat production during the past decade from about one million to more than two million tons. In 1980, Brazil imported about two-thirds of the wheat consumed during that year. Lack of reliable data prevented the final demand for wheat from being expressed as final demands, such as for bread, paste, etc. A series of apparent consumption was estimated as follows: domestic consumption = .75 (total production - seed [100 kg/ha] - exports + imports - waste [3 percent of total wheat]), where .75 indicated the conversion rate from wheat to wheat flour. The absence of data related to carryover stocks of wheat apparently did not affect the apparent consumption measure as seriously as in the case of rice because there have been some indications in recent years that only a small percentage of the total wheat has been held.

The aggregate domestic demand for wheat flour was postulated to be a function of its own price, the price of potential substitutes (rice and corn), and disposable income. The price of rice did not show satisfactory results in any of several models attempted to estimate the demand for wheat; therefore, it was dropped from the final version of the equation shown below.

$$DWFL = 37.1263 - \underset{(.7263)}{2.3850^{***}}\ RPWFL + \underset{(2.1522)}{1.7295}\ PC + \underset{(.2643)}{.2384}\ INCOME$$

$$R^2 = .91 \qquad D.W. = 2.17$$

where:

DWFL = per-capita apparent consumption of wheat flour (kg)

RPWFL = retail price of wheat flour (Cr$/kg)

PC = producer price of corn (Cr$/kg)

INCOME = disposable income (Cr$/inhabitant)

The equation had a reasonable R^2, and all of the parameters had the correct expected signs. The results indicated that the coefficient for the retail price of wheat flour was the most important and the only statistically significant parameter affecting the domestic consumption of wheat flour. The failure to represent all the forms of government intervention taken to protect the urban consumer and the use of aggregate demand to represent the wheat demand probably affected the true response estimates of the explanatory variables. The estimated elasticity of wheat-flour demand with respect to a change in its own price was -.46. This was very close to the estimated price elasticity (-.50) obtained in a recent study conducted by the Commission of Production Financing (CFP, 1981). The low cross-price elasticity (.09) indicated that changes in the price of corn did not affect significantly the quantity of wheat flour consumed. The income elasticity was also small and positive (.10), which was reasonable because the main final product of wheat flour is bread and it can be considered a necessity.

Meat

In this study, three basic meats--beef, pork, and broilers--were considered. It was intended to explore the interrelated nature of these three important products for Brazilian consumers. These results are essential for the final phase of this study, in which the model developed in this study represents an attempt to illustrate the interrelationship between the feed-grain and the livestock-meat sectors. The model allows for the simultaneous interaction between the consumer and farm levels of the market system for several important commodities.

As in the case of supply, one ideally should have monthly or at least quarterly data to analyze the allocation of available supplies of meat. Lack of data, however, prohibited a more refined approach, so the analysis was carried out in terms of annual data. The theory of consumer demand, discussed at the beginning of this chapter, suggests that the quantity demanded of a particular good depends on the good's own price, the consumer income, and the prices of the most important substitutes. Beef, pork, and broilers constitute the three most important items in terms of meat consumption in Brazil; therefore, at the retail level, beef, pork, and broilers are considered substitutes for each other. The effects of storage changes were not considered because of unavailability of data. It was assumed that year-to-year differences in cold-storage holdings are relatively small and that yearly consumption of each of the three meats is close to domestic production minus net trade. This seems reasonable because most of the cold storage, mainly in the case of beef, occurs during the dry season (June through August). The statistical results for the respective retail-demand equations for beef, pork, and chicken are as follows:

$$DB = 19.2472 - \underset{(.0813)}{.4325^{***}}\ RPB + \underset{(.0475)}{.0119}\ RPP + \underset{(.1148)}{.1718}\ RPCH + \underset{(.1066)}{.3355^{***}}\ INCOME$$

$$R^2 = .67 \qquad D.W. = 1.58$$

$$DH = 5.2995 - \underset{(.0834)}{.2925^{***}}\ RPP + \underset{(.0699)}{.0763}\ RPB + \underset{(.1992)}{.2995}\ RPCH + \underset{(.1551)}{.0715}\ INCOME$$

$$R^2 = .88 \qquad D.W. = 2.36$$

$$DCH = .2675 - \underset{(.0614)}{.1515^{**}}\ RPCH + \underset{(.0307)}{.0448}\ RPB + \underset{(.0454)}{.2891^{***}}\ INCOME$$

$$R^2 = .98 \qquad D.W. = 1.39$$

where:

DB = per-capita consumption of beef meat (kg/inhabitant)

DH = per-capita consumption of pork meat (kg/inhabitant)

DCH = per-capita consumption of broiler meat (kg/inhabitant)

RPB = retail price of beef meat (Cr$/kg)

RPH = retail price of pork meat (Cr$/kg)

RPCH = retail price of broiler meat (Cr$/kg)

INCOME = disposable income per capita (Cr$1,000/inhabitant)

In general, the estimated coefficients were consistent with a priori expectations. The coefficient for price of pork in the broiler-demand equation was expected to be positive. In the initial run this coefficient was negative, and because the ratio of the estimate to its standard error (t-ratio) was too low, suggesting that the price of pork did not significantly affect the quantity of broilers demanded, that variable was deleted from the equation. In the demand equation for beef, the price of pork again was not significantly different from zero, but it had the correct sign. The own-price and income variables seemed to explain a great deal of the variation in the three meat demands, with the exception of demand for pork, in which income had a relatively low t-ratio.

Estimates of elasticities and cross-elasticities for each product evaluated at the data means are presented in Table 5.1. Beef is usually considered to present a more price-elastic demand than pork. However, the results of this study indicated a more price-elastic demand for pork than for beef during the sample period. The price elasticity for beef (-.5811) was similar to that (-.555) found in a study by Lattimore (1974). This inelastic demand for beef with respect to its own price reflects the fact that beef consumption in Brazil is highly concentrated in the upper-income classes, and the variation in price does not greatly affect the quantity of beef consumed by these people. The small elasticities of substitution between beef and pork, and between beef and broilers, and the low income elasticity help support this point. Chicken is most responsive to changes in income and to changes in its own price. In general, the computed cross-elasticities of price indicated that beef, pork, and broilers are substitutes for each other.

Table 5.1.--Average elasticities and cross-elasticities of demand at the retail level for beef, pork, and broilers.

Variable	Elasticities or Cross-Elasticities With Respect to:			
	RPB	RPH	RPCH	INCOME
DB	-.5811	.0194	.2198	.2452
DH	.3354	-1.4842	1.0213	.2050
DCH	.3580	..	-.9596	1.4838

Crush Demand (Soybeans)

The total demand for soybeans in Brazil is derived from the export demand and the domestic crushing demand. The demand for soybeans as food or feed is negligible and, therefore, can be considered practically a crush demand. This crush demand is derived essentially from the demand for soyoil at the retail level and the demand for soymeal as an important component, because of its high protein content, in mixed feeds (Williams, 1977).

The domestic soybean crush was postulated to be determined by crush capacity, availability of soybeans, and the crushing margin or relative profitability of soybeans. The soybean-crushing demand was assumed to be a positive function of the capital invested in crushing facilities, represented by the crush capacity, and of the availability of beans, represented by the total production of soybeans.

The larger the availability and the capacity, the greater can be the volume of soybeans to be crushed.

Soybeans, when crushed, yield two joint products: soymeal and soyoil. The variable used to represent the crushing margin was calculated as the ratio between the price paid by the crusher to the farmer for a ton of soybeans and the value of the meal and oil in a ton of soybeans (Spriggs, 1981). Thus, this variable was expected to have a negative sign. The larger the expected value of soymeal and soyoil relative to the price of soybeans, the greater the volume that can be crushed. The results of the equation used to represent the crushing demand are presented on the following page:

$$DSB = 743111 - \underset{(1052470)}{1216310}\ CRUSHM + \underset{(37.435)}{288.410^{***}}\ CRUSHC + \underset{(.051133)}{.361463^{***}}\ TPSB$$

$$R^2 = .98 \qquad D.W. = 2.53$$

where:

DSB = domestic crush demand for soybeans (MT)

CRUSHC = soybean-crushing capacity (1000 MT)

TPSB = total production of soybeans (MT)

CRUSHM = crushing margin for soybeans (Cr$/MT), defined as:

$$CRUSHM = \frac{PSOYBEANS}{YSOYMEAL * PSOYMEAL + YSOYOIL * PSOYOIL}$$

where the letters P and Y at the beginning of the words mean, respectively, the price and the yield for the corresponding product.

The rates of extraction were not considered to be fixed during the study period because of the increasing level of technology

adopted by the soybean-processing firms. The prices of the two subproducts were considered to be expected prices; therefore, they were the observed prices for the preceding year.

All the coefficients were greater than their respective standard errors and had the expected signs. The estimated price elasticity (margin) at the observation means was -.24. Although inelastic, this result indicated that changes in the relative prices seemed to exert some influence on the volume to be crushed. No direct comparisons with other studies were possible because the only investigator known to have estimated a similar equation (Williams, 1977), in which the crushing margin was defined as the difference between the equivalent value of soymeal and soyoil and the price of soybeans, reported no results because this variable had a low t-ratio. In the present study it seemed that the variable used to represent the crushing margin was to a certain degree dominated by the other factors (relatively high t-ratios).

Feed Demand

Soymeal

Brazil has become a major force in the world soybean-products market. In recent years, Brazil and the United States have shared the position as the largest exporter of soymeal and soyoil in the world. In addition to this dramatic expansion in exports, the internal consumption of these soybean products has also increased markedly in the last decade. From 1971 through 1980, meal consumption increased tenfold.

Soymeal is the main component of livestock feed because of its high protein content (40-50 percent). In Brazil, soymeal is used primarily in the broiler industry, which consumes about 75 percent of the total. Swine and dairy cattle consume a small percentage of mixed feed, whereas beef cattle are mainly grass fed and fattened (Nogueira & Criscuolo, 1979).

In this study it was hypothesized that demand for soymeal in Brazil is a function of its own price, the price of corn, and broiler production. The price of chicken should have been used instead of production, but it was not possible to obtain any acceptable results with this variable. The reasons for that situation are not known, and the problem remains to be explained. A negative relationship was expected between feed demand and the price of soymeal, whereas a positive relationship was expected between feed demand and production of broilers. The production of broilers should capture the effects of income and population in the poultry-demand equation; therefore, the income and population variables are not repeated here. Whereas corn and soybeans are complementary in terms of nutritional aspects, they can also be considered economic substitutes (Williams, 1977). Their relative economic costs determine the final combination of these products in poultry feed rations; therefore, the sign for price of corn in the demand-for-soymeal equation depends on which of the two effects is dominant. The results of the demand-for-soymeal equation are reported below:

$$DSM = 401756 - \underset{(174.512)}{342.716^{*}}\ PSM + \underset{(245.100)}{273.493}\ PC + \underset{(.219)}{2.431^{***}}\ TPCH$$

$$R^2 = .91 \qquad D.W. = 1.59$$

where:

DSM = domestic feed demand for soymeal (MT)

PSM = wholesale price of soymeal (Cr$/MT)

PC = producer price of corn (Cr$/MT)

TPCH = total production of broilers (MT in e.c.w.)

The variables chosen as arguments seemed to explain relatively well the feed demand for soymeal in Brazil. All the coefficient estimates had the expected sign and values greater than their respective standard errors. The result for corn, although less robust, indicated that the substitution effect was dominant, whereas poultry production could be considered the main determinant of the demand for soymeal during the period under consideration. The estimated elasticity in relation to price of soymeal was -1.54; the elasticity with respect to the price of corn was .78. These results seemed plausible, although Williams (1977) reported a higher own-price elasticity in absolute value (-3.74), which can be explained by his use of a different sample period and different explanatory variables.

Corn

Only about 10 percent of all the available corn in Brazil is used for human consumption, whether industrialized or "in natura." The remaining 90 percent is used primarily for animal consumption. In 1974, about 35 percent of the total domestic disappearance of corn

was used for the mixed-feed industry, and 53 percent was used on the farms for seed and animal feed. In 1981, those figures were 71 percent and 17 percent, respectively, while human consumption remained more or less constant (CFP, 1981).

Ideally, one should have several demand functions, one for each different use. Unfortunately, data for such an approach were not available. The only possibility was to have an aggregate function for domestic disappearance of corn, which was calculated as volume of corn produced - seed (20 kg/ha) - 5 percent for waste - net trade of corn. Another problem was that no reliable data existed for the carryover stocks of corn in Brazil for the study period. Therefore, the data used to represent domestic consumption of corn were a residual and as such were subject to random fluctuations.

The demand for corn was then hypothesized to be derived from the final demand for hog and poultry meats. In the following equation, corn demand is expressed as a function of its own price, the price of a close substitute (soymeal), the production of hogs, the production of poultry, and the price of wheat flour. As in the case of soymeal demand, income was not included among the explanatory variables; it was hypothesized that the income effect was captured in the demand equations for hog and poultry meats. The price of wheat flour was included in the corn-demand equation to represent the price of substitutes in human consumption (Thompson & Schuh, 1977). The statistical results for the equation used in the analysis were as follows:

$$DC = 430284 - \underset{(1157.86)}{2039.93^{*}}\ PC + \underset{(718.78)}{2086.54^{**}}\ PSM + \underset{(425.906)}{732.447^{*}}\ RPWFL$$

$$+ \underset{(3.273)}{3.650}\ TPH + \underset{(3.146)}{17.333^{***}}\ TPCH$$

$$R^2 = .94 \qquad D.W. = 1.81$$

where:

DC = domestic disappearance of corn (MT)

PC = producer price of corn (Cr$/MT)

PSM = wholesale price of soymeal (Cr$/MT)

RPWFL = retail price of wheat flour (Cr$/MT)

TPH = total production of hog meat (MT e.c.w.)

TPCH = total production of chicken meat (MT e.c.w.)

In general, the statistical results for this equation were satisfactory. The signs of the coefficients were all consistent with a priori expectations, based on the economic theory and on the background given above. All the variables had coefficients larger than their respective standard errors.

The estimated own-price elasticity at observation means was -.2458. This result was not far from the -.2010 figure obtained by Thompson and Schuh (1977) for the sample period 1947-70. The cross-price elasticities were .3979 for soymeal and .3303 for wheat flour. Both elasticities were greater in absolute value than the own-price elasticity, clearly indicating that soymeal is a strong substitute in animal consumption and that wheat flour is a strong substitute in human consumption.

Validation

As in the case of supply, the estimated equations were simulated over the 1971-80 period to validate the model. The results are presented in Figures 5.1 to 5.3, which include the actual values. Table 5.2 presents the values of Theil's U-statistics for all the products considered. The demand equations were estimated based on apparent-consumption data. This procedure leads to errors larger than usual, since they are calculated as residual. The unavailability of consumption data is aggravated by the fact that, even when available, data on carryover stocks are not reliable.

Table 5.2.--U-statistics for demand equations.

Equation	U_1	U_2	UM	UR	UD	R_1
Corn	.0454	.7047	.0042	.0693	.9265	.82
Rice	.0349	.4842	.1548	.0116	.8316	.83
Wheat flour	.0280	.5707	.0289	.4587	.5124	.97
Soybeans	.0423	.3656	.0013	.0048	.9939	.98
Soymeal	.1484	.6377	.0001	.0064	.9936	.88
Soyoil	.0455	.4731	.0362	.1684	.7954	.98
Beef	.0249	.5652	.1279	.3278	.5449	.94
Hogs	.0510	1.0554	.0213	.4195	.5592	.85
Chickens	.0254	.3421	.0025	.0297	.9677	.99

The U-statistics suggest that the demand equations for wheat flour, beef, hogs, and soyoil are not as good forecasters as the others. The least reliable, though, was the wheat-flour demand equation. The failure to include variables explaining government intervention in the domestic market mainly in the cases of soyoil and wheat flour may

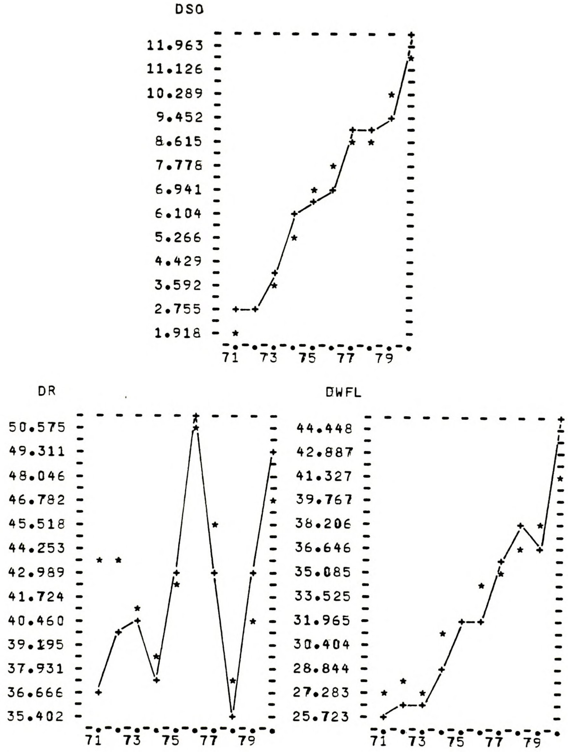

Figure 5.1.--Actual (+) and simulated (*) values for demand: soyoil (DSO), rice (DR), and wheat flour (DWFL) in kg/capita, 1971-80.

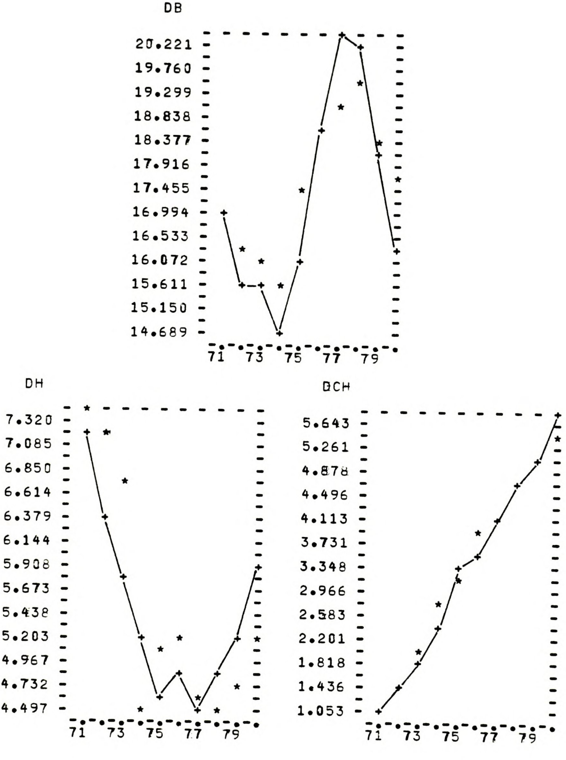

Figure 5.2.--Actual (+) and simulated (*) values for meat demand: beef (DB), hogs (DH), and chickens (DCH) in kg/capita, 1971-80.

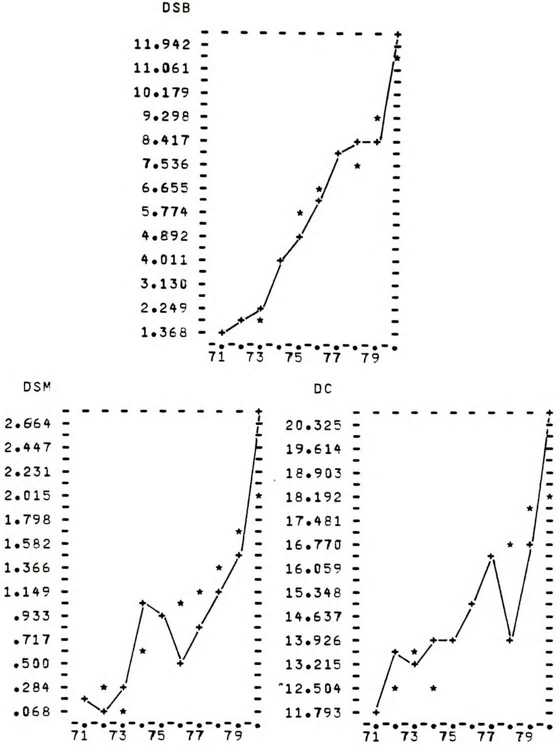

Figure 5.3.--Actual (+) and simulated (*) values: soybean crushing demand (DSB), and feed demand for soymeal (DSM) and corn (DC) in million MT, 1971-80.

be in part responsible for the poor performance of these equations. In the case of beef and hogs, other omitted variables and/or more detailed and accurate data prevent the model from forecasting well.

CHAPTER VI

PRICES, STOCKS, AND NET TRADE

Price Determination

A single price relationship cannot describe the price mechanism correctly without taking into consideration the assumptions included in other equations within the same model. Unfortunately, there does not exist a general theory that considers actual rather than ideal market structure. Factors such as expectations are also important to speculation and hedging as well as to physical trading (Labys, 1973, p. 92). According to Labys, several factors have contributed to this situation. Among them is the fact that in most studies, price relationships have been derived simply by inverting or normalizing the demand relationship. In the absence of such a theory, it was decided to concentrate on an approach that considers separately the factors that best appear to explain price behavior for each commodity.

For most of the commodities analyzed in this study, Brazil is relatively unimportant in world markets. This is not the case for soybeans and products. However, because it was beyond the scope of this study to estimate a world model for soybeans and products, the same basic approach was adopted for soybeans as for the other commodities. That is, Brazil was assumed to be facing a horizontal world demand for all the commodities analyzed. Brazil was then considered a

price taker in the world market, and the world prices are given exogenously. In spite of the fact that most world prices are given exogenously, the government often intervenes to establish domestic market price. The intervention is usually through trade policy, with the purpose of keeping domestic prices below the level that would exist under other circumstances.

The device most persistently used by the government during the study period was the maintenance of an overvalued exchange rate, which constitutes an implicit export taxation. Whereas this policy could be considered reasonable in the past when Brazil faced an inelastic international demand for coffee and consequently could shift the burden of the taxation onto the foreign consumer, even then it was harmful because it discouraged the export of other commodities that had a potential to become important in the world market.

As pointed out before, the present government has selected the agricultural sector as its top priority because it is believed that this sector can help improve the balance of trade by increasing its exports. But to expand agricultural exports, the government has to adopt a series of policy actions. One important policy related to the export market is the adoption of a more "near equilibrium" exchange rate. This, it is believed would improve the competitiveness of Brazilian products in foreign markets and at the same time translate into higher producer prices, which could be an incentive to increase production.

Price Relationships: Soybeans, Soymeal, Soyoil, Rice, Corn, and Beef

It was postulated that the level of government intervention in the export market for the agricultural commodities considered in this study could be explained through economic variables. According to Lattimore (1974), the level of intervention can be assumed to be predictable on the basis of certain exogenous and predetermined variables. He showed that the level of intervention can be estimated as the difference between the FOB price evaluated at the equilibrium exchange rate and the domestic price of a particular product. To explain past levels of intervention, Lattimore formulated an equation relating the calculated level of intervention to variables intended to account for the reasons behind the governmental decisions with respect to agricultural export policy. The current rate of inflation was hypothesized to be one measure of the government's interest in holding down the price of food items to domestic consumers. Another factor considered--the desire to increase foreign-exchange earnings, which would reduce the level of intervention--was hypothesized to be a function of the overall position of the balance of payments.

In this study, those factors suggested above were incorporated directly into a price-determination equation. It is very important to have a relationship between domestic and international prices, which would allow for analysis of a possible removal of the restrictive policy considered.

According to Abbot (1979), a country may choose different directions in determining its domestic prices. The situation generally used in equilibrium analysis is that the domestic price of a commodity is equal to its world-market price at the country's border (DP = WP) or the world price times one plus an ad valorem tariff (DP = WP [1+t]). Another situation is when a country ignores the world market and controls its domestic prices by using, for example, a constant quota or a variable-levy system. Finally, in some cases there is a limit to which domestic prices can follow world prices. Only a partial adjustment may be allowed in some periods, but domestic prices should, in the long run, follow international market prices (DP = b WP).

It was believed that the assumption of a partial-adjustment model was the most adequate in the case of Brazil. Although for most of the products Brazil can be considered a price taker in the international market, the domestic prices only partially follow the international prices. In order to accomplish some domestic social goals, the government intervenes through the overvaluation of the exchange rate and/or other policy measures.

The aspects discussed so far were incorporated in the following equation for determining the domestic price of a particular agricultural commodity.

$$DP = b_0 + b_1 \; WP + b_2 \; EXCH + b_3 \; INFL + b_4 \; BOP + b_5 \; TPROD$$

where:

DP = domestic price

WP = world market price

EXCH = exchange rate

INFL = rate of inflation (the rate of increase of the general price level)

BOP = the overall position of the balance of payments

TPROD = total domestic production of the particular commodity

b_0 = constant parameter

$b_1 \ldots b_5$ = parameters measuring the influence of the respective variables on domestic price

The estimate of parameter b_1 is used to calculate the elasticity of price transmission,[1] which provides a measure of the response of domestic prices to changes in world prices. Usually, for simplicity, a perfect price transmission ($b_1 = 1$) is assumed, but given the evidence that the internal price is to some extent insulated from the world-market price, the size of international price adjustments cannot be ignored.

The reason for the use of the world-price and exchange-rate variables as separate regressors was based on the study by Chambers and Just (1981). They argued that there are differential adjustments to price and exchange-rate movements, and, therefore, the use of one variable, like the world price expressed in cruzeiros (world price times the exchange rate), cannot be considered to represent both effects.

Production may affect the degree chosen for a controlled domestic price because in bad years a higher price may be permitted

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[1]See Bredahl, Meyers, and Collins (1979) for a discussion of the importance of this price-transmission elasticity.

in order to cope with the temporary shortage (Abbot, 1979). Based on this evidence, total production was included as an explanatory variable.

Because the prices of food items have a significant effect on the general price index, the level of intervention was hypothesized to be a positive function of the rate of domestic inflation. Therefore, a negative relationship was expected between the domestic price and the rate of increase of the general price level. The controlled domestic prices were postulated to be an inverse function of the expected overall position of the balance of payments. The need for foreign-exchange receipts (when the balance-of-payments account is in deficit) leads policy makers to lessen the degree of interference in the agricultural export sector.

The domestic prices were expressed in national currency, and the international prices were expressed in dollars. As with the other monetary variables of the complete model, the international and domestic prices and the exchange rate were expressed in real values, with the respective price deflators having the same base year (1977 = 100).[1] The conversion to a different exchange rate for simulation can be made by using alternative exchange rates or directly by making appropriate changes in the respective coefficient of the price-linkage equations.

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[1]Notice that the exchange rate was deflated by multiplying the nominal rate by the ratio of the wholesale price index in the U.S. to the wholesale price index in Brazil, both indices having a common base 1977 = 100.

It was impossible to find complete series of published data on the export or import prices for the considered agricultural commodities that were traded by Brazil during the studied period. In the absence of such data, the alternative appeared to be the use of the average FOB price of exports in each category. However, when data for the value of exports were found, inconsistencies were noticed in a number of cases, making it impossible to use the data. As a result, series of international prices (published by the IMF, FAO, and USDA) were used in the analysis as proxies for the world (export and import) prices of Brazilian agricultural commodities.[1] Following are the results for soybeans, soymeal, soyoil, rice, corn, and beef, which have similar specifications. The numbers in parentheses are standard errors; numbers in brackets are elasticities.

$$PSB = 707.180 + \underset{\substack{(.73809)\\ [.7389]}}{9.11789^{***}}\ WOPSB + \underset{\substack{(27.2374)\\ [\ .1906]}}{38.1829}\ EXCH$$

$$- \underset{(1.44436)}{5.40461^{***}}\ INFL - \underset{(.02818)}{.06930^{**}}\ LBOP - \underset{\substack{(.00508)\\ [-.0778]}}{.04971^{***}}\ TPSB$$

$$R^2 = .98 \qquad D.W. = 1.94 \qquad \rho = \underset{(.2089)}{-.6307^{***}}$$

$$PSM = 1750.35 + \underset{\substack{(.92260)\\ [.3264]}}{3.86164^{***}}\ WOPSM + \underset{\substack{(39.4756)\\ [.0843]}}{13.6015}\ EXCH$$

$$- \underset{(2.43584)}{6.40846^{**}}\ INFL - \underset{(.03378)}{.01802}\ LBOP + \underset{\substack{(.01559)\\ [-.0246]}}{.02434}\ TPSM$$

$$R^2 = .77 \qquad D.W. = 1.67$$

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[1] See Appendix A for the description of these variables.

$$PSO = -8854.68 + \underset{\substack{(6.1975)\\ [.5860]}}{18.6771^{***}}\ WOPSO + \underset{\substack{(447.86)\\ [1.1985]}}{1332.52^{***}}\ EXCH$$

$$- \underset{(2807.66)}{6827.16^{**}}\ D_{7374} - \underset{\substack{(.8614)\\ [-.2090]}}{5.9157^{***}}\ TPSO$$

$R^2 = .80$ D.W. = 1.36

$$PC = -873.819 + \underset{\substack{(1.79831)\\ [.4057]}}{5.72959^{***}}\ WOPC + \underset{\substack{(30.288)\\ [1.3797]}}{140.642^{***}}\ EXCH$$

$$- \underset{(1.70078)}{4.27928^{**}}\ INFL - \underset{(.02199)}{.01417}\ LBOP - \underset{\substack{(.01024)\\ [-.0891]}}{.00976}\ TPC$$

$R^2 = .73$ D.W. = 2.31

$$PR = 4907.94 + \underset{\substack{(2.05251)\\ [.5780]}}{5.53340^{**}}\ WOPR - \underset{(8.05618)}{1.11938}\ INFL$$

$$- \underset{(.125674)}{.224934^{*}}\ LBOP - \underset{\substack{(.14018)\\ [-.8658]}}{.44929^{***}}\ TPR$$

$R^2 = .56$ D.W. = 2.06

$$PB = 3436.29 + \underset{(.18219)}{.42563^{**}}\ LPB + \underset{\substack{(1.29914)\\ [.2934]}}{3.63778^{**}}\ WOPB$$

$$- \underset{\substack{(476.638)\\ [.1033]}}{108.866}\ EXCH - \underset{(27.3088)}{13.2129}\ INFL$$

$R^2 = .60$ D.W. = 1.78 h = .84

where:

PSB = price of soybeans (Cr$/MT)

PSM = price of soymeal (Cr$/MT)

PSO = price of soyoil (Cr$/MT)

PR = price of rice (Cr$/MT)

PC = price of corn (Cr$/MT)

PB = price of beef (Cr$/MT e.c.w.)

LPB = PB lagged one year

EXCH = exchange rate (Cr$/US$)

WOPSB = world price of soybeans (US$/MT)

WOPSM = world price of soymeal (US$/MT)

WOPSO = world price of soyoil (US$/MT)

WOPR = world price of rice (US$/MT)

WOPC = world price of corn (US$/MT)

WOPB = world price of beef (US$/MT)

LBOP = the overall position in the balance of payments (US$1,000,000) in the previous year

INFL = the rate of increase in the general price level (percent)

D_{7374} = policy dummy, =1, 1973-74, =0 otherwise, representing the years when the government imposed an embargo on the exports of soyoil

TPSB = total production of soybeans (1000 MT)

TPSM = total production of soymeal (1000 MT)

TPSO = total production of soyoil (1000 MT)

TPR = total production of rice (1000 MT)

TPC = total production of corn (1000 MT)

Overall, the statistical support given by the coefficients of the above price equations was considered satisfactory. The coefficients for the world-price variables, in all cases, were highly significant, indicating that they play an important role in the determination of domestic prices. The price-transmission elasticities provide an idea of the response of domestic prices to changes in world prices. Only a fraction of the increase in the world prices was transmitted to the domestic prices. A 10 percent increase in the world price of soybeans, for example, resulted in only a 7.1 percent increase in the domestic price of soybeans because of several ways of government intervention. The elasticity results show how strong the policy mechanism was in offsetting the changes in world prices.

The exchange-rate variable was highly significant in the cases of corn and soyoil price equations. Furthermore, the estimated structural exchange-rate elasticities for prices, both larger than unity, indicate that the levels of domestic prices of corn and soyoil were very sensitive to the fluctuations of the exchange rate. The exchange-rate effect was relatively low in the cases of the other commodities. In the case of rice, this effect was negative, and for that reason the exchange-rate variable was dropped from the respective equation.

The effects of the balance-of-payments and the rate-of-inflation variables in some cases appeared to contribute to the explanation of the trade-intervention policies in determining

domestic price. This contribution was more evident in the case of the rate of inflation. In terms of the total-production variable, the elasticity results indicate that only in the case of rice was the level of domestic price very sensitive to an increase in total production.

Support Price of Wheat

The wheat support price equation was postulated to be a function of the international price of wheat, the exchange rate, the level of foreign-exchange reserves, and domestic wheat production. Because of the planting schedule, the variables relating to the preceding period were considered. Self-sufficiency in wheat production has been a long-term goal of the Brazilian government. A decrease in wheat production forces the government to raise the support price of wheat to stimulate domestic production. Because the government regulates wheat imports, the level of foreign-exchange reserves was believed to explain variations in the wheat support price. When the level of foreign-exchange reserves is low, the government may be unwilling to maintain a low domestic price (see Abbot, 1979).

$$PW = 1510.27 + \underset{\substack{(3.1341)\\ [.4502]}}{12.1631^{***}} \, LWOPW + \underset{\substack{(71.2834)\\ [.3704]}}{91.5264} \, EXCH$$

$$- \underset{(.05388)}{.15995^{***}} \, LFER - \underset{\substack{(.17622)\\ [-.0835]}}{.22867} \, LTPW$$

$$R^2 = .79 \qquad D.W. = 1.77$$

where:

PW = support price of wheat (Cr$/MT)

LWOPW = world price of wheat in the previous year (US$/MT)

LFER = the level of foreign-exchange reserves in the previous year (US$million)

LTPW = lagged domestic wheat production (1000 MT)

Only the coefficients for the world price and level of foreign-exchange reserves were highly significant. The estimated structural exchange rate elasticity, although inelastic, indicates that the devaluation of the exchange rate would bring some increase in the domestic price of wheat.

Producer Prices of Hogs and Chickens

Because of the insignificance of the swine and poultry sectors in agricultural exports during most of the sample period, a different price relationship was considered in these cases. The prices of hogs and chickens were assumed to be a function of their total production, the price of beef, and a trend variable to capture the effects of any variables that might have been omitted. The results are presented below.

$$PH = 26837.1 - \underset{(4.4689)}{6.1689}\ TPH + \underset{(.1291)}{.2288^{*}}\ PB - \underset{(105.295)}{177.164}\ TREND + \underset{(1388.86)}{5190.09^{**}}\ D_{74}$$

$R^2 = .81$ D.W. $= 2.65$

$$PCH = 37210.9 - \underset{(2.3458)}{3.5089}\ TPCH + \underset{(.1026)}{.3248^{***}}\ PB - \underset{(105.922)}{403.192^{***}}\ TREND$$

$$R^2 = .88 \qquad D.W. = 2.96$$

where:

PH = price of hogs (Cr$/MT e.c.w.)

TPH = total production of hogs (MT e.c.w.)

PCH = price of chickens (Cr$/MT e.c.w.)

TPCH = total production of chickens (MT e.c.w.)

PB = price of beef (Cr$/MT e.c.w.)

TREND = trend variable, measured as the last two digits of the calendar year

D_{74} = dummy variable, =1 in 1974, =0 otherwise

The results suggested that the beef price was the most important explanatory variable in the above price equations. A dummy variable was added to the hog-price equation because of the discrepant price that occurred in 1974, probably as a result of the significant decrease in the supply of pork meat caused by the African swine fever.

Retail Prices

The retail margins were not considered to be constant but rather to be affected by several factors such as the quantities of commodities produced, processing costs, and the levels of producer prices (see Myers & Havlicek, 1975). The procedure used in this study was to estimate directly a retail-price equation in which the retail price was hypothesized to be a function of the respective producer price, the urban salary, and a trend variable. The

influence of inflation and quantity produced was assumed to be captured in the respective producer-price equation. The urban salary was used to represent the costs in the pertinent processing industry and marketing services. Following are the results related to the retail-price equations for hogs, beef, chickens, and rice.[1]

$$RPH = -36164.9 + \underset{(.2428)}{1.0482^{***}}\ PH + \underset{(5.1796)}{14.4857^{**}}\ WAGE + \underset{(165.687)}{360.992^{*}}\ TREND$$

$$R^2 = .91 \qquad D.W. = 2.29$$

$$RPB = -2627.67 + \underset{(.1093)}{1.0887^{***}}\ PB + \underset{(2.9623)}{3.3672}\ WAGE + \underset{(106.548)}{47.8662}\ TREND$$

$$R^2 = .95 \qquad D.W. = 1.55$$

$$RPCH = 26074.8 + \underset{(.1935)}{.9448^{***}}\ PCH + \underset{(2.4302}{2.0540}\ WAGE - \underset{(113.860)}{271.210^{**}}\ TREND$$

$$R^2 = .94 \qquad D.W. = 2.56$$

$$RPR = 1841.6 + \underset{(.1909)}{1.0427^{***}}\ PR + \underset{(1.4408)}{3.7699^{**}}\ WAGE - \underset{(53.2931)}{61.0173}\ TREND$$

$$R^2 = .87 \qquad D.W. = 2.14$$

where:

RPH = retail price of hog meat (Cr$/MT)

RPB = retail price of beef meat (Cr$/MT)

RPCH = retail price of frying chicken (Cr$/MT)

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[1]No price relationships were specified in the cases of soy-oil, soymeal, and soybeans because only their respective retail, wholesale, and producer prices were used in estimating the equations. On the other hand, no information exists at the retail level in the case of corn; producer price was then the only price considered because of some inconsistencies found in the wholesale-price series.

RPR = retail price of milled rice (Cr$/MT)

WAGE = average monthly wages paid to workers in the urban area (Cr$/month)

The other variables were previously defined. The statistical results showed that the respective producer price was the most important element in the determination of retail prices. As expected, an increase in the factor cost was associated with an increase in the retail-price level. A negative sign for the parameter of the trend variable in the rice and chickens equations, although highly significant only in the latter case, suggested that technological advances in the processing and retailing sectors of these products have tended to decrease the retail-price level over time. Overall, the results were considered good.

A different relationship was considered in the case of the retail price of wheat flour. The Marketing Department of the Bank of Brazil (CITRIN), which annually sets the purchase price of wheat, is also the sole buyer of domestic wheat, the sole importer, and the sole supplier to domestic mills. Imported and domestic wheat is sold to the mills at the same price, which is generally lower than the producer support price but higher than the import price. The revenue gained from the sale of imported wheat is used to subsidize domestic producers (see Knight, 1971, p. 91, and Paiva et al., 1973, p. 174). Therefore, the levels of domestic support and international wheat prices influence the retail price of wheat flour and consequently the final product. Because the price paid by the domestic mills is a result of the proportion of domestic and imported wheat grain, the

retail price of wheat flour was postulated to be a function of a weighted average of domestic and international prices. The price that consumers pay for wheat flour is subsidized. Although the government has recently embarked on a program to reduce this subsidy, it was present throughout the entire study period. It was hypothesized that the current rate of inflation was the main measure of the government's interest in holding down wheat-flour prices, and a variable indicating the rate of increase of the general price level was included among the explanatory variables. As in the previous retail-price relationships, a trend variable was considered to take technological advances into account in the processing and retailing industries. This variable was also expected to capture the influence of other omitted variables that were highly correlated with time.

The result of the estimated equation is shown below.

$$\underset{}{RPWFL} = 26469.6 + \underset{(.3261)}{.5893^{*}}\ APW - \underset{(11.4805)}{16.5386}\ INFL - \underset{(51.9756)}{307.496^{**}}\ TREND$$

$$R^2 = .94 \qquad D.W. = 2.12$$

$$APW = \left[\frac{(LPW * LTPW) + (WOPW * MW)}{(LTPW + MW)}\right]$$

where:

RPWFL = retail price of wheat flour (Cr$/MT)

APW = proxy for the wheat price paid by the domestic mills (Cr$/MT)

LPW = domestic price of wheat in the previous year (Cr$/MT)

LTPW = domestic production of wheat in the previous year (Cr$/MT)

WOPW = world price of wheat (Cr$/MT)

MW = imports of wheat (MT)

The other variables were previously defined. The statistical support for the hypothesized equation for the retail price of wheat flour was considered acceptable. The independent variables that were included had the expected signs, with standard errors always smaller than the respective coefficient values. The explanatory power of the equation was relatively high, meaning that the chosen explanatory variables explained a large portion of the changes in the level of subsidized price of wheat flour during the sample period.

Carryover Stocks

Inventory data series were available only for soybeans and products. Estimates of stocks of soybeans and products in Brazil differ considerably. The USDA estimates of carryover stocks in Brazil were used because this source was the only one to provide a complete series of observations (1965-80). The results obtained are acceptable only to the extent that the information available is considered reliable.

According to Labys (1973, p. 61), theoretical and empirical studies in this area have been limited mainly because data at the national level can only reflect crudely the true motives of major groups of stockholders. The unavailability of adequate data usually has led many commodity models to omit the consideration of inventory

price adjustments. Most of the studies are conducted with relatively simple empirical relationships.

In this study, the carryover-stock relationships were hypothesized to be a function of lagged stocks, the product price and/or change in price, and the respective total production. The lagged stocks and the price variables reflect the speculative demand for holding stocks. Production was included as an explanatory variable to represent the transaction motive for holding stocks (see Labys, 1973, pp. 65 and 70). A dummy variable was introduced for certain years to reflect the abnormally large carryover in those years. The results presented in Tables 6.1, 6.2, and 6.3 were derived from these hypotheses.

Several equations were tried in each case. A close examination of the estimated results showed that total production alone explained quite well the variation in the dependent variable in all the years in the first half of the study period. This fact raises some doubt about the quality of the inventory data. In the absence of more reliable data, the analysis was carried out with the available information. It should be kept in mind, however, that econometric models are very sensitive to data errors, and they are only as reliable as the data used in their estimation. Fortunately, in the case of soybeans and products, the carryover stocks represented only a small fraction of the total amount marketed.

The inclusion of other explanatory variables improved the explanation of the variation of the stock variable in the most recent

Table 6.1.--Parameter estimates for the soybean-inventory equations.[a] Dependent variable: ESSB

Independent Variables	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
CONSTANT	147626 (86412)	105123 (92680)	-250720 (367575)	-395676 (478308)	-470937 (277431)
TPSB	.0291* (.0142)	.0258* (.0134)	.0247 (.0140)	.0242 (.0145)	.0141 (.0087)
BSSB	...	.2976 (.2540)	.2888 (.2542)	.2915 (.2626)	.1822 (.1538)
PSB	...	...	112.316 (112.271)	160.480 (150.967)	200.412** (87.822)
CHPSB	...	...	...	-62.598 (125.633)	-123.367 (73.857)
D_{77}	...	...	...	...	716070*** (149957)
R^2	.32	.38	.43	.44	.83
D.W.	1.15	1.67	1.82	1.90	1.62
h	..	..	..	..	.97

[a]Standard error in parentheses.

where:

ESSB = stocks of soybeans existing at the end of the year (MT)

TPSB = total production of soybeans (MT)

BSSB = stocks of soybeans existing at the beginning of the year (MT)

PSB = price of soybeans (Cr$/MT)

CHPSB = change in price of soybeans (Cr$/MT)

D_{77} = dummy variable, =1 in 1977, =0 otherwise

Table 6.2.--Parameter estimates for soyoil-inventory equations.[a]
Dependent variable: ESSO

Independent Variable	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
CONSTANT	-881.7 (11311.6)	-1062.1 (11480.8)	-39970.7 (59381.2)	-23375.1 (59788.5)	18609.7 (9431.9)
TPSO	.1090*** (.0123)	.8890*** (.0285)	.1001*** (.0336)	.0887** (.0343)	.0363 (.0240)
BSSO	...	.2453 (.3178)	.2215 (.3267)	.3297 (.3323)	.6095** (.2404)
PSO	...	...	2.0985 (3.1396)	1.4789 (3.1197)	...
CHPSO	...	...	...	4.3696 (3.5859)	8.6625*** (2.7169)
D_{80}	...	...	...	...	111402*** (31907)
R^2	.87	.88	.88	.89	.95
D.W.	1.20	1.27	1.14	1.18	1.77
h	..	..	..	..	1.62

[a]Standard errors in parentheses.

where:

ESSO = stocks of soyoil existing at the end of the year (MT)

TPSO = total production of soyoil (MT)

BSSO = stocks of soyoil existing at the beginning of the year (MT)

PSO = price of soyoil (Cr$/MT)

CHPSO = change in price of soyoil (Cr$/MT)

D_{80} = dummy variable, =1 in 1980, =0 otherwise

Table 6.3.--Parameter estimates for the soymeal-inventory equations.[a] Dependent variable: ESSM

Independent Variables	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5
CONSTANT	-377.367 (5892.40)	1413.67 (4701.24)	-28276.0 (27346.9)	-26712.9 (32318.9)	-1079.33 (6246.85)
TPSM	.0200*** (.0014)	.0300*** (.0033)	.0309*** (.0035)	.0309*** (.0037)	.0203*** (.0016)
BSSM	...	-.6687*** (.2188)	-.7204*** (.2220)	-.7178*** (.2332)	...
PSM	...	...	11.7229 (10.6398)	11.2297 (12.8823)	...
CHPSM	...	...	...	1.2297 (11.9169)	6.0350 (12.8992)
R^2	.92	.96	.97	.97	.94
D.W.	1.79	1.69	1.77	1.78	1.81

[a]Standard errors in parentheses.

where:

ESSM = stocks of soymeal at the end of the year (MT)

TPSM = total production of soymeal (MT)

BSSM = stocks of soymeal at the beginning of the year (MT)

PSM = price of soymeal (Cr$/MT)

CHPSM = change in price of soymeal (Cr$/MT)

years. Only Equation 5 in each case is considered in the final analysis of the model.

The statistical results were considered to be relatively satisfactory. The negative sign accompanying the change-in-price variable in the case of soybeans was hard to interpret, except that stockholders may expect that the most recent change in prices will be reversed (see Labys, 1973, p. 81). Examination of the price-change variable showed that the price reversals actually took place several times throughout the study period.

The transaction motive was shown to provide an adequate explanation of soymeal stocks. The speculative motive was not expected to play any important role because soymeal is highly perishable and cannot be stored for long periods.

It was necessary to introduce a dummy variable to account for the unusually large stock holding that occurred in 1977 in the case of soybeans and in 1980 in the case of soyoil. The large carryover of soybeans was likely a result of the fact that the growth in the crushing capacity did not follow the increase in bean production. After 1977, a significant expansion of the crushing industry occurred when it surpassed the increase in soybean production. Also in March of 1977, when the world market prices approached their historic highs, the Brazilian government first imposed an export embargo and later an *ad valorem* tax on soybean exports to hold down domestic prices (Thompson, 1979). In 1980, when the soyoil price reached the lowest level of the study period, the crushing industry refused to sell its

inventory of soyoil in an attempt to force the Comissão Interministerial de Preço (CIP), a government price committee, to raise the ceiling price. The statistical support given by the coefficients of the dummy variables seemed to reflect the abnormally large stocks for those years.

Net Trade

The production and consumption sides of the model were assumed to be propelled by the policy-adjusted prices. Since the amounts of the several commodities available for export were the surpluses above the levels of domestic consumption, the demands for exports were considered as residuals. What happens in domestic consumption of agricultural commodities determines the course of Brazilian exports of those products. Because a large portion of the wheat demanded must be imported from foreign markets, a wheat import behavioral equation should be added to the model. The government, however, regulates all wheat imports, foreseeing the levels of domestic production and domestic consumption. For this reason, the wheat import demand was considered also as residual. In all cases, therefore, the net trade representing the difference between domestic availability and domestic disappearance was used as an indicator of potential surpluses or deficits.

Validation

The simulation period was the same as before (1971-80). Figures 6.1 to 6.6 present the results for actual and simulated values for the price and stocks equations. Although some turning

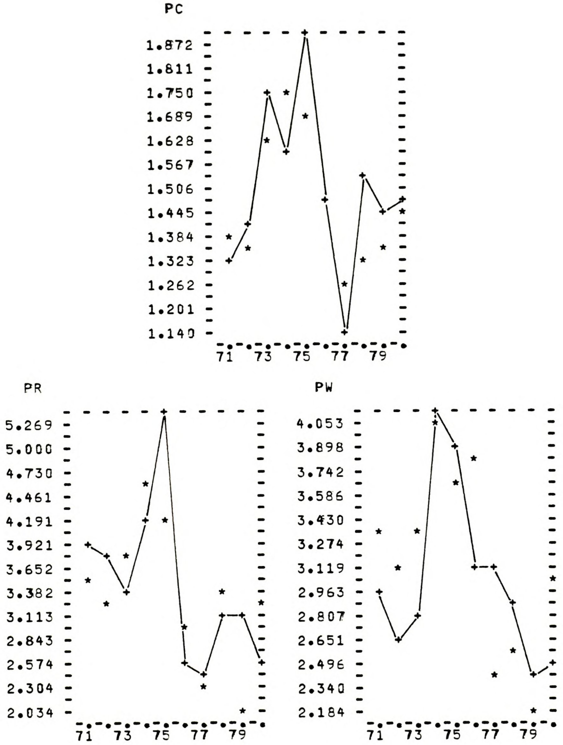

Figure 6.1.--Actual (+) and simulated (*) values for prices: corn (PC), rice (PR), and wheat (PW) in real Cr$/kg, 1971-80.

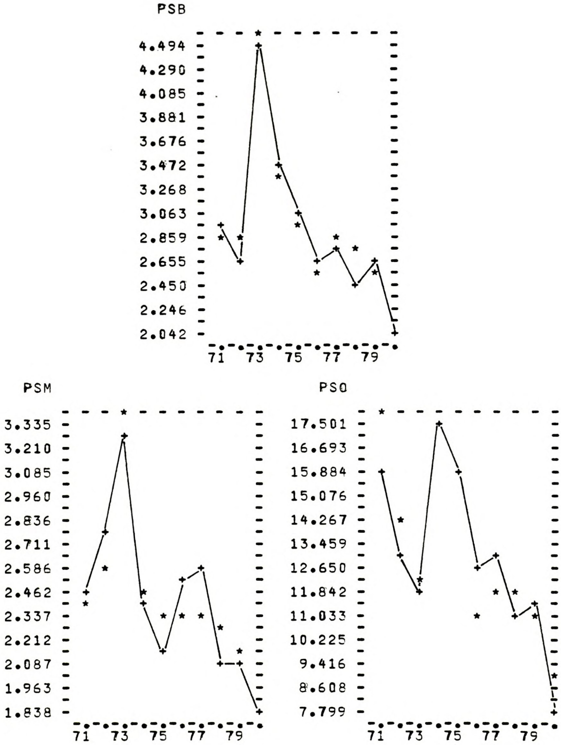

Figure 6.2.--Actual (+) and simulated (*) values for prices: soybeans (PSB), soymeal (PSM), and soyoil (PSO) in real Cr$/kg, 1971-80.

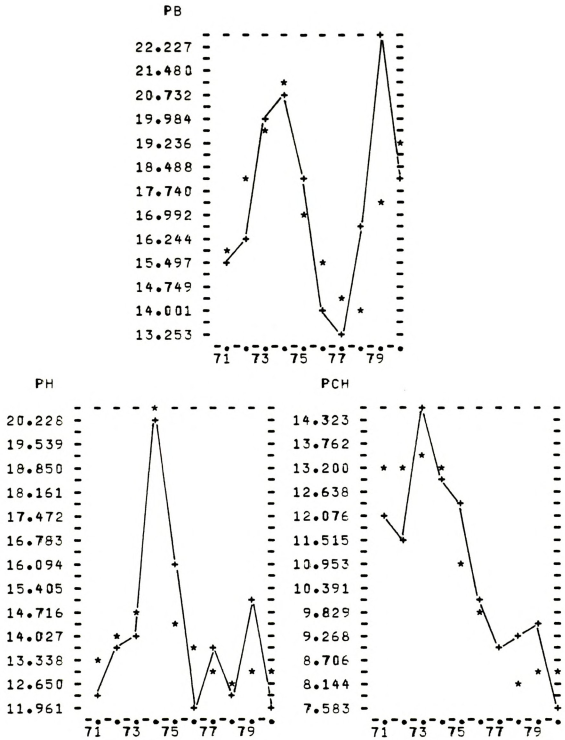

Figure 6.3.--Actual (+) and simulated (*) values for prices: beef cattle (PB), hogs (PH), and chickens (PCH) in real Cr$/kg e.c.w., 1971-80.

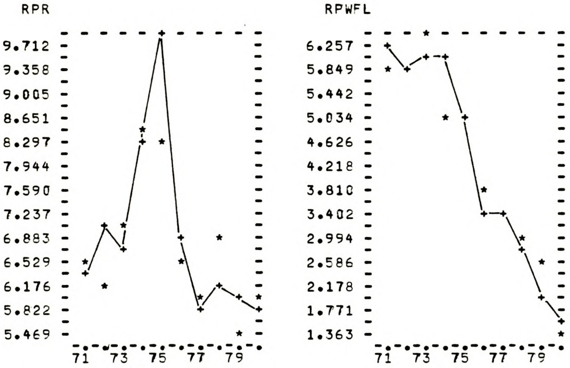

Figure 6.4.--Actual (+) and simulated (*) values for retail prices: rice (RPR) and wheat flour (RPWFL) in real Cr$/kg, 1971-80.

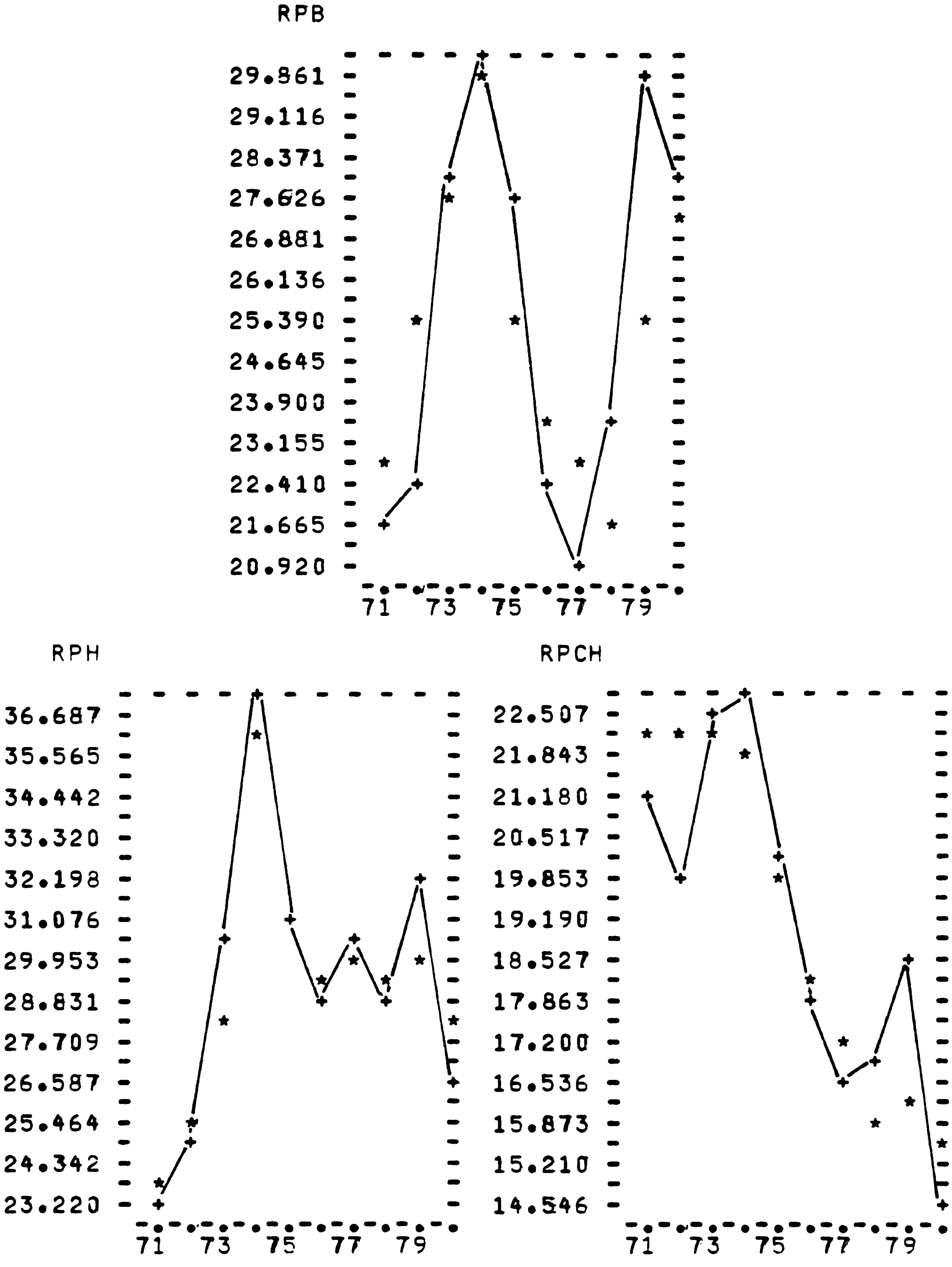

Figure 6.5.--Actual (+) and simulated (*) values for meat retail prices: beef (RPB), hogs (RPH), and chickens (RPCH) in real Cr$/kg, 1971-80.

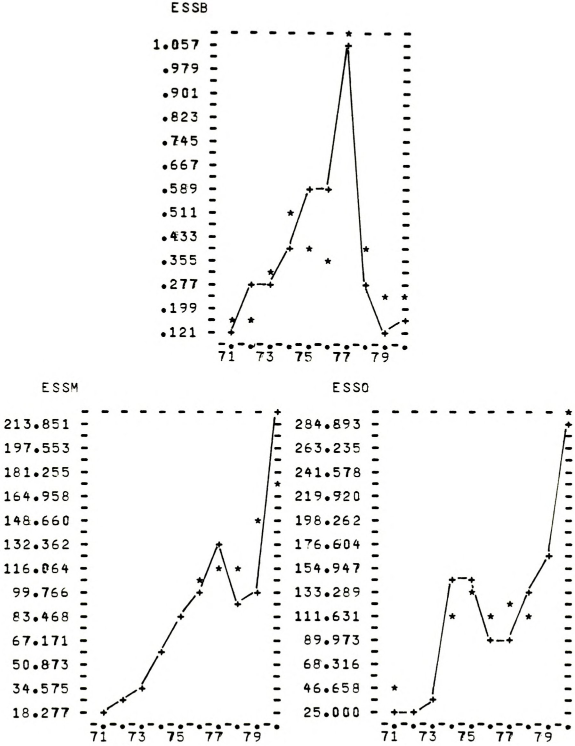

Figure 6.6.--Actual (+) and simulated (*) values for ending stocks: soybeans (ESSB) in million MT, and soymeal (ESSM) and soyoil (ESSO) in thousand MT, 1971-80.

points were missed, the simulated values tracked relatively well the major movements in the historical period. Tables 6.4 to 6.6 present Theil's U-statistics. They generally suggest that the estimated price equations can be considered good forecasters. Under the criterion adopted before (UM and UR have to be close to zero and UD close to one), the equations turned out to be almost perfect forecasters. This may be looked at with certain skepticism because of the problems with the data already discussed.

Table 6.4.--U-statistics for producer-price equations.

Equation	U_1	U_2	UM	UR	UD	R_1
Corn	.0416	.4607	.0727	.0007	.9267	.80
Rice	.0905	.5874	.0614	.0637	.8750	.71
Wheat	.0697	.8138	.0450	.2045	.7507	.70
Soybeans	.0229	.1819	.0009	.0086	.9905	.98
Soymeal	.0306	.3407	.0120	.0010	.9870	.93
Soyoil	.0382	.3790	.0427	.1088	.8485	.93
Beef	.0602	.6252	.0217	.0214	.9570	.68
Hogs	.0406	.3608	.0051	.0008	.9941	.88
Chickens	.0453	.6366	.0026	.1605	.8370	.89

Table 6.5.--U-statistics for retail-price equations.

Equation	U_1	U_2	UM	UR	UD	R_1
Rice	.0472	.5094	.0615	.0083	.9302	.85
Wheat flour	.0471	.5660	.0033	.0312	.9656	.97
Beef	.0401	.5562	.0182	.0352	.9465	.81
Hogs	.0223	.3370	.0071	.0890	.9039	.94
Chickens	.0313	.5705	.0058	.1214	.8728	.90

Table 6.6.--U-statistics for stock equations.

Equation	U_1	U_2	UM	UR	UD	R_1
Soybeans	.1304	.3889	.0004	.0002	.9994	.89
Soymeal	.1067	.4909	.0001	.0006	.9994	.91
Soyoil	.0624	.3090	.0012	.0106	.9882	.97

Figures 6.7 to 6.9 present the actual and predicted results for the net-trade equations. In some cases the difference between these values was extremely large. Two facts, however, should be mentioned here. First, net trade was treated as a residual in this model, so the export (import) predictions contained the net effect of errors made in predicting the other endogenous variables pertaining to those identity equations. Second, these errors were large because in most cases Brazil is only a marginal trader. This means that relatively small errors in the production and/or consumption equations result in very large errors in the residual equations when actual and predicted values are compared. Exceptions are made in the cases of soybeans, soymeal, and wheat, the most intensively traded products, where errors are relatively small. Despite large errors in some cases, in general, the predicted results seemed to follow the trade pattern revealed by the actual values. Theil's U-statistics are not presented, since the equations were not estimated statistically.

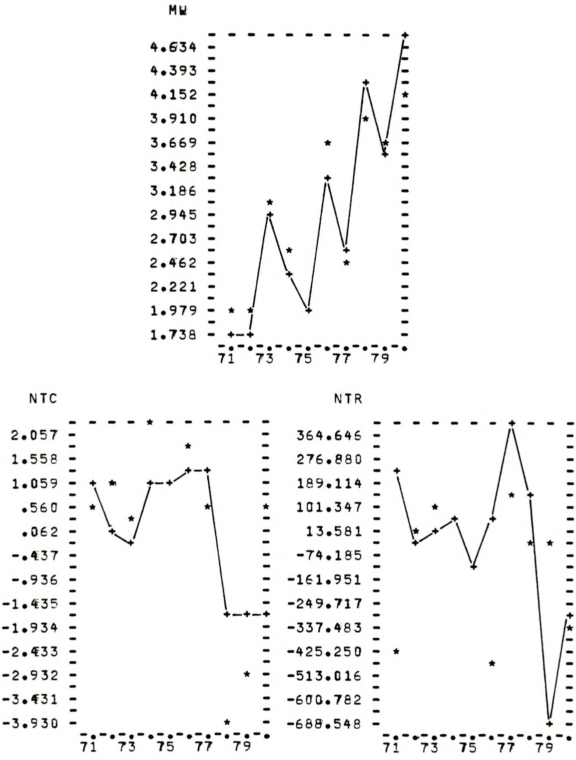

Figure 6.7.--Actual (+) and simulated (*) values for net trade: wheat imports (MW) and corn (NTC) in million MT, and rice (NTR) in thousand MT, 1971-80.

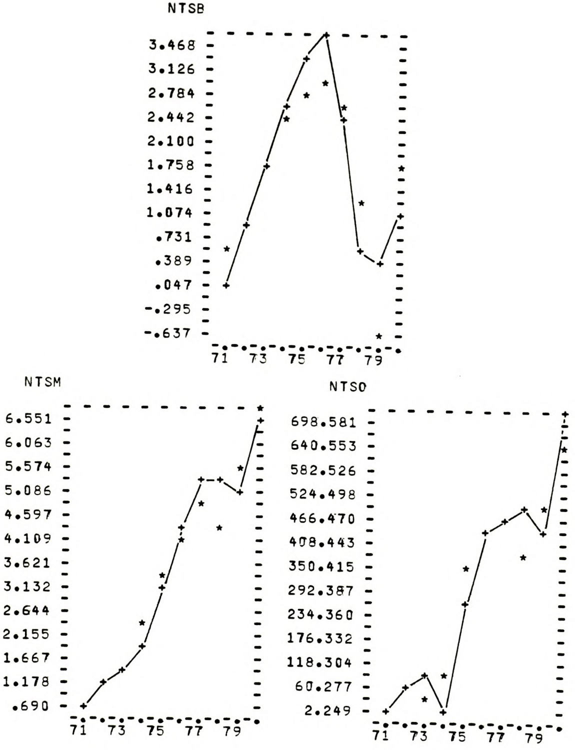

Figure 6.8.--Actual (+) and simulated (*) values for net trade: soybeans (NTSB) and soymeal (NTSM) in million MT, and soyoil (NTSO) in thousand MT, 1971-80.

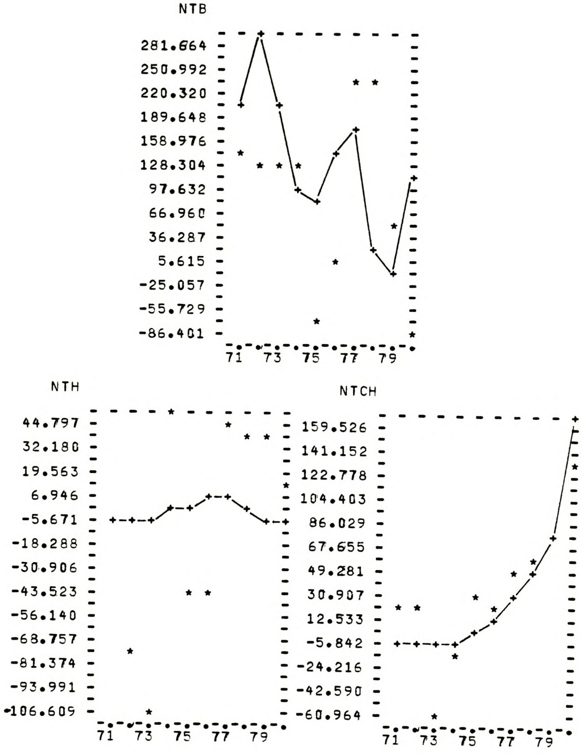

Figure 6.9.--Actual (+) and simulated (*) values for meat net trade: beef (NTB), hogs (NTH), and chickens (NTCH) in thousand MT, 1971-80.

CHAPTER VII

ANALYSIS OF THE MODEL

Introduction

In this chapter, the model developed in the three previous chapters is used to evaluate the effects of a change in the exchange-rate policy on Brazilian agriculture. To assess the possible implications of such a change, simulations were carried out during the historical period (1971-80), under two different scenarios. The baseline scenario was obtained by simulating the model using a base set of exogenous variables. The alternative scenario was obtained under a different assumption concerning the exchange rate, with all other exogenous variables equal to the base case. The changes in the endogenous agricultural variables between the two scenarios are attributed to the assumed change in the policy variable. This exercise is carried out over the historical period in an attempt to show whether agriculture as an exporting sector has been discriminated against by the persistence of an overvalued exchange rate. The forecasts are heavily dependent on the assumptions, and the primary usefulness of the analysis is related to the comparative static results.

"Equilibrium" Exchange Rates

To accomplish the objective of this chapter, it is necessary to have an idea of the degree of overvaluation in the historical

period. In recent years, Conjuntura Econômica has been publishing monthly data of "equilibrium" exchange rate based on the parity theory. Figure 7.1 shows the degree of overvaluation from January 1979 through March 1982. In November 1979, the cruzeiro was devalued by 30 percent. With additional mini-devaluations, it reached the "equilibrium" position in January 1980. Although the mini-devaluations continued, the cruzeiro became overvalued again only a few months later. (See Figure 7.1.) The average rate of overvaluation was 12.28 percent in 1980 and 26.58 in 1981.

Following the same approach used by Conjuntura Econômica, the "equilibrium" exchange rate and the respective rates of overvaluation were calculated for the remaining years of the historical period (Table 7.1). The calculations were carried out using the relationship below.[1]

$$EEXCH_t = EXCH_b * \left(\frac{WPI_b}{IPA_b}\right) * \left(\frac{IPA_t}{WPI_t}\right)$$

where:

$EEXCH_t$ = "equilibrium" exchange rate in period t

$EXCH_b$ = official exchange rate in the base period

WPI_b = wholesale price index in the base period at the external level (USA)

WPI_t = wholesale price index in period t at the external level (USA)

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[1]See Conjuntura Econômica, May 1976, p. 90.

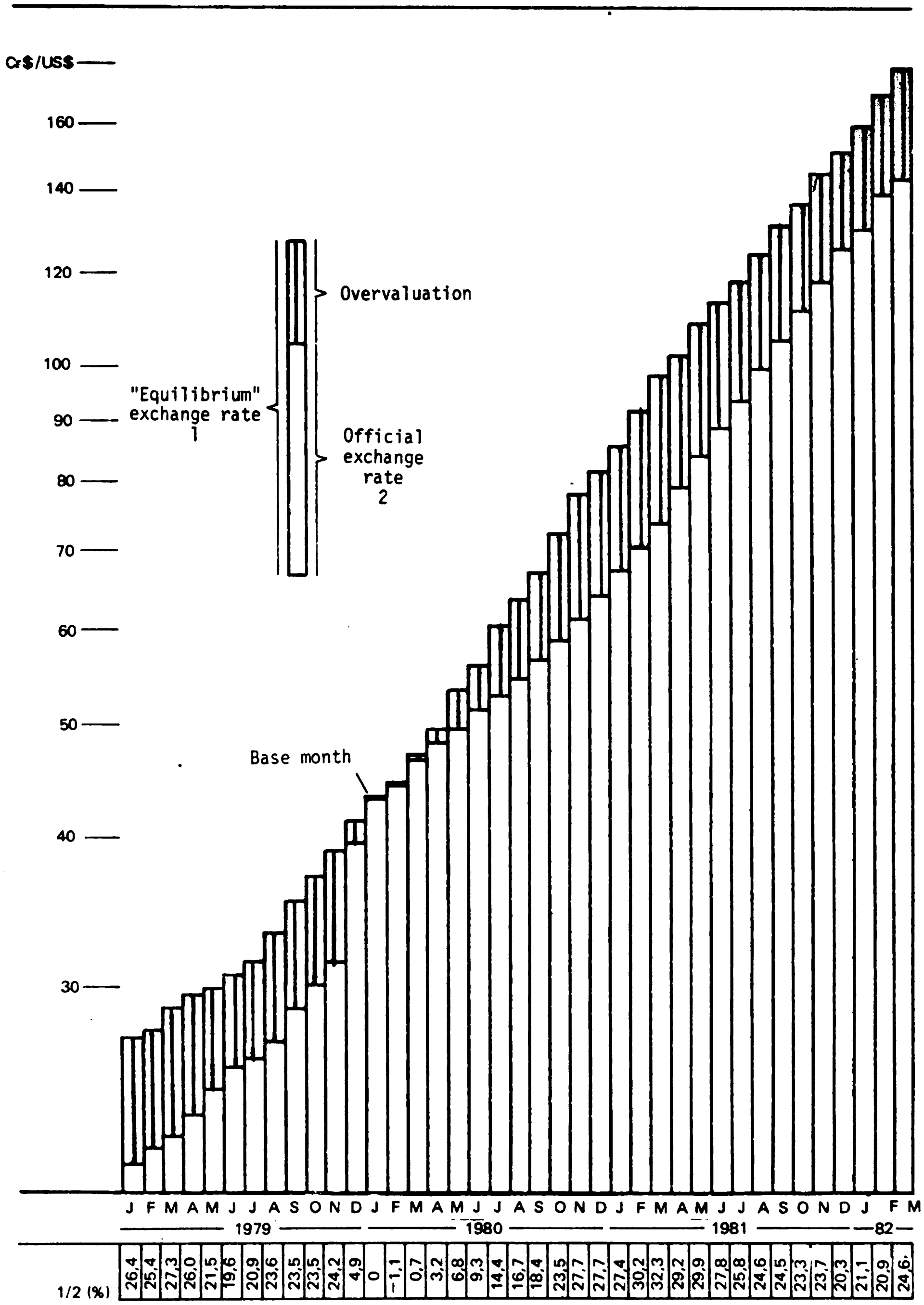

Figure 7.1.--Official and "equilibrium" exchange rates: Cr$/US$--Base: January 1980. (From Conjuntura Econômica 36 [May 1982].)

IPA_b = wholesale price index in the base period at the internal level (Brazil)

IPA_t = wholesale price index in period t at the internal level (Brazil)

Table 7.1.--Current values of Brazilian official and "equilibrium" exchange rates and degree of overvaluation, 1971-80.

Year	Official Exchange Rate (Cr$/US$) A	"Equilibrium" Exchange Rate (Cr$/US$) B	Degree of Overvaluation (%) [(B-A)/A]*100
1971	5.29	7.02	32.7
1972	5.93	7.90	33.2
1973	6.13	7.96	29.9
1974	6.79	8.71	28.3
1975	8.13	10.23	25.8
1976	10.67	13.69	28.3
1977	14.14	18.20	28.7
1978	18.06	23.38	29.5
1979	26.87	32.84	22.2
1980	52.70	59.17	12.3

Source of base data: Conjuntura Econômica and International Monetary Fund, various issues.

Evidently in January 1980, as shown by the formula, the "equilibrium" and the official exchange rates were identical. The degree of overvaluation, as shown in Figure 7.1, is obtained by the ratio between the theoretical equilibrium and the official exchange rates.

Simulation Analysis

To assess the effect of governmental intervention on the agricultural sector through the maintenance of an overvalued exchange

rate, it is necessary first to construct a baseline scenario for the 1971-80 period. The results of this baseline scenario are then compared with those under a new scenario, in which changes in the exogenous variables influencing the government's decision to restrict trade would be permitted.

As previously stated, the current rate of inflation and the country's overall balance-of-payments position were hypothesized to influence the government's decision to intervene in the export market. The desire to hold down the domestic price of exportable goods is closely related to the current rate of inflation. So a higher rate of inflation may serve as a proxy for an increase in government intervention, introducing a larger differential between the prices facing exporters and the prices in the local market. On the other hand, the need to increase foreign-exchange earnings and consequently to improve the overall balance-of-payments position may influence the government's decision to reduce the level of intervention.

To construct an alternative scenario, in which the net effect of governmental intervention would be smaller, different assumptions about the rate of inflation and the overall balance-of-payments position should be made. However, these assumptions would introduce unnecessary artibrariness in the simulation. Consequently, an alternative scenario was run changing only the "equilibrium" exchange rates for the period, presented in Table 7.1, instead of the official rates used in the baseline scenario. As a result of that, the changes observed in the endogenous variables between the two scenarios are attributed only to changes in the exchange rate.

Comparison Between the Baseline and Alternative Scenarios

Comparing the results of the two scenarios provides a means of analyzing the effect of a reduction of the degree of intervention on the agricultural sector. Because the model allows for some cross-price effects among products and is solved as a simultaneous dynamic system, commodity interaction is to be expected and all commodities must be considered simultaneously.

The percentage changes in the endogenous variables between the two scenarios for the 1971-80 period are presented, for each commodity, in Tables 7.2 to 7.10. The changes for the average values in the period are shown in Table 7.11. The percentage changes related to net trade are reported only in the cases where the simulated results did not change from a deficit to a surplus position and vice-versa during the considered period. However, the average net trade values for all the commodities are presented in Table 7.12.

Comparisons between the rates of overvaluation (Table 7.1) and percentage increase in prices (Tables 7.2 to 7.10) in general reinforced the results obtained in the previous chapter. These results showed that the exchange-rate elasticity of the price was greater than one only for corn and soyoil. The other commodities showed price changes smaller than the corresponding change in the exchange rate in all years.

The use of "equilibrium" exchange rate in the simulation caused an increase in the areas of corn and wheat and consequently

Table 7.2.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: corn (in percent).

Year	Production	Price	Demand
1971	0.00	45.39	-9.32
1972	5.59	46.72	-8.53
1973	9.52	34.94	-5.07
1974	13.04	31.25	-7.87
1975	15.24	30.18	-7.04
1976	16.76	36.24	-8.00
1977	18.92	42.19	-7.23
1978	20.29	41.35	-7.51
1979	22.70	32.12	-1.47
1980	22.66	17.12	-3.85

Table 7.3.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: rice (in percent).

Year	Production	Price	Demand	Retail Price
1971	0.00	0.00	0.69	0.00
1972	-0.41	0.60	0.91	0.16
1973	-0.53	0.53	1.67	0.28
1974	-0.54	0.44	0.77	0.24
1975	-0.62	0.49	0.47	0.24
1976	-0.59	0.64	0.40	0.30
1977	-0.47	0.78	0.44	0.31
1978	-0.55	0.86	0.53	0.28
1979	-0.61	1.00	0.49	0.37
1980	-0.55	0.61	0.21	0.49

Table 7.4.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: wheat (in percent).

Year	Production	Price	Wheat-Flour Demand	Wheat-Flour Retail Price	Imports
1971	0.00	12.46	2.16	3.99	3.54
1972	5.41	13.04	0.00	7.81	0.46
1973	8.09	11.11	-2.54	11.26	-4.38
1974	7.82	8.25	0.00	7.40	-7.23
1975	7.14	8.01	0.62	5.96	-10.05
1976	6.71	8.92	0.57	7.29	-1.90
1977	6.98	12.79	0.85	7.32	-4.48
1978	6.71	13.31	0.81	8.58	-1.76
1979	6.95	12.50	0.52	9.30	-4.78
1980	6.55	4.79	0.24	10.24	-3.03

Table 7.5.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: soybeans (in percent).

Year	Production	Price	Crush Demand	Ending Stocks	Exports
1971	0.00	6.29	-3.65	6.81	5.35
1972	-0.28	5.98	4.81	18.50	-12.31
1973	-0.66	3.83	8.60	11.63	-13.25
1974	-0.99	4.46	2.60	7.56	-6.79
1975	-0.89	5.03	1.07	9.00	-4.84
1976	-0.99	5.63	0.90	10.75	-5.28
1977	-0.89	5.50	1.62	3.84	-9.63
1978	-0.57	5.67	1.52	9.05	-14.71
1979	-0.50	5.26	1.04	12.68	-17.25
1980	-0.66	3.64	0.86	10.78	-7.04

Table 7.6.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: soymeal (in percent).

Year	Production	Price	Demand	Ending Stocks	Exports
1971	-3.24	2.47	52.85	-1.64	-24.78
1972	4.55	2.70	43.49	4.82	-4.96
1973	8.43	1.47	164.78	7.94	0.63
1974	2.68	2.01	16.78	2.97	-1.78
1975	0.92	2.12	11.00	0.93	-1.82
1976	0.97	2.51	10.09	0.96	-1.73
1977	1.57	2.10	9.17	1.74	-0.44
1978	1.60	2.18	7.64	0.88	-0.71
1979	0.94	2.33	4.71	1.34	-0.17
1980	0.79	1.60	1.94	0.56	0.30

Table 7.7.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: soyoil (in percent)

Year	Production	Price	Demand	Ending Stocks	Exports
1971	-3.25	34.08	-20.83	103.92	-86.44
1972	4.55	42.36	-4.92	96.10	55.65
1973	8.35	44.72	-2.99	43.53	108.83
1974	2.67	29.12	-4.04	8.55	66.43
1975	0.96	30.67	-3.57	2.68	12.61
1976	0.81	45.30	-3.58	5.83	9.85
1977	1.46	42.06	-2.84	2.27	12.41
1978	1.47	43.55	-3.01	2.74	13.64
1979	1.13	39.29	-1.18	-3.73	9.79
1980	0.93	29.63	-0.86	-5.88	6.76

Table 7.8.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: beef (in percent).

Year	Production	Price	Meat Demand	Retail Price
1971	-0.56	1.03	-1.18	2.16
1972	-1.18	4.37	-1.84	2.72
1973	-0.61	3.37	-1.91	2.79
1974	0.00	3.24	-2.53	2.66
1975	1.06	4.62	-1.70	3.10
1976	1.39	5.23	-1.59	3.43
1977	2.13	4.61	-2.11	3.42
1978	2.50	5.41	-1.55	3.49
1979	3.02	4.24	-1.59	2.82
1980	3.59	2.96	-1.06	2.43

Table 7.9.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: hogs (in percent).

Year	Production	Price	Meat Demand	Retail Price
1971	0.00	0.74	0.81	0.83
1972	-2.33	2.10	0.83	1.17
1973	-5.06	2.67	0.43	1.41
1974	-7.62	2.44	0.21	1.09
1975	-10.42	2.76	-0.19	1.58
1976	-10.78	3.68	-0.38	1.69
1977	-11.76	4.55	-0.63	1.96
1978	-12.73	5.51	-1.06	2.36
1979	-13.40	4.69	-1.48	2.33
1980	-13.61	5.60	-2.20	2.50

Table 7.10.--Rate of change between the results of the baseline and alternative scenarios for the 1971-80 period: chicken (in percent)

Year	Production	Price	Meat Demand	Retail Price
1971	-4.72	1.49	0.00	0.45
1972	-3.43	2.22	-0.67	0.90
1973	-4.46	1.43	0.00	0.88
1974	-2.16	2.24	0.00	0.90
1975	-1.79	2.68	0.00	1.00
1976	-1.55	2.31	-0.25	1.09
1977	-1.54	2.91	0.00	1.71
1978	-1.34	3.30	0.00	1.22
1979	-1.02	3.00	0.00	1.25
1980	-0.77	2.47	0.00	1.38

Table 7.11.--Rate of change between the average results of the baseline and alternative scenarios for the 1971-80 period: all nine commodities (in percent).

Product	Production	Price	Demand	Retail Price	Ending Stocks
Corn	14.81	35.81	-7.28	..	..
Rice	-0.51	0.59	0.69	0.29	..
Wheat	6.38	10.03	0.60	7.62	..
Soybeans	-0.61	5.32	1.56	..	8.46
Soymeal	1.58	2.05	11.07	..	1.58
Soyoil	0.93	37.50	-3.24	..	8.55
Beef	1.49	4.05	-1.69	3.17	..
Hogs	-8.57	2.80	-0.36	1.69	..
Chickens	-1.68	2.75	-0.29	1.56	..

in their productions, due to an increase in their respective producer prices (Tables 7.2 and 7.4). Wheat production also responded positively to an increase in the price of soybeans, as postulated by the equation used to estimate area of wheat. As expected, the increase was more evident in the case of corn, which presented a more elastic response of domestic price to change in the exchange rate. The average increase in production during the period considered was around 15 percent (Table 7.11). This growth in production was mainly due to an average increase of 35.81 percent in producer price. As pointed out earlier, although the response of corn hectarage to price was rather inelastic, price policy efforts could still contribute to expand its production. The area and production of soybeans decreased slightly (less than 1 percent) in spite of the 5.32 percent average increase in its producer price. This was a consequence of a much larger increase in the price of wheat in all the years of the simulation analysis. (See Tables 7.4 and 7.5.) The negative cross-effect of the price of wheat was stronger than the incentive given by the price of soybeans. Because the producer price of rice was not responsive to changes in exchange rate, it showed no change in area or production between the two scenarios (Table 7.3).

Soymeal and soyoil productions had insignificant increases; they averaged, respectively, 1.58 percent and .93 percent (Table 7.11). Although the price of soyoil increased substantially (Table 7.7), this did not increase production significantly. This is explained by the fact that supplies of soyoil and soymeal are directly related to

the domestic crush of soybeans. The price of soyoil has only a small weight given by the extraction rate (.185), in the composition of crush margin, or relative profitability of soybeans. A rather inelastic price (margin) elasticity, the increase in the price of soybeans, and the decrease in soybean production resulted in a small increase in the amount of beans demanded for crushing (Table 7.5).

Producer prices of hogs and chickens also rose, following the increase in beef price. But in both cases the increase was not enough to expand production, since the prices of corn and soymeal also increased in the same period. Production, in fact, declined due to the higher costs of production (Tables 7.9 and 7.10). Beef production, because of its investment nature, fell at the beginning of the period in response to an increase in the respective producer price (Table 7.8). As discussed earlier, the first reaction of a beef-cattle producer to an increase in price is to withhold animals from slaughter to increase future production. But within the analyzed period, an increase in price was sufficient to increase production slightly.

Because retail prices were hypothesized to be a direct function of farmer prices, they moved together. The increases in retail prices were generally smaller due to the effect of other variables included in the structural equations. The quantity demanded of rice and wheat flour increased slightly in spite of a rise in retail prices due to cross-price effects. In the case of soyoil and the three meats, the increase in their respective retail prices and the

cross-price effects led to decreases in the quantities demanded. With the exception of soyoil, the decline in consumption was almost negligible.

The most significant changes in demand occurred in feed use. The large increase in the price of corn caused quantity demanded to decline, inducing at the same time an increase in the demand for soymeal since corn is a substitute in the soymeal-demand equation. Further decline in the demand for corn resulted from a decrease in the number of chickens and hogs during the simulation period. Stocks showed an average increase when comparisons were made between the two different scenarios.

Table 7.12 presents average net trade results for the period simulated. The changes in these values are a consequence of changes in production and consumption caused by the adoption of "equilibrium" exchange-rate scenario. The most significant results related to corn. On average, the simulated results indicated that it would be possible to export approximately 35 times more corn under the "equilibrium" exchange-rate scenario. Corn exports would increase from 96,000 metric tons to 3.4 million metric tons. The surpluses of soyoil and beef would have increased by 14 and 50 percent, respectively. The average import of wheat would decline by 100,000 metric tons (3.5 percent), and the exports of soybeans would have been about 9 percent less, on the average. The average deficit of rice would increase, and hogs would move from a surplus to a deficit position. These changes, though, are only a small fraction of the total amount consumed. Soymeal exports would decline 1.2 percent.

Table 7.12.--Net trade average results of the simulated baseline and alternative scenarios for the 1971-80 period: all nine commodities (in metric tons).[a]

Product	Scenario	
	Baseline	Alternative
Corn	96,100	3,400,000
Rice	-112,000	-161,000
Wheat	-3,010,000	-2,910,000
Soybeans	1,450,000	1,320,000
Soymeal	3,430,000	3,390,000
Soyoil	291,000	332,000
Beef	111,000	167,000
Hogs	3,710	-45,200
Chickens	37,500	30,600

[a]Exports are shown with a positive sign, and imports have a negative sign.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Summary

Previous studies have suggested that overvaluation of the exchange rate was one of the restrictive policies that have discriminated against the Brazilian agricultural sector. This study was an attempt to measure the effect of this restriction on several important agricultural commodities. To accomplish this, an econometric simulation model was constructed, in which simultaneous interactions between the consumer and farm levels of the market channels were possible.

The specific objectives of this study were:

1. To build an econometric model that linked the supply, demand, trade, and government sectors for the major agricultural-commodity markets.

2. To integrate this econometric model into a model system that can be used for prediction and policy-analysis simulation, i.e., for testing the operation of stabilization schemes under alternative assumed conditions.

3. To quantify the effects of overvaluation of the domestic currency on Brazilian agriculture.

The products considered in this study included corn, rice, wheat, soybeans, soymeal, soyoil, beef, hog meat, and chicken meat.

These products were chosen mainly because of their importance in the domestic economy and because of their interrelationships.

The basic approach to constructing the conceptual models for the analyzed commodities was very similar. Functional relationships were established for domestic disappearance, including food and industrial use, feed, seed (in the case of crops), carry-over stocks, and production. The conceptual model focused on the effect of government intervention on the values of several agricultural prices. A set of price relationships was postulated to explain the level of government intervention through economic variables.

The full model consisted of 48 equations, 37 of which were structural equations. The remaining 11 equations were technical relationships and identities. Estimation of the econometric equations was based on yearly time-series data covering the period from 1961 through 1980. It was felt that this was the most representative period to capture the current structure of production, consumption, and trade in Brazil. The simulations described in this study were carried out using the GSIM program developed in the Agricultural Economics Department at Michigan State University. GSIM uses the Gauss-Seidel straightforward numerical method to obtain the solution of simultaneous systems of equations.

The model developed in this study was then used to evaluate the effect of changes in government policy on Brazilian agriculture, represented by the products mentioned above. To assess the implications

of policy changes, simulations were carried out during the historical period (1971-80). The model was used to obtain baseline forecasts and alternative forecasts under different assumed conditions.

Conclusions

This study's results are only as reliable as the assumptions made in constructing the model and the data used. Nonetheless, they are very useful in pointing out the directions of changes in the agricultural sector if a different policy related to the exchange rate had been adopted.

Strong evidence of government intervention in domestic agricultural prices emanating from an overvalued exchange rate was found for corn and soyoil. Some indications of this kind of intervention were found for soybeans and wheat, and no evidence of such intervention was found for soymeal, rice, or beef. The consequences of the price intervention were to reduce domestic prices for corn, soyoil, and perhaps soybeans and to encourage domestic feed and food consumption. Exports of these products are also discouraged by such a policy. All agricultural commodities are affected by the price intervention even though the intervention is only evident for corn, soyoil, and perhaps soybeans. This occurs because of the interdependence between commodities. Low domestic corn prices, for example, encourage livestock feeding and larger livestock numbers. A removal of the price intervention on corn, wheat, soyoil, and soybeans would affect all Brazilian agricultural commodities.

The simulation results from the two scenarios show that the existence of "equilibrium" exchange rates over the 1971-80 period would have had the greatest impact on domestic corn price and production. Soybeans showed relatively small changes under the "equilibrium" exchange-rate scenario compared to the base scenario. This is somewhat surprising, given the large changes in corn. However, soybeans remain very profitable relative to corn even with the higher corn prices under the "equilibrium" exchange-rate scenario.[1]

Wheat, the second most important Brazilian import commodity, showed a slight reduction in imported volume under the alternative scenario. Since being self-sufficient in wheat production is a long-term Brazilian goal, this could be an indication that a devalued exchange rate alone would only partially reduce the country's dependence on foreign markets. The rice sector was practically unaffected in the alternative scenario.

Soymeal and soyoil productions had insignificant increases in spite of a large increase in soyoil price. This was due to the fact that supplies of soyoil and soymeal are directly related to the domestic crush of soybeans, which increased only marginally.

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[1]A comparison of corn and soybean revenue per hectare over the 1971-80 period shows how profitable soybean production was relative to corn. Brazilian corn and soybean yields over the 1971-80 period averaged 1488 and 1482 kg/ha, respectively. Under the "equilibrium" exchange-rate scenario, the 1971-80 average prices were Cr$2.06/kg and Cr$3.14/kg, respectively, for corn and soybeans. This gives a per-hectare revenue for corn of Cr$3065 and for soybeans, Cr$4653. Assuming production costs are approximately equal for the two crops, soybean production is much more profitable even when the "equilibrium" exchange rate was considered.

In the case of beef, where price effects are usually adverse in the short run, it is not appealing to policy makers to increase the price of beef because they have a tendency to care only about the short-run effects of the policies. As a result, beef production has been declining due to unprofitable prices, and demand has been increasing due to lower consumer prices, higher urbanization rates, and per-capita income. The beef price was shown to be only slightly responsive to variations in exchange rate. The simulation analysis, however, indicated that in the long run this sector responds positively even to small increases in prices. This result is somewhat surprising given different responses in the case of the other two livestock commodities. A reason for that could be the failure to include a variable representing the opportunity cost of land for pasture in the beef-production equation. A more complete specification, including cost variables, would probably give different results.

Overvaluation of the exchange rate was not the only governmental policy aimed at protecting the domestic consumer over the last two decades. A combination of quantitative export restrictions, taxation, and policies intervening directly in the domestic market have been depressing the prices of products considered important for the supply of the domestic market. Those policies that kept prices consistently lower than they would otherwise have been if they were allowed to follow world prices have had two opposite effects. On the one hand, they depressed production; on the other hand, they stimulated demand.

As previously stated, the improvement of Brazil's balance-of-payments position is of primary concern to the present government. This can be accomplished in the short run mainly through an increase in exports. However, this increase will be possible only if producers can expect better relative price conditions, which means not only higher producer prices but relatively lower input prices, as well.

In the aggregate, the results of this study contradict the argument that devaluation would benefit only exported products such as soybeans and products. Instead, the results showed that the maintenance of overvalued exchange rates had significant negative effects primarily on corn.

Suggestions for Further Research

This study is the first attempt to analyze the effect of a policy change on several Brazilian agricultural products simultaneously. Further work concerning the specification and estimation of the model equations may prove useful. One possible limitation was the use of residual net-trade equations, which carried the effect of errors throughout the model. This problem was even worse because of the absence of data on carryover stocks for most of the products.

Because of the number of products included, the necessity to keep the model manageable, and the unavailability of necessary data, various simplifications had to be made. For example, in the case of rice, the model could be improved if separate equations were estimated for irrigated and dryland areas. Several important explanatory variables could add additional validity to the model. These variables

are mainly related to cost of principal inputs, credit availability for certain products, and changes in the level of technology during the study period. The inclusion of these variables would permit a more accurate representation of Brazilian agriculture.

More detailed data on stocks and at a more disaggregated level would improve the model substantially. Consumption data, if available, would better represent the true demand relationships than did the "apparent" consumption used here. Stock data were another source of weakness in the model because it is known that stocks are held for several important commodities, but there are no statistics that take them into account. Consequently, there is a need to generate more refined and consistent series of data.

Finally, attempts should be made to extend the model developed in this study in order to quantify the effects of explicit forms of intervention on Brazilian agriculture.

APPENDICES

APPENDIX A

VARIABLE DEFINITION AND SOURCES

Variable	Description/Units	Source
AC	corn area (ha)	AEB, CFP
AR	rice area (ha)	AEB, CFP
AW	wheat area (ha)	AEB, CFP
AS	soybeans area (ha)	AEB, CFP
YC	corn yield (kg/ha)	AEB, CFP
YR	rice yield (kg/ha)	AEB, CFP
YW	wheat yield (kg/ha	AEB, CFP
YSB	soybeans yield (kg/ha)	AEB, CFP
YSM	soymeal extraction rate (percent)	AS
YSO	soyoil extraction rate (percent)	AS
TPC	corn production (MT)	AEB, CFP
TPR	rice production (MT)	AEB, CFP
TPW	wheat production (MT)	AEB, CFP
TPSB	soybeans production (MT)	AEB, AS
TPSM	soymeal production (MT)	AEB, AS
TPSO	soyoil production (MT)	AEB, AS
TPB	beef production (MT e.c.w.)	CFP
TPH	hog-meat production (MT e.c.w.)	CFP
TPCH	chicken-meat production (MT e.c.w.)	CFP
PC	corn producer price (real Cr$/MT), deflator = IND 17	PRA
PR	rice producer price (real Cr$/MT), deflator = IND 17	PRA
PW	wheat producer price (real Cr$/MT), deflator = IND 17	PRA, IWC
PSB	soybeans producer price (real Cr$/MT), deflator = IND 17	PRA
PSM	soymeal wholesale price (real Cr$/MT), deflator = IND 4	AE
PSO	soyoil retail price (real Cr$/MT), deflator = IND 6	AEB
PB	beef producer price (real Cr$/MT e.c.w.), deflator = IND 17	PRA

Variable	Description/Units	Source
PH	hog producer price (real Cr$/MT e.c.w.), deflator = IND 17	PRA
PCH	chicken producer price (real Cr$/MT e.c.w.), deflator = IND 17	PRA, CFP
ESSB	soybeans ending stocks (MT)	AS
ESSM	soymeal ending stocks (MT)	AS
ESSO	soyoil ending stocks (MT)	AS
NTC	corn net trade (MT)	AEB, CFP
NTR	rice net trade (MT)	AEB, CFP
MW	wheat imports (MT)	AEB, CFP
NTSB	soybeans net trade (MT)	AEB, CFP
NTSM	soymeal net trade (MT)	AEB, AS
NTSO	soyoil net trade (MT)	AEB, AS, GP
NTB	beef net trade (MT e.c.w.)	AEB, FAO
NTH	hog-meat net trade (MT e.c.w.)	AEB, FAO
NTCH	chicken-meat net trade (MT e.c.w.)	AEB, FAO
DC	corn disappearance (MT)	..
DR	rice apparent consumption (kg/capita)	..
DWFL	wheat-flour apparent consumption (kg/capita)	..
DSB	soybeans crushing demand (MT)	..
DSM	soymeal disappearance (MT)	..
DSO	soyoil apparent consumption (kg/capita)	..
DB	beef apparent consumption (kg/capita)	..
DH	hog-meat apparent consumption (kg/capita)	..
DCH	chicken-meat apparent consumption (kg/capita)	..
RPR	rice retail price (real Cr$/MT), deflator = IND 6	AEB
RPWFL	wheat-flour retail price (real Cr$/MT), deflator = IND 6	AEB
RPMFL	manioc-flour retail price (real Cr$/MT), deflator = IND 6	AEB
RPLARD	lard retail price (real Cr$/MT), deflator = IND 6	AEB
RPB	beef retail price (real Cr$/MT), deflator = IND 6	AEB

Variable	Description/Units	Source
RPH	hog-meat retail price (real Cr$/MT), deflator = IND 6	AEB
RPCH	chicken-meat retail price (real Cr$/MT), deflator = IND 6	AEB
WOPC	corn world price, U.S. origin, Rotterdam CIF (US$/MT)	AS
WOPR	rice world price, U.S.--New Orleans (US$/MT)	FAO, IFS
WOPW	wheat world price, U.S. Gulf Ports, (US$/MT)	IWC
WOPSB	soybeans world price, U.S. origin, Rotterdam CIF (US$/MT)	IFS, FAO
WPSM	soymeal world price, U.S. origin, Rotterdam CIF (US$/MT)	IFS, FAO
WPSO	soyoil world price, all origins, Dutch Ports, FOB (US$/MT)	IFS, FAO
WPB	beef world price, frozen, Argentina (US$/MT)	IFS
CCAP	crushing capacity (1,000 MT)	CFP
EXCH	exchange rate, annual average (Cr$/US$)	CE
BOP	overall position in the balance of payments (US$ million)	CE, IFS
FOREXCH	level of foreign-exchange reserves (US$ million)	CE, IFS
POP	population (1,000 heads)	AEB, CE
INCOME	disposable income (real Cr$), deflator = IND 2	CE
WAGE	average monthly wages paid to workers in the urban area (real Cr$/month), deflator = IND 2	CFP
IND2	general price index, 1977 = 100	CE
IND4	wholesale price index--all commodities, 1977 = 100	CE
IND6	wholesale price index--foodstuffs, 1977 = 100	CE
IND17	farm produce price index, 1977 = 100	CE
WPI	wholesale price index, U.S.A., 1977 = 100	IFS
INFL	inflation, annual change in the IND2	CE

Units

ha	hectares
kg	kilograms
MT	metric tons
e.c.w.	equivalent carcass weight
Cr$	cruzeiros

Sources

AS	U.S.D.A. Agricultural Statistics. Washington, D.C. (various issues).
AE	Anuário Estatístico. Ministerio da Agricultura, Comissão de Financiamento de Produção (CFP) (various issues).
AEB	Anuário Estatístico do Brazil. IBGE, Rio de Janeiro (various issues).
CFP	Comissão de Financiamento da Produçao. Estudo do Consumo de Alimentos Básicos no Brasil. Vol. I: Resumo e Conclusões Finais, Outubro 1981.
CE	Conjuntura Econômica. Rio de Janeiro, Fundação Getúlio Vargas (various issues).
FAO	Food and Agriculture Organization of the United Nations. Production and Trade Yearbook. Rome, Italy: FAO (various issues).
IFS	International Financial Statistics. Washington, D.C.: International Monetary Fund (IMF), (various issues).
IWC	International Wheat Council. Review of the World Wheat Situation. London: IWC (various issues).
PRA	Preços Recebidos Pelos Agricultores. Fundação Getúlio Vargas, Instituto Brasileiro de Economia (various issues).

APPENDIX B

HISTORICAL DATA

	AC	AR	AW	ASB
1961	.686570E+07	.317404E+07	.102223E+07	240919.
1962	.734790E+07	.334981E+07	743458.	313640.
1963	.792040E+07	.372180E+07	793494.	339796.
1964	.810590E+07	.418236E+07	733597.	359622.
1965	.877130E+07	.461890E+07	766640.	431834.
1966	.870320E+07	.400485E+07	716981.	490687.
1967	.925630E+07	.429115E+07	830869.	612115.
1968	.958480E+07	.445695E+07	970128.	721913.
1969	.965380E+07	.462070E+07	.140712E+07	906073.
1970	.985810E+07	.497917E+07	.186120E+07	.131881E+07
1971	.105505E+08	.476386E+07	.200822E+07	.171642E+07
1972	.105589E+08	.453300E+07	.234043E+07	.284000E+07
1973	.992357E+07	.478938E+07	.183939E+07	.361525E+07
1974	.106725E+08	.466468E+07	.247115E+07	.514312E+07
1975	.108547E+08	.530627E+07	.293151E+07	.582374E+07
1976	.111176E+08	.665648E+07	.353989E+07	.646311E+07
1977	.117974E+08	.599209E+07	.315333E+07	.706988E+07
1978	.111248E+08	.562352E+07	.281119E+07	.777841E+07
1979	.113136E+08	.543937E+07	.383000E+07	.825610E+07
1980	.114380E+08	.620768E+07	.308300E+07	.877450E+07
	1	2	3	4

	YC	YR	YW	YSB
1961	1312.00	1699.00	533.000	1127.00
1962	1305.00	1659.00	909.000	1101.00
1963	1345.00	1542.00	494.000	950.000
1964	1161.00	1517.00	877.000	848.000
1965	1381.00	1641.00	764.000	1212.00
1966	1307.00	1449.00	857.000	1213.00
1967	1395.00	1583.00	757.000	1169.00
1968	1337.00	1492.00	883.000	907.000
1969	1315.00	1384.00	976.000	1166.00
1970	1442.00	1517.00	991.000	1144.00
1971	1339.00	1384.00	1002.00	1210.00
1972	1413.00	1491.00	420.000	1291.00
1973	1430.00	1495.00	1104.00	1386.00
1974	1525.00	145.000	1157.00	1531.00
1975	1505.00	1466.00	607.000	1699.00
1976	1597.00	1466.00	908.000	1739.00
1977	1632.00	1501.00	655.000	1770.00
1978	1220.00	1297.00	957.000	1226.00
1979	1442.00	1394.00	775.000	1240.00
1980	1781.00	1570.00	878.000	1727.00
	1	2	3	4

	YSM	YSO	TPC	TPR
1961	.602800	.159500	.903620E+07	.539249E+07
1962	.602800	.159500	.958730E+07	.555683E+07
1963	.602800	.159500	.104183E+08	.574007E+07
1964	.602800	.159500	.940800E+07	.634493E+07
1965	.602800	.159500	.121119E+08	.757965E+07
1966	.615100	.156900	.113715E+08	.580181E+07
1967	.650100	.158300	.128243E+08	.679199E+07
1968	.702700	.161300	.128136E+08	.665251E+07
1969	.674800	.161700	.126934E+08	.639429E+07
1970	.741400	.178100	.142160E+08	.755308E+07
1971	.700000	.180000	.141297E+08	.659318E+07
1972	.740100	.179600	.148914E+08	.676100E+07
1973	.749800	.194900	.141859E+08	.716013E+07
1974	.775600	.185200	.162732E+08	.676404E+07
1975	.775700	.185200	.163345E+08	.778154E+07
1976	.775800	.185100	.177511E+08	.975708E+07
1977	.775700	.185100	.192559E+08	.899370E+07
1978	.775800	.185200	.135694E+08	.729514E+07
1979	.774000	.183300	.163090E+08	.757982E+07
1980	.765100	.186900	.203739E+08	.974788E+07
	1	2	3	4

Note: The variables' names and units are defined in Appendix A.

	TPW	TPSB	TPSM	TPSO
1961	544858.	271488.	96788.4	25610.1
1962	675619.	345175.	120428.	31865.1
1963	392363.	322915.	144337.	38191.3
1964	643004.	304897.	152933.	40465.8
1965	585384.	523176.	157661.	41716.9
1966	614657.	594975.	231844.	59139.0
1967	629301.	715606.	258766.	63014.7
1968	856170.	654476.	319572.	73355.7
1969	.137369E+07	.105661E+07	402870.	96538.4
1970	.184426E+07	.150254E+07	662524.	159152.
1971	.201133E+07	.207729E+07	.120164E+07	308994.
1972	982901.	.366644E+07	.148838E+07	361184.
1973	.203134E+07	.501161E+07	.195936E+07	509309.
1974	.285853E+07	.787598E+07	.320000E+07	764104.
1975	.177818E+07	.989229E+07	.409892E+07	978627.
1976	.321575E+07	.112377E+08	.494880E+07	.118075E+07
1977	.206604E+07	.125130E+08	.630214E+07	.150384E+07
1978	.269100E+07	.953472E+07	.659506E+07	.157438E+07
1979	.296700E+07	.102403E+08	.670027E+07	.158677E+07
1980	.270800E+07	.151558E+08	.947368E+07	.231425E+07
	1	2	3	4

	TPB	TPH	TPCH	PC
1961	.136908E+07	534119.	7763.00	2036.66
1962	.135596E+07	588408.	7849.00	1802.76
1963	.136093E+07	574680.	7947.00	1346.67
1964	.143719E+07	577989.	15619.0	1670.63
1965	.149685E+07	595849.	18075.0	1444.14
1966	.145233E+07	665106.	25252.0	1415.64
1967	.150550E+07	667993.	30650.0	1456.35
1968	.169445E+07	717524.	43880.0	1230.43
1969	.182644E+07	719313.	63115.0	1428.07
1970	.184518E+07	766523.	85439.0	1410.55
1971	.183783E+07	690000.	113265.	1338.70
1972	.184496E+07	634970.	150153.	1425.91
1973	.178565E+07	584980.	199055.	1754.02
1974	.162186E+07	539010.	263884.	1622.97
1975	.179025E+07	495639.	372767.	1902.04
1976	.217578E+07	541503.	413170.	1480.13
1977	.244552E+07	509814.	496613.	1140.00
1978	.231995E+07	566259.	587394.	1537.92
1979	.211420E+07	610683.	682774.	1468.31
1980	.207760E+07	705285.	863586.	1477.56
	1	2	3	4

	PR	PW	PSB	PSM
1961	3054.99	4412.76	3054.99	2465.18
1962	5302.23	4630.97	3075.29	2625.75
1963	5899.71	4596.00	2949.85	2377.40
1964	3598.28	4786.99	2923.60	1983.82
1965	2459.55	4738.59	3001.11	2141.72
1966	4008.33	4215.11	3419.81	2230.00
1967	4190.19	4087.99	2759.40	2512.95
1968	4159.50	4173.98	3016.18	2342.65
1969	3323.95	3693.28	2798.68	2449.33
1970	2640.45	3404.79	2939.23	2442.24
1971	3993.87	3036.62	2966.24	2485.20
1972	3859.95	2724.67	2756.46	2832.57
1973	3452.48	2859.82	4575.72	3331.88
1974	4252.18	4131.19	3482.01	2424.34
1975	5404.16	3970.50	3162.13	2167.26
1976	2620.88	3184.52	2750.95	2561.55
1977	2481.00	3170.00	2300.00	2629.00
1978	3181.18	2914.33	2507.02	2111.59
1979	3222.47	2426.97	2695.73	2144.58
1980	2698.98	2505.29	2102.03	1837.87
	1	2	3	4

	PSO	PB	PH	PCH
1961	26263.6	14765.8	16802.4	16972.2
1962	16225.4	13997.9	12089.1	16967.1
1963	16309.5	13466.7	14685.1	16673.1
1964	27151.9	11308.9	19115.9	13172.3
1965	25631.5	12726.5	18841.5	17374.8
1966	20453.0	17210.4	13472.5	15588.0
1967	17426.6	14308.0	13158.2	14919.0
1968	17626.2	13480.3	13447.6	15570.9
1969	16054.4	11662.5	14174.0	11161.9
1970	16181.7	13980.5	13779.0	13688.6
1971	15978.7	15731.1	12592.6	12276.0
1972	13420.0	16434.3	13746.0	11716.1
1973	12182.3	20320.0	14337.2	14604.2
1974	17563.7	21104.5	20419.9	12983.8
1975	16160.2	18219.1	16286.2	12434.6
1976	12752.0	14200.3	11960.6	10241.3
1977	13230.0	13253.0	13752.0	9190.00
1978	11415.0	16934.7	12445.9	9283.71
1979	11641.6	22601.3	15151.5	9820.22
1980	7799.27	18377.2	12136.5	7582.56
	1	2	3	4

	ESSB	ESSM	ESSO	NTC
1961	0.	0.	0.	4400.00
1962	0.	0.	0.	-5200.00
1963	0.	0.	0.	699000.
1964	56000.0	2000.00	2000.00	62300.0
1965	173000.	3000.00	4000.00	558600.
1966	191000.	5000.00	5000.00	615300.
1967	107000.	6000.00	5000.00	422700.
1968	136000.	7000.00	6000.00	.123340E+07
1969	142000.	8000.00	8000.00	648500.
1970	260000.	14000.0	14000.0	.146850E+07
1971	133000.	24000.0	25000.0	.127850E+07
1972	289000.	32000.0	32000.0	170000.
1973	294000.	41000.0	44000.0	36749.0
1974	412000.	67000.0	150000.	.109957E+07
1975	610000.	86000.0	150000.	.114587E+07
1976	621000.	106000.	100000.	.137081E+07
1977	.109000E+07	138000.	100000.	.141954E+07
1978	300000.	94000.0	141000.	-.161141E+07
1979	121000.	102000.	176000.	-.151601E+07
1980	171000.	222000.	298000.	-.155368E+07
	1	2	3	4

	NTR	MW	NTSB	NTSM
1961	219283.	.188659E+07	73257.0	35000.0
1962	64065.0	.219955E+07	95771.0	49100.0
1963	-6.00000	.218608E+07	33346.0	62014.0
1964	18271.0	.262125E+07	-14.0000	43821.0
1965	348052.	.188883E+07	75286.0	105058.
1966	414795.	.240565E+07	121236.	184949.
1967	33650.0	.246162E+07	304543.	125359.
1968	232506.	.263747E+07	65763.0	234530.
1969	101510.	.237242E+07	310148.	295366.
1970	139623.	.199256E+07	289620.	525365.
1971	238236.	.173796E+07	212152.	911407.
1972	-2419.00	.181106E+07	.103207E+07	.140533E+07
1973	33021.0	.295516E+07	.178133E+07	.158149E+07
1974	63527.0	.240575E+07	.272404E+07	.203094E+07
1975	-88667.0	.208238E+07	.333314E+07	.313358E+07
1976	99762.0	.342600E+07	.363950E+07	.436765E+07
1977	408529.	.260807E+07	.258687E+07	.535366E+07
1978	160643.	.433443E+07	569158.	.541900E+07
1979	-688548.	.366621E+07	424992.	.517081E+07
1980	-253109.	.475512E+07	.108829E+07	.658193E+07
	1	2	3	4

	NTSO	NTB	NTH	NTCH
1961	-54.0000	50000.0	0.	0.
1962	-2770.00	37200.0	0.	0.
1963	-1421.00	29200.0	0.	0.
1964	-2374.00	41100.0	0.	0.
1965	-9666.00	85100.0	0.	0.
1966	-11495.0	51700.0	0.	0.
1967	-15273.0	30600.0	0.	0.
1968	-9914.00	93900.0	0.	0.
1969	-3575.00	145200.	0.	0.
1970	-2035.00	171700.	0.	0.
1971	3729.00	205400.	0.	0.
1972	61320.0	297000.	0.	0.
1973	92007.0	220000.	0.	0.
1974	2249.00	112400.	1623.00	0.
1975	264384.	85200.0	5652.00	3469.00
1976	452889.	148800.	11700.0	19636.0
1977	487225.	183000.	12338.0	32829.0
1978	504432.	21800.0	4895.00	50805.0
1979	447755.	-5500.00	1.00000	81096.0
1980	727595.	116900.	29.0000	168713.
	1	2	3	4

	DC	DR	DWFL	DSB
1961	.844228E+07	40.5866	25.2494	160565.
1962	.896518E+07	42.6960	26.1930	199781.
1963	.903998E+07	43.4580	26.4678	239444.
1964	.871318E+07	46.2978	27.1211	253704.
1965	.107723E+08	50.0208	22.0281	261548.
1966	.100126E+08	35.1434	23.4634	376922.
1967	.115754E+08	45.4971	25.3407	398071.
1968	.107478E+08	40.9001	26.1139	454778.
1969	.112172E+08	39.3640	24.7142	597021.
1970	.113395E+08	45.3681	24.7948	893612.
1971	.119337E+08	37.1957	25.7231	.171663E+07
1972	.137657E+08	39.9240	26.6297	.201105E+07
1973	.132414E+08	40.9050	27.1970	.261318E+07
1974	.141465E+08	37.3184	29.6081	.412563E+07
1975	.141348E+08	43.4547	32.0412	.528416E+07
1976	.152704E+08	51.2077	32.6146	.637897E+07
1977	.165377E+08	43.2604	36.1592	.812446E+07
1978	.142798E+08	35.4016	38.9784	.850098E+07
1979	.167832E+08	43.4254	37.3270	.865668E+07
1980	.206801E+08	49.5218	45.2280	.123823E+08
	1	2	3	4

	DSM	DSO	DB	DH
1961	61788.4	.357100	18.3542	7.43194
1962	71328.1	.467436	17.7980	7.94116
1963	82322.6	.518424	17.4289	7.52372
1964	109112.	.543590	17.7148	7.33405
1965	51603.0	.609620	17.4277	7.35562
1966	44895.4	.835511	16.8056	7.98035
1967	132427.	.912997	17.2004	7.79019
1968	84042.4	.932530	18.1423	8.13316
1969	106504.	1.08092	18.5224	7.92474
1970	131159.	1.66619	17.9676	8.22988
1971	260236.	3.08270	17.1012	7.22839
1972	75047.6	2.99351	15.8225	6.49035
1973	368871.	4.04219	15.6147	5.93416
1974	.114305E+07	6.38215	14.6886	5.22933
1975	946344.	6.78152	16.1890	4.65228
1976	561758.	7.20613	18.7780	4.90813
1977	916481.	9.18922	20.4510	4.49671
1978	.122006E+07	9.07491	20.2688	4.95100
1979	.152146E+07	9.50050	18.2409	5.25517
1980	.277175E+07	12.3817	16.4628	5.92159
	1	2	3	4

	DCH	RPR	RPWFL	RPMFL
1961	.108017	5497.02	8092.84	3359.29
1962	.105930	7780.62	6262.45	5408.48
1963	.104006	9017.53	7013.64	4063.46
1964	.198188	7145.25	6810.79	2675.67
1965	.223132	5684.40	7999.50	3100.58
1966	.302989	7755.66	6863.42	3431.71
1967	.357443	7584.39	6685.66	3945.64
1968	.497382	7257.85	7257.85	3770.31
1969	.695344	6090.82	6337.27	3098.22
1970	.917328	5982.90	7005.88	3781.94
1971	1.18656	6459.06	6372.16	4392.93
1972	1.53479	7192.16	5906.41	4379.59
1973	1.99523	6815.10	6125.94	4107.16
1974	2.56786	8414.81	6171.77	4404.52
1975	3.50637	9888.61	5118.81	5414.94
1976	3.64572	6971.29	3471.30	6995.68
1977	4.19217	5960.00	3560.00	5452.90
1978	4.73249	6289.78	2891.00	3838.86
1979	5.17768	6140.95	2131.50	3976.24
1980	5.83442	5842.40	1652.36	6396.61
	1	2	3	4

	RPLARD	RPB	RPH	RPCH
1961	27790.5	22751.6	31149.8	28401.3
1962	17839.5	21823.7	23152.1	28275.9
1963	19259.7	21486.2	26996.9	27943.2
1964	29006.7	20371.6	39371.5	23746.5
1965	29724.3	22324.2	36793.6	28070.6
1966	19080.3	25765.3	24735.8	22717.9
1967	19399.4	21372.2	24013.6	26961.9
1968	18003.2	20406.8	22904.6	25638.1
1969	19504.7	17533.1	20842.6	21546.7
1970	17855.7	21172.6	23745.6	23683.6
1971	15978.7	21964.7	23219.8	21192.3
1972	18201.4	22741.7	25192.7	20049.7
1973	15628.1	28158.4	30873.3	22693.8
1974	29472.2	30233.5	37248.1	22838.3
1975	21448.2	27963.1	31601.3	20200.3
1976	17485.6	22463.0	28975.3	17944.6
1977	20289.0	20920.0	30860.0	16760.0
1978	17298.6	23777.9	29174.0	16993.9
1979	21536.3	30097.1	32749.0	18599.1
1980	11150.5	28220.1	26876.3	14546.4
	1	2	3	4

	WOPC	WOPR	WOPW	WOPSB
1961	47.6355	132.280	62.9330	111.000
1962	48.8166	207.230	64.3000	100.000
1963	53.9344	205.030	66.1400	110.000
1964	54.7218	189.600	53.9300	110.000
1965	55.5092	182.980	59.5200	117.000
1966	57.8713	182.980	67.2400	126.000
1967	54.3281	187.390	62.4600	112.000
1968	47.6355	191.800	63.2000	106.000
1969	51.9660	187.390	53.2700	103.000
1970	58.2649	189.600	60.0000	117.000
1971	58.2649	191.800	60.0000	126.000
1972	55.9028	216.050	91.0000	140.000
1973	97.6331	396.830	177.000	291.000
1974	132.277	555.560	164.000	277.000
1975	119.286	418.870	152.000	220.000
1976	112.199	308.640	113.000	231.000
1977	95.2710	332.890	116.000	279.000
1978	100.783	399.030	141.000	268.000
1979	115.743	381.400	174.000	297.000
1980	125.585	496.040	181.750	297.000
	1	2	3	4

	WOPSM	WOPSO	WOPB	CCAP
1961	81.0000	286.900	400.139	210.000
1962	89.0000	227.500	359.574	380.000
1963	91.0000	223.800	380.738	380.000
1964	89.0000	235.200	515.881	530.000
1965	94.0000	269.700	625.451	544.000
1966	101.000	261.600	567.910	562.000
1967	98.0000	216.500	473.111	596.000
1968	97.0000	178.200	617.735	614.000
1969	95.0000	198.300	562.399	775.000
1970	103.000	291.400	730.611	1405.00
1971	102.000	306.000	865.375	2040.00
1972	130.000	230.600	1142.88	2671.00
1973	302.000	436.000	1568.81	3300.00
1974	184.000	832.200	1851.22	5000.00
1975	155.000	563.300	856.936	7963.00
1976	198.000	438.000	910.067	10273.0
1977	229.000	574.200	1165.36	12157.0
1978	214.000	606.700	1158.31	14387.0
1979	243.000	662.600	1916.04	20925.0
1980	260.000	597.800	2232.84	21000.0
	1	2	3	4

	EXCH	BOP	FOREXCH	POP
1961	.272300	115.000	185.000	71868.0
1962	.387700	-346.000	60.0000	74096.0
1963	.577000	-244.000	69.0000	76409.0
1964	1.27110	4.00000	154.000	78809.0
1965	1.89140	331.000	421.000	81006.0
1966	2.21630	153.000	368.000	83343.0
1967	2.66220	-245.000	142.000	85748.0
1968	3.39380	32.0000	200.000	88222.0
1969	4.07130	549.000	599.000	90768.0
1970	4.58900	545.000	962.000	93139.0
1971	5.28700	530.000	1450.00	95457.0
1972	5.93400	2439.00	3836.00	97333.0
1973	6.12600	2179.00	6030.00	100268.
1974	6.79000	-938.000	4874.00	102764.
1975	8.12600	-950.000	3653.00	105322.
1976	10.5700	1192.00	6101.00	107944.
1977	14.1380	630.000	6787.00	110631.
1978	18.0630	4262.00	11406.0	113384.
1979	26.8700	-3215.00	8342.00	116206.
1980	52.6990	-3490.00	5042.00	119099.
	1	2	3	4

	INCOME	WAGE	IND2	IND4
1961	559927.	1534.49	.736400	.811300
1962	614622.	1495.34	1.11680	1.21870
1963	626731.	1378.68	1.95840	2.14520
1964	644182.	1265.18	3.73070	3.88140
1965	654547.	1351.93	5.85090	5.97650
1966	660934.	1362.01	8.07630	8.43050
1967	715348.	1525.33	10.3584	10.2668
1968	799193.	1336.74	12.8671	13.1048
1969	866918.	1393.38	15.5019	16.4535
1970	938260.	1408.96	18.5953	18.6304
1971	.103120E+07	1416.62	22.3772	22.6139
1972	.116327E+07	1443.91	26.2481	26.6189
1973	.139477E+07	1554.98	30.1611	30.7034
1974	.162381E+07	1692.71	38.8136	39.6397
1975	.178930E+07	1770.99	49.6333	50.6630
1976	.201271E+07	1659.05	70.1003	71.1289
1977	.212707E+07	1736.00	100.000	100.000
1978	.230493E+07	1683.49	138.700	138.900
1979	.249660E+07	1676.81	213.500	215.800
1980	.261296E+07	1531.70	427.500	451.500
	1	2	3	4

	IND6	IND17	WPI	INFL
1961	.654900	.589200	48.9000	37.0600
1962	1.05390	.943000	48.9000	51.6600
1963	1.79650	1.55940	48.0000	75.3600
1964	3.28890	3.11260	49.0000	90.5000
1965	4.83780	4.43170	50.0000	56.8200
1966	7.28500	6.28690	51.6000	38.0400
1967	9.12400	7.82780	51.7000	28.2600
1968	10.6092	9.18380	53.0000	24.2200
1969	14.2017	12.1843	55.6000	20.4800
1970	16.1293	14.3915	56.8000	19.9500
1971	20.7151	18.0026	58.7000	20.3400
1972	24.8862	22.0210	61.4000	17.3000
1973	28.7303	26.2254	69.9000	14.9100
1974	36.7804	33.8885	83.0000	28.6900
1975	47.2766	42.0602	89.8000	27.8800
1976	69.7145	66.8860	94.3000	41.2400
1977	100.000	100.000	100.000	42.6500
1978	147.700	142.400	108.000	38.7000
1979	232.700	222.500	120.700	53.9300
1980	496.200	472.400	138.700	100.230
	1	2	3	4

APPENDIX C

COPY OF THE FORTRAN SUBROUTINES USED TO SOLVE FOR THE ENDOGENOUS VARIABLES IN THE MODEL

GSIM VERSION 1
SIMULTANEOUS EQUATION SOLUTION BY GAUSS-SIEDEL METHOD
AGRICULTURAL ECONOMICS DEPARTMENT
MICHIGAN STATE UNIVERSITY
(BASED ON GASSP, COURTESY OF USDA/ERS 1976)

ENDOGENOUS VARIABLES

1	AC	2	AR	3	AW
4	ASB	5	?	6	?
7	?	8	?	9	?
10	?	11	TPC	12	TPR
13	TPW	14	TPSB	15	TPSM
16	TPSO	17	TPB	18	TPH
19	TPCH	20	?	21	PC
22	PR	23	PW	24	PSB
25	PSM	26	PSO	27	PB
28	PH	29	PCH	30	?
31	DC	32	DR	33	DWFL
34	DSB	35	DSM	36	DSO
37	DB	38	DH	39	DCH
40	?	41	NTC	42	NTR
43	?	44	NTSB	45	NTSM
46	NTSO	47	NTB	48	NTH
49	NTCH	50	?	51	?
52	RPR	53	RPWFL	54	?
55	?	56	?	57	RPB
58	RPH	59	RPCH	60	?
61	?	62	?	63	MW
64	ESSB	65	ESSM	66	ESSO

EXOGENOUS VARIABLES

1	WOPC	2	WOPR	3	WOPW
4	WOPSB	5	WOPSM	6	WOPSO
7	WOPB	8	WOPWCR	9	EX
10	?	11	YC	12	YR
13	YW	14	YSB	15	YSM
16	YSO	17	?	18	?
19	?	20	?	21	TYC
22	TYR	23	TYW	24	TYSB
25	?	26	?	27	?
28	?	29	EXCH	30	EEXCH
31	TREND	32	D6168	33	D6973
34	D7175	35	D7374	36	D74
37	D77	38	D80	39	?
40	?	41	FOREXCH	42	BOP
43	INFL	44	WAGE	45	INCOME
46	RPMFL	47	RPLARD	48	POP
49	CCAP	50	XW	51	D72

```
      SUBROUTINE NONITR(J)
      COMMON NY, NZ, NYMAX, NZMAX, NCMAX, NYRMAX, CRIT, IYR0, IYR1,
     1       IYRFIN, INPAR(13),COMPON(20), EXOG (200), DEFINY(200),
     2       NFY(200),NLY(200),NFZ(200), NLZ(200), NAMY(200), NAMZ(200),
     3       EY(200),PREVY(200),YY(200),Y(200,40),ACTY(200,40),Z(200,40)
      INTEGER COMPON, DEFINY, EXOG
C AREA EQUATIONS    *COEF EREV / 1000 *
C CORN AREA
      IF(EXOG(1).EQ.0)YY(1) = 322337 + .87721 * Y(1,J-1) + .572338 * (Z(
     +21,J) * Y(21,J-1)) - .0236924 * (Z(22,J) * Y(22,J-1)) + EY(1)
C RICE AREA
      IF(EXOG(2).EQ.0)YY(2) = -4720390 + .504150 * Y(2,J-1) + .176669 *
     1(Z(22,J) * Y(22,J-1))- .08361 * (Z(24,J) * Y(24,J-1)) + 92228.5 *
     2 Z(31,J) + EY(2)
C WHEAT AREA          * RHO = -.4
      IF(EXOG(3).EQ.0)YY(3) = -8554154  + .179537 * Y(3,J-1) + .231815 *
     1 Y(3,J-2) + .220225 * (Z(23,J) * Y(23,J-1)) +.08809 * (Z(23,J-1) *
     2Y(23,J-2)) + .136256 * (Z(24,J) * Y(24,J-1)) + .054502 * (Z(24,J-1
     3) * Y(24,J-2)) + 81527.5 * Z(31,J) + 32611 * Z(31,J-1) + EY(3)
C SOYBEAN AREA
      IF(EXOG(4).EQ.0)YY(4) = 41962.2 + .999726 * Y(4,J-1) + .427635 *
     1 (Z(24,J) * Y(24,J-1)) - .276294 * (Z(23,J) * Y(23,J-1))   -
     2 29.1665 * Y(27,J-1) + 550451 * Z(51,J) + EY(4)
C CORN PRODUCTION
      IF(EXOG(11).EQ.0)YY(11) = YY(1) * .001 * Z(11,J) +EY(11)
C RICE PRODUCTION
      IF(EXOG(12).EQ.0)YY(12) = YY(2) * .001 * Z(12,J) +EY(12)
C WHEAT PRODUCTION
      IF(EXOG(13).EQ.0)YY(13) = YY(3) * .001 * Z(13,J) +EY(13)
C SOYBEANS PRODUCTION
      IF(EXOG(14).EQ.0)YY(14) = YY(4) * .001 * Z(14,J) +EY(14)
C HOG PRODUCTION
      IF(EXOG(18).EQ.0)YY(18) = 15437.1 + .941573 * Y(18,J-1) + 5164.83
     1* (Y(28,J-1) / Y(21,J-1)) - 83244.8 * Z(34,J) + EY(18)
C CORN PRICE
      IF(EXOG(21).EQ.0)YY(21) = -873.819 + 5.72959 * Z(1,J) +
     1 140.642 * Z(9,J) - 4.27928 *Z(43,J) - .141737E-01 * Z(42,J-1)
     2 - .976029E-05 *YY(11) + EY(21)
C RICE PRICE
      IF(EXOG(22).EQ.0)YY(22) = 4907.94 + 5.53340 * Z(2,J) - 1.11938
     1 * Z(43,J) - .224934 * Z(42,J-1) - .449290E-03 *YY(12) + EY(22)
C WHEAT PRICE
      IF(EXOG(23).EQ.0)YY(23)= 1510.27 + 12.1631 * Z(3,J-1)
     1 + 91.5264 * Z(9,J) - .159949 * Z(41,J-1) - .228675E-03 *
     2 Y(13,J-1) + EY(23)
C SOYBEANS PRICE      * RHO = -.630677
      IF(EXOG(24).EQ.0)YY(24) = - .630677 * Y(24,J-1) + (1.630677)
     1 * 707.180 + 9.11789 * (Z(4,J) + .630677 * Z(4,J-1)) + 38.1829
     2 *(Z(9,J) + .630677 * Z(9,J-1)) - 5.40461 * (Z(43,J) + .630677 *
     3 Z(43,J-1)) -.0693049 * (Z(42,J-1) + .630677 * Z(42,J-2))
     4 - .497102E-04 * (YY(14) + .630677 * Y(14,J-1)) + EY(24)
C SOYMEAL PRICE
      IF(EXOG(25).EQ.0)YY(25) = 1750.35 + 3.86164 * Z(5,J) + 13.6015
     1 * Z(9,J) - 6.40846 * Z(43,J) - .180191E-01 * Z(42,J-1)
     2 - .243454E-04 *YY(15) + EY(25)
C SOYBEANS CRUSH DEMAND
      IF(EXOG(34).EQ.0)YY(34) = 743111 + 288.410 * Z(49,J) + .361463 *
     1YY(14) - 1216310 * YY(24) / (Z(15,J) * Y(25,J-1) + Z(16,J) * Y(26,
     2J-1)) + EY(34)
C SOYOIL PRODUCTION
      IF(EXOG(16).EQ.0)YY(16) = YY(34) * Z(16,J) + EY(16)
C SOYMEAL PRODUCTION
      IF(EXOG(15).EQ.0)YY(15) = YY(34) * Z(15,J) + EY(15)
C SOYOIL PRICE
      IF(EXOG(26).EQ.0)YY(26) = - 8854.68 + 18.6771 * Z(6,J) +
     1 1332.52 * Z(9,J) - .591571E-02 *YY(16) - 6827.16 * Z(35,J)
     2 + EY(26)
C SOYBEANS STOCKS
      IF(EXOG(64).EQ.0)YY(64) = -470937 + .182177 * Y(64,J-1) + .0141159
     + * YY(14) + 200.412 * YY(24) - 123.367 * ( YY(24) - Y(24,J-1)) +
     + 716070 * Z(37,J) + EY(64)
C SOYMEAL STOCKS
      IF(EXOG(65).EQ.0)YY(65) = -1079.33 + .0202733 * YY(15) + 6.03498
     1*(YY(25) - Y(25,J-1)) + EY(65)
C SOYOIL STOCKS
      IF(EXOG(66).EQ.0)YY(66) = 18609.7 + .609565 * Y(66,J-1) + .0362919
     + * YY(16) + 8.66248 * (YY(26) - Y(26,J-1)) + 111402 * Z(38,J) +
     + EY(66)
      RETURN
      END
```

```
      SUBROUTINE XMODL(J,ITR)
      COMMON NY, NZ, NYMAX, NZMAX, NCMAX, NYRMAX, CRIT, IYR0, IYR1,
     1        IYRFIN, INPAR(13),COMPON(20), EXOG (200), DEFINY(200),
     2        NFY(200),NLY(200),NFZ(200), NLZ(200), NAMY(200), NAMZ(200),
     3        EY(200),PREVY(200),YY(200),Y(200,40),ACTY(200,40),Z(200,40)
      INTEGER COMPON, DEFINY, EXOG
C BEEF PRODUCTION
      IF(EXOG(17).EQ.0)YY(17) = 21207.2 + .766016 * Y(17,J-1) - 17.04 *
     1YY(27) + 2.612 * Y(27,J-1) + 14.14 * Y(27,J-2) + 17.55 * Y(27,J-3)
     2 + 12.83 * Y(27,J-4) + EY(17)
C BEEF PRICE
      IF(EXOG(27).EQ.0)YY(27) = 3436.29 + .425633 * Y(27,J-1)
     1 + 3.63778 * Z(7,J) + 108.866 * Z(9,J) - 13.2129 * Z(43,J)
     2 + EY(27)
C CHICKEN PRODUCTION
      IF(EXOG(19).EQ.0)YY(19) =-5033320 + 193417 * (YY(29)/YY(28)) -
     + 111.236 * YY(25) + 73813.1 * Z(31,J) + EY(19)
C CHICKEN PRICE
      IF(EXOG(29).EQ.0)YY(29) = 37210.9 - .350857E-02 * YY(19) + .324789
     1 * YY(27) - 403.192 * Z(31,J) + EY(29)
C HOG PRICE
      IF(EXOG(28).EQ.0)YY(28) = 26837.1 - .616893E-02 * YY(18) + .228766
     + * YY(27) - 177.164 * Z(31,J) + 5190.09 * Z(36,J) + EY028)
C WHEAT IMPORTS
      IF(EXOG(63).EQ.0)YY(63) = (YY(33)*Z(48,J))/(.75 * .97) - Y(13,J-1)
     1 + (.1/.97) * YY(3) + EY(63) + Z(50,J)
C RICE RETAIL PRICE
      IF(EXOG(52).EQ.0)YY(52) = 1841.06 + 1.04272 * YY(22) + 3.76997 *
     1 Z(44,J) - 61.0173 * Z(31,J) + EY(52)
C WHEAT-FLOUR RETAIL PRICE
      IF(EXOG(53).EQ.0)YY(53) = 26469.6 + .589265 * (Y(23,J-1) * Y(13,J-
     +1) + Z(8,J) * YY(63)) / (Y(13,J-1) + YY(63)) - 16.5386 * Z(43,J)
     1 - 307.496 * Z(31,J) + EY(53)
C BEEF RETAIL PRICE
      IF(EXOG(57).EQ.0)YY(57) = - 2627.67 + 1.08865 * YY(27) + 3.36715
     1 * Z(44,J) + 47.8662 * Z(31,J) + EY(57)
C HOG MEAT RETAIL PRICE
      IF(EXOG(58).EQ.0)YY(58) = -36164.9 + 1.04815 * YY(28)  + 14.4857
     1 * Z(44,J) + 360.992 * Z(31,J) + EY(58)
C CHICKEN MEAT RETAIL PRICE
      IF(EXOG(59).EQ.0)YY(59) = 26074.8 + .944777 * YY(29) + 2.054 *
     1 Z(44,J) - 271.21 * Z(31,J) + EY(59)
C CORN DEMAND
      IF(EXOG(31).EQ.0)YY(31) = 430284 - 2039.93 * YY(21) + 2086.54 *
     1 YY(25) + 732.447 * YY(53) + 3.65049 * YY(18) + 17.3326 * YY(19)
     2 + EY(31)
C RICE DEMAND
      IF(EXOG(32).EQ.0)YY(32) = 36.1603 - .199659E-02 * YY(52) + .886606
     1E-03 * YY(53) + .360187E-02 * Z(46,J) - .434969E-04 * Z(45,J)
     2 + EY(32)
C WHEAT-FLOUR DEMAND
      IF(EXOG(33).EQ.0)YY(33) = 37.1263 - .238501E-02 * YY(53) + .172947
     1E-02 * YY(21) + .238411E-03 * Z(45,J) + EY(33)
C SOYMEAL DEMAND
      IF(EXOG(35).EQ.0)YY(35) = 401756 - 342.716 * YY(25) + 273.493 *
     1 YY(21) + 2.43184 * YY(19) + EY(35)
C SOYOIL  DEMAND
      IF(EXOG(36).EQ.0)YY(36) = -1.41509 -.613581E-04 * YY(26) + .523997
     1E-04 * Z(47,J) + .318123E-05 * (YY(16) + Y(66,J-1)) + .255774E-03
     2 * Z(45,J) + EY(36)
C BEEF DEMAND
      IF(EXOG(37).EQ.0)YY(37) = 19.2472 - .432515E-03 * YY(57) + .119273
     1E-04 * YY(58) + .171858E-03 * YY(59) + .335504E-03 * Z(45,J) +
     2 EY(37)
C HOG MEAT DEMAND
      IF(EXOG(38).EQ.0)YY(38) = 5.29951 - .292639E-03 * YY(58) + .763243
     1E-04 * YY(57) + .299504E-03 * YY(59) + .715536E-04 * Z(45,J) +
     2 EY(38)
C CHICKEN MEAT DEMAND
      IF(EXOG(39).EQ.0)YY(39) = .267545 - .151471E-03 * YY(59) + .454834
     1E-04 * YY(57) + .289071E-03 * Z(45,J) + EY(39)
      RETURN
      END
```

```
      SUBROUTINE YREND(J)
      COMMON NY, NZ, NYMAX, NZMAX, NCMAX, NYRMAX, CRIT, IYR0, IYR1,
     1        IYRFIN, INPAR(13),COMPON(20), EXOG (200), DEFINY(200),
     2        NFY(200),NLY(200),NFZ(200), NLZ(200), NAMY(200), NAMZ(200),
     3        EY(200),PREVY(200),YY(200),Y(200,40),ACTY(200,40),Z(200,40)
      INTEGER COMPON, DEFINY, EXOG
C CORN NET TRADE
      IF(EXOG(41).EQ.0)YY(41) = .95 * YY(11) - .02 * YY(1) - YY(31)  +
     1EY(41)
C MILLED RICE NET TRADE
      IF(EXOG(42).EQ.0)YY(42) = .68 * ( .90 * YY(12) - .076 * YY(2)) -
     1 YY(32) * Z(48,J) + EY(42)
C SOYBEANS NET TRADE
      IF(EXOG(44).EQ.0)YY(44) = .95 * YY(14) - .10 * YY(4) - YY(64) +
     1 Y(64,J-1) - YY(34) + EY(44)
C SOYMEAL NET TRADE
      IF(EXOG(45).EQ.0)YY(45) = YY(15) - YY(35) - YY(65) + Y(65,J-1) +
     1 EY(45)
C SOYOIL NET TRADE
      IF(EXOG(46).EQ.0)YY(46) = YY(16) - YY(36) * Z(48,J) - YY(66)  +
     1 Y(66,J-1) + EY(46)
C BEEF NET TRADE
      IF(EXOG(47).EQ.0)YY(47) = YY(17) - YY(37) * Z(48,J) + EY(47)
C HOG NET TRADE
      IF(EXOG(48).EQ.0)YY(48) = YY(18) - YY(38) * Z(48,J) + EY(48)
C CHICKEN NET TRADE
      IF(EXOG(49).EQ.0)YY(49) = YY(19) - YY(39) * Z(48,J) + EY(49)
      RETURN
      END
```

```
      SUBROUTINE COEF
      COMMON NY, NZ, NYMAX, NZMAX, NCMAX, NYRMAX, CRIT, IYR0, IYR1,
     1        IYRFIN, INPAR(13),COMPON(20), EXOG (200), DEFINY(200),
     2        NFY(200),NLY(200),NFZ(200), NLZ(200), NAMY(200), NAMZ(200),
     3        EY(200),PREVY(200),YY(200),Y(200,40),ACTY(200,40),Z(200,40)
      INTEGER COMPON, DEFINY, EXOG
      DO 100 J=1,NYRMAX
      Z(21,J)= 280.594 + 16.0015 * Z(31,J)
      Z(22,J)= 2206.92 - 10.0293 * Z(31,J)
      Z(23,J)= 299.471 + 7.45714 * Z(31,J)
      Z(24,J)= -1125.33 + 34.1579 * Z(31,J)
  100 CONTINUE
      NFZ(21) = NFZ(31)
      NLZ(21) = NLZ(31)
      NFZ(22) = NFZ(32)
      NLZ(22) = NLZ(32)
      NFZ(23) = NFZ(33)
      NLZ(23) = NLZ(33)
      NFZ(24) = NFZ(34)
      NLZ(24) = NLZ(34)
      RETURN
      END
```

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