AN ECONOMETRIC STUDY ON THE MARKET STRUCTURES OF THE WORLD DEMAND FOR HIGH PROTEIN MEALS, WITH SPECIAL EMPHASIS UPON THE UNITED STATES SOYBEAN ECONOMY

by

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CHAPTER I

INTRODUCTION

The predominant feature of the world commodity markets in the past three years has been a sharp and accelerating rise in prices of a large number of agricultural products and an increase in their within-year price variability. The value of world trade in principal agricultural commodities (excluding forestry and fishery products) increased a record 46 percent from approximately U.S. $41 billion in 1972 to about U.S. $60 billion in 1973.[1] The extraordinary price explosion of 1973 indicates a growing interdependency of countries in the production, consumption, and trade of agricultural products.

The concurrent upward price movements of primary products since mid-1972 was the steepest in recent years. The United Nations Export Prices Index for all primary agricultural commodities which had increased by 13 percent from 1971 to 1972 increased 48 percent from 1972 to 1973 (Table I-1). A striking feature of price movements in 1973 was the relatively greater increase in those products which are used as inputs in other industries. For instance, the prices of

[1] Food and Agriculture Organization of the United Nations, FAO Commodity Review and Outlook, 1973-1974, Rome: CCP 74/24, 1974, p. 3.

Table I-1. Changes in International Price Indices of Selected Agricultural Commodities (1963 = 100)

Commodity	Annual			Quarterly 1973 and 1974					Rates of Change (%)			
	1971	1972	1973	I	II	III	IV	V	1961/ 1971	1971/ 1972	1972/ 1973	1973/ 1974
All Primary Commodity	112	126	190	158	180	207	215	216	1.2	13	48	36
Sugar	54	88	114	109	111	110	127	231	-2.8	63	30	112
Cocoa	97	116	206	140	203	262	217	240	4.4	20	77	71
Coffee	131	150	196	178	192	206	209	207	2.7	15	31	19
Rubber	69	70	104	82	93	116	123	158	-3.1	1	49	97
Cotton	114	119	216	146	170	261	286	279	0.4	4	81	91
Rice	83	96	229	151	182	244	338	370	1.3	16	138	146
Fats and Oils	131	114	204	141	171	234	265	366	1.8	-13	80	158
Oilcakes and Meals	109	136	295	240	321	356	266	245	1.5	24	117	2
Wheat	95	99	222	147	152	282	280	...	-0.5	5	124	...

Table I-1. (Continued)

Commodity	Annual			Quarterly 1973 and 1974					Rates of Change (%)			
	1971	1972	1973	I	II	III	IV	V	1961/ 1971	1971/ 1972	1972/ 1973	1973/ 1974
Maize	109	108	186	140	173	217	213	241	1.3	- 1	73	69
Beef	136	149	186	180	192	205	168	188	3.0	10	25	4
Pigs	...	174	264	232	240	316	267	256	...	...	51	10
Poultry	...	73	83	75	80	86	90	91	...	...	14	21
Wool	59	104	245	253	255	252	220	216	- 3	76	135	- 2

Source: Food and Agriculture Organization, FAO Commodity Review and Outlook 1972-1973 and 1973-1974, Rome: CCP 73/15, 1973, and CCP 74/24, 1974.

feedgrains and oilcakes and meals rose much more than prices of meat and dairy products.

During the last two decades changes in the value of United States agricultural exports primarily resulted from increases in volume. However, in fiscal year 1973, approximately 35 percent of the increase in value of U.S. agricultural exports were due to higher prices of many agricultural products. In fiscal 1974, exports of farm products reached $21.3 billion surpassing 1973's record by a hefty $8.4 billion.[2] Approximately 80 percent of this value gain was attributable to a sharp advance in prices.

The growing importance of exports in the total demand for United States farm products makes United States prices more dependent on fluctuations in foreign supply and demand. Even though foreign trade amounts to only about 5 percent of gross national product that is no assurance that inflationary pressures transmitted from abroad will not be strong. Between mid-1972 and January 1973, the domestic food prices rose faster than at any other time since 1951. Retail food prices increased 4.6 percent, wholesale prices of processed foods and feeds 11.3 percent, and farm food prices 13 percent during the seven month period. Unfavorable circumstances of decreases in foreign supplies and strong export demand have been suggested as the main factors.[3]

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[2]U.S. Department of Agriculture, Foreign Agricultural Trade of the United States, Washington, D.C.: Economic Research Service, USDA, December 1974, p. 41.

[3]U.S. Government Printing Office, Economic Report of the President, Washington, D.C., January 1973.

Statement of Problem

World production of oilcakes and meals (including fish meal) in 1972 and 1973 have shown an unusually small annual increase of some 0.5 and 0.4 million tons (compared with an average annual growth of about 1 million tons over the preceding decade) for 1972 and 1973, respectively (Table I-2). With much of the expansion taking place in major exporting countries, and with a strong import demand encouraging heavy drawings from existing stocks, gross world exports expanded by 0.8 and 0.22 million tons in 1972 and 1973, respectively. The expansion of exports in 1972 was greater than the average annual export increase during the sixties of 0.65 million tons. Even the relatively small increase in export level in 1973 could only be achieved by a reduction of exporters' stocks. Indeed, the reduction in the U.S. and Canadian stocks alone (of soybean, rapeseed and linseed meals) was more than the increase in export levels of all oilcakes and meals between 1972 and 1973.[4]

As a result, the price of international protein feeds increased dramatically. The Food and Agriculture Organization (FAO) price index for all oilcakes and meals which had fallen somewhat in 1971 to a level of 103, started to rise again in February 1972. It reached 125 by August, and 192 by December, averaging 129 for 1972. The rapid rise in the price index continued to an average of 279 for 1973 against 129 for 1972.

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[4]<u>FAO Commodity Review and Outlook, 1973-1974</u>, p. 101.

Table I-2. World Total Production and Trade of Oilcakes Unit: Thousand Tons.

	1966-70 Average	1970	1971	1972	1973[a]	% Change 1972/1971	% Change 1973/1972
Total Production	23,280	25,530	26,590	27,050	27,460	2	2
Soybean	11,480	12,900	13,470	14,430	15,710	7	9
Cottonseed	2,980	3,020	3,020	3,340	3,600	11	8
Groundnut	2,090	2,170	2,330	2,380	1,930	2	-19
Sunflowerseed	1,410	1,490	1,420	1,460	1,430	3	- 2
Rapeseed	970	1,060	1,360	1,390	1,320	2	- 5
Linseed	600	690	780	550	460	-29	-16
Copra	240	250	280	320	300	14	- 6
Palm Kernel	120	130	130	120	130	- 8	8
Fish Meal	3,130	3,540	3,480	2,770	2,310	-14	-17
Total Export[b]	10,210	12,020	12,280	13,120	13,340	7	2
Soybean	5,060	6,920	7,160	7,850	9,100	10	16
Cottonseed	520	570	490	550	560	12	2
Groundnut	1,110	980	890	920	860	3	- 7
Sunflowerseed	430	360	270	270	320	0	19
Rapeseed	250	300	470	470	490	0	4
Linseed	310	290	380	370	290	- 3	-22
Copra	200	190	210	240	220	14	- 8

[a] Preliminary.

[b] Including the meal equivalent of oilseed.

Table I-2. (Continued)

	1966-70 Average	1970	1971	1972	1973[a]	% Change 1972/1971	1973/1972
Palm Kernel	80	90	100	110	90	10	-18
Fish Meal	1,970	1,990	1,970	1,950	1,010	- 1	-48
FAO Price Index (1964-66 = 100)							
All Cakes and Meals	99	107	103	129	279	25	116
Vegetable Oilcakes[b]	100	104	103	125	268	21	114
Fish Meal	95	117	104	141	315	36	123

[a]Preliminary.

[b]Includes series for copra, cottonseed, groundnut, linseed and palm kernel cakes, as well as for soybean and sunflowerseed meals.

Source: <u>FAO Commodity Review and Outlook 1973-1974</u>, pp. 102-104.

Recent developments such as those outlined about suggest that trade in agricultural products is moving toward a more free market posture with an increase in uncertainty -- about world availability of supplies, demand and prices. The illusion of a closed agricultural economy has been dealt a series of severe blows, specifically, the international monetary crisis, the dollar devaluations, and sharply increased foreign demand for U.S. exports all of which have suggested that the market for farm commodities is worldwide.[5] Insulation of domestic markets from events in other countries becomes increasingly more difficult as nations become more interdependent with respect to production, consumption, and trade of agricultural products combined with low levels of stocks. This higher degree of interdependency often requires substantial readjustments in international commodity markets when either demand or supply conditions are radically changed.

The difficult thing to explain about resulting prices was the intensity rather than the direction of the change. "Even with all the sophisticated models and analytical expertise with the profession,"[6] scarcely anyone had correctly anticipated the magnitude of the price increases during late 1972 and early 1973.

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[5] Arthur B. Mackie, "International Dimension of Agricultural Prices," Southern Journal of Agricultural Economics, Vol. 6, No. 1 (July 1974), p. 11.

[6] J. S. Plaxico and D. E. Ray, "Implications for Agricultural Economists," American Journal of Agricultural Economics, Vol. 55, No. 3 (August 1973), p. 399.

Review of Literature

Concentrated attention has been given to price analysis of United States soybeans and soybean product since World War II. However, relatively little statistical analysis of the pricing of soybean meal and other high protein meals as an interrelated simultaneous process in the world market has been done. Previous research on soybeans and soybean products has been largely approached with correlation and multiple regression techniques. A few investigations employing other methods have appeared, however, in recent years.

Hildreth and Jarrett[7] undertook a study in 1955 which analyzed the U.S. livestock and feed industry by means of an eight-equation model. Throughout the study "livestock and livestock products" were treated as a single aggregate. Feeds for most part were classified into three main groups, roughage, feed grains, and protein feeds. The study was a significant contribution to an understanding of the simultaneous equations approach in economics. Considerable theoretical discussion was given in support of the various postulated relations. Five of the eight relations were fitted to annual data for the period 1920-49. Since the model was incompletely specified, the structural parameters were estimated by the limited information method and also by the least squares procedure. In particular, these methods were used to estimate parameters of one equation at a time neglecting information about which variables appear in particular equations in the remainder of the system. The computational economy

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[7]Clifford Hildreth and F. G. Jarrett, A Statistical Study of Livestock Production and Marketing, Cowles Commission Monograph 15 (New York: John Wiley & Sons, Inc., 1955).

and the difficulty in specifying additional observable variables were argued in support of not having the model completely specified and thus, the application of incomplete system methods.

Viewing the pricing of soybeans and soybean products as an interrelated simultaneous process, Houck[8] conducted several basically similar studies of the U.S. soybean economy. Ordinary least squares and two-stage least squares were employed to estimate the parameters of the simultaneous models which focused on the demand and price relationships for U.S. soybeans and related products. Although these investigations, in general, attained relative success in the empirical estimation of parameters, it was noted that there were no clear *a priori* grounds on which to base the theoretical and statistical analyses made. The contributions of these studies in the practical union of economic theory, measurement methodology and logical simplication in approximating a realistic model to analyze the pricing of soybeans and soybean products as an integrated process should be emphasized.

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[8]See, for example, James P. Houck, *Demand and Price Analysis of the U.S. Soybean Market*, University of Minnesota Agricultural Experiment Station, Technical Bulletin 244, June 1963; James P. Houck, "A Statistical Model of the Demand for Soybeans," *Journal of Farm Economics*, Vol. 46, No. 2 (May 1964), pp. 366-74; James P. Houck and J. S. Mann, *An Analyses of Domestic and Foreign Demand for U.S. Soybeans and Soybean Products*, University of Minnesota, Agric. Experiment Station, Technical Bulletin 256, 1968; and James P. Houck, Mary E. Ryan and Abraham Subotnik, *Soybeans and Their Products, Markets, Models and Policy*, (Minneapolis: University of Minnesota Press, 1972).

Two studies on the soybean economy were reported by Vandenborre in 1966[9] and 1967,[10] respectively. A 10-equation simultaneous model was constructed to analyze the market structure of soybean oil and meal. The structural coefficients were estimated by employing two-stage least squares procedure using first differences of the crop year data 1948-63, with the year 1950 deleted because of the outbreak of the Korean War. Vandenborre noted that the estimated meal export and storage functions were the weakest of relations in the model. He attributed this to the lack of any unique identity during the 1950's to clearly isolate determinants for the demand for meal export and meal storage from export and storage of oil. Vandenborre, thus suggested that as time progresses, with rising incomes and increasing demand for meat products, these relationships may become more clearly defined.

In 1970, Vandenborre followed up the preceding studies by reformulating and expanding the original model into a 24-equation model.[11] An important aspect of this study was the attempt to quan-

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[9] R. J. Vandenborre, "Demand Analysis of the Markets for Soybean Oil and Soybean Meal," Journal of Farm Economics, Vol. 48, No. 4, Part I (November 1966), pp. 920-34.

[10] R. J. Vandenborre, An Econometric Analysis of the Market for Soybean Oil and Soybean Meal, University of Illinois, Agricultural Experiment Station Bulletin 723, March 1967.

[11] R. J. Vandenborre, Economic Analysis of Relationships in the International Vegetable Oil and Meal Sector, University of Illinois, Department of Agricultural Economics, AERR-106, July 1970.

tify the relationships such as those representing the degree of competition between two kinds of oils and meals in world markets. This was done by using relative prices and by specifying export demands for the most important consuming regions.

In general, these previously reported studies have led to two major conclusions with a considerable amount of justification. First, that logical and relevant approximation models can be specified and quantified for complex sectors of U.S. agriculture. Secondly, decisions on production and marketing in the private sector and on public policy programs can be improved and discussed more objectively by means of these quantified relationships than by less analytic information bases. Nevertheless, the increasing tendency of agricultural products in moving toward a more free market and the increasing degree of interdependency among international commodity markets were obviously not fully recognized and analyzed. It is noted that none of the above-mentioned statistical analyses employed the complete system methods in estimating the unknown paramters of the simultaneous structural equations. Moreover, most of the studies also did not utilize the estimated structures for economic forecastings. The present study is, therefore, intended to undertake these unfulfilled tasks.

Objectives of the Study

The general objectives of the study are to examine the growing interdependency of countries and markets and to explore the implications of recent fluctuation in world high protein meals production on world demand and prices. Namely, it is to identify and measure empirically the underlying economic forces, interrelationships, and processes which determine and influence the price behavior of the world high protein meal market. More specifically, the objectives of the present study are:

1. To develop a complete econometric model of world protein meal economy which isolates components of foregin and domestic demands.

2. To obtain parameter estimates of the economic model.

3. To analyze the statistical results.

4. To utilize the estimated structural model as a basis for developing and evaluating short-term forecasting instruments for high protein meal prices and utilization.

More accurate and adequate information of this nature would be useful in order to better assess the effects of foreign demand and supply changes on the U.S. domestic markets. Also an improvement in the ability to predict future values of economic variables would allow the consequences of economic policies to be estimated. The results of the study, when appraised in the light of the information they provide, should be helpful to many groups. Among these are producers, producer organizations, business firms and policy makers in government.

Delimitation and Scope of the Study

The failure of the agricultural economists to anticipate the exceptional world-wide price movements during the fall of 1972 caught the profession in great surprise. Speculations about causes of recent price increases have focused on such diverse factors as changes in demand and supply conditions, exchange rate fluctuations and international monetary uncertainty. Several hypotheses were proposed as to which the situation could be attributed:

1. Speculative activity associated with currency realignments and the resulting monetary uncertainty.

2. General inflationary factors.

3. Market factors such as changes in production, import demand and stocks.

According to the United Nations' Food and Agriculture Organization, "there is no evidence for attributing price instability in 1972 to any sudden increase in speculative activity."[12] Recent studies also indicated that the net effect of exchange rate uncertainties is not clear, even on short run price movement.[13]

The rise in general commodity price levels appears to be a result more than a cause of inflation in international markets. In fact, "as an explanation of the general surge in prices of most com-

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[12] FAO Commodity Review and Outlook, 1972-1973, p. 8.

[13] For example, Mackie states that the results obtained from his study "do not support the hypothesis that devaluation or other kinds of exchange rate changes were responsible for the rapid changes in the United States agricultural exports and commodity prices between 1971 and 1973 or between 1971 and 1972." Arthur B. Mackie, op. cit., p. 20. A similar conclusion was also reached by Greenshields. See Bruce L. Greenshields, Changes in Exchange Rates, Impact on U.S. Grain and Soybean Exports to Japan, ERS-Foreign 364, Washington, D.C.: ERS, USDA, July 1974.

modities in 1972, cost-push inflationary forces are unlikely to have been of immediate importance."[14]

In view of the previously depicted world economic situation, it appears that the principal cause of the agricultural price movements in mid-1973 is more likely to result from production shortfalls or slow growth in some major producing countries. The incident of supply shortages of most major agricultural commodities, hence, induced a sharp increase in import demand as reflected in the massive purchases of grains, soybeans, and other commodities by the U.S.S.R. and Mainland China. At the same time, the severity of the pressures of demand caused by coincidental shortfalls or slow growth of output relative to demand in a number of interrelated commodities, such as wheat and rice, and feedgrains, fish meal and some oilcakes, was aggravated by the quickening pace of economic activity in industrial countries and countries around the world.[15] Moreover, possibilities of substituting commodities in short supply by others were limited because of general shortages and substantial low level of stocks in most agricultural commodities, and price increases in one commodity market were consequently transmitted rapidly to others.

This study was undertaken to examine and analyze the above mentioned general hypothesis with respect to the world economy of high protein meal sector. Specifically, the scope of the study was delimitated to the following three propositions:

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[14] FAO, op. cit., p. 10.

[15] Mackie, op. cit., p. 15.

1. Although protein meal and oil are joint products of the crushing industry, each product is part of a more or less distinct sub-sector of the economic structure because of the differences in their utilization. A certain degree of interrelatedness is expected to exist between these sub-sectors, but this relationship is probably much less complex and weaker than that within the sub-sectors. Studies on the oil sector, thus, were not to be included in this study.

2. The interest of this study concerns primarily the behavior relationships of demand and prices for the United States and foreign economies. Factors that affect supply conditions will be considered exogenous and ignored in this study.

3. Finally, the model to be employed in this study is constructed to utilize the available statistical data based on annual observations during the period from 1955 to 1972. The results of the analysis will then be used for comparisons with estimates obtained in previous studies and for the purpose of short-term forecasting.

Methodology, Procedure and Organization

The methodology and procedure of this study has two dimensions: (a) a descriptive survey of the market structures designed to provide a foundation for an understanding of the economic factors and relationships which comprise the high protein meal economy, and (b) an empirical analysis which constitutes the core of this study. The statistical method of three-stage least squares is employed to estimate the structural coefficients of a formal econometric model which consists essentially of a system of simultaneous equations that recognizes the economic variables and determines their relationships, interrelatedness, and most importantly, the magnitude and direction of influence of these economic factors.

The six-chapter organization of this study generally follows the sequence of above dimensions. Chapter II is basically a general review of the foreign and domestic markets for high protein meals with respect to production, trade, and consumption, during the sample period under study. The development and the theoretical framework of the economic model to be used in the present study is described in Chapter III. In Chapter IV, the emphasis is focused on the statistical results obtained from the three-stage least squares estimator and comparisons of results reported by other researchers. The economic applications of the estimated structure of world protein meal economy in terms of reduced form equations are presented in Chapter V. Specifically, Chapter V is concerned with the implications of the statistical results for policy considerations and the performances of the model for the short-term economic forecasts. Finally, Chapter VI contains a summary of the major results and conclusions.

CHAPTER II

THE WORLD ECONOMY OF HIGH PROTEIN MEALS

In this chapter, the objective is to present background information for a basic understanding of the rather complex setting of the world market for high protein meals. The demand for high protein meals is related to the demand for various animal feeds since they are both inputs to the livestock industry. Many technical factors relating to animal nutrition have influenced the development of the protein meal market. In considering the protein meal market, it is necessary to bear in mind the relationship between protein meal and the other main types of feed. Livestock feeds may be considered as consisting of roughages and concentrates.

Roughages, such as hay and silage, are high in fiber content and normally low in digestible nutrients. They are nevertheless a valuable source of carbohydrates and are fed mainly to ruminants. Concentrates are high in nutrients and can be divided into two groups, i.e., low and high protein concentrates. The low protein concentrates provide a concentrated source of energy and essential nutrients for various physiological reactions, such as production of milk or body fats. This class of feeds consists primarily of feedgrains, wheat and high quality cereal byproducts such as wheat bran. The high protein concentrates provide a major source of protein requirements both for animal growth and the production of milk or eggs. Oilseed cakes and meals are the major component of high protein concentrates. Animal proteins and grain proteins have traditionally competed with oilmeals, but supplies of these protein feeds have increased much less than supplies of oilseed meals. More recently, synthetics have made some inroad into the market but so far they still account for a small proportion of the total protein fed.

Animal proteins consist of fish meal, tankage and meat meal, skim milk powder, and dried blood. Gluten meal, brewers' and distillers' dried grains are considered as grain proteins. Synthetics such as urea and petroleum-based high proteins are suitable for ruminant feed only; in contrast, the other products are fed primarily to nonruminants. Fish meal, which is consumed mainly in poultry rations, is the most important high protein feed competing with oilseed meals in the international markets. For the purpose of this study, high protein meals will include fish meal and the major oilseed meals, which include soybean, peanut, cottonseed, linseed, rapeseed, sunflowerseed, copra and palm kernel meals.

Oilseed meals are now one of the main agricultural commodities traded in the world market. The increased demand in the developed regions of the world is largely dependent upon the high effective demand for meat, milk and eggs. In the less developed countries, where a substantial proportion of the world's supply of protein meals is produced, they are exported rather than consumed domestically. In 1972, exports of oilcakes and meals valued at $2667 million (Table II-1) ranked eighth among food and fishery products groups. How-

Table II-1. Changes in the Value of World Exports of Selected Agricultural Commodities.

Commodity Group	1972	1973	% Change 1973/1972
	----- Million U.S. Dollars	------------	
Meat Products	$5,686	$8,192	44
Wheat and Wheat Flour	4,407	7,880	79
Coarse Grains	3,615	6,050	67
Oilcakes and Meals[a]	2,667	5,885	109
Fats and Oils	3,780	5,131	36
Fishery Products	3,871	4,790	24
Sugar	3,413	4,500	32
Milk Products	3,035	3,560	17
Rice	1,024	1,648	61

[a]Excluding fish meal included in fishery products.

Source: Food and Agriculture Organization of the United Nations, FAO Commodity Review and Outlook 1973-1974 (Rome: CCP 74/24, 1974).

ever, it ranked fourth at $5.6 billion among the same commodity groups in 1973. More significantly, oilseed meals were ranked first when percentage change in export values were considered. Among the oilseed meals, soybean meal is the most important product produced, consumed and traded in the world market for livestock feed. Other oilseed meals when considered individually were relatively unimportant in these respects.

Production of High Protein Meals

Calendar year production of oilseed crops is officially reported in the FAO Production Yearbook for each country. This data were used in this study as an estimate of oilseed meal production.[1] For all countries, production was allocated to the calendar year during which the crop's processing chiefly occurred. The schedule which assigns the year of oilseed crops to be processed for each country is presented in Appendix A, Table A-1. There is no easy division of supplies into one year or the next, inasmuch as oilseeds are grown throughout the world and harvest months vary from country to country. Assigning production to calendar years allows the measurement of annual production, trade and consumption in the same time period.

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[1] Except for the U.S. where soybean production was obtained from Soybean Bluebook and production of other meal was obtained from Feed Situation.

Oilseed meal production was estimated on the basis of (1) annual calendar year production,[2] (2) assumed average crushing levels, and (3) assumed average meal extraction percentages. This approach was used in an attempt to avoid understating the total potential meal production during periods when stocks of oilseeds are being accumulated in the indigenous producing countries. Furthermore, actual production data for many countries is not available. Also, actual production data from different origins using different methods of processing and in some cases the practice of adding back hulls to the meal from hulled seed, would make such data uncomparable. The assumed crushing and extraction levels used varied between crops and between countries, and they are presented in Appendix A, Table A-2 and Table A-3, respectively. Finally, the data for the various meals were adjusted for the average differences in crude protein content and protein digestibility to obtain a common base, expressed in terms of soybean meal equivalent. These adjustment factors are provided in Appendix A, Table A-4.

General Production Trends--1955-1972

Total world high protein meal production during the 1955-72 period increased at the annual rate of about 5.1 percent (Table II-2), expanding from 24.9 million metric tons in 1955 to 58.2 million metric tons in 1972. Production of individual meals that have exceeded this average rate are fish, soybean, and sunflowerseed

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[2]The actual calendar year production of fish meal for each country is reported in the FAO Yearbook of Fishery Statistics and is used in this study.

Table II-2. Estimated World Production of High Protein Meals by Commodity, Percentage of World Total, and Annual Growth Rates, 1955-72.

Type of Meal	1955-72 Average Million Metric Tons	Percentage of World Production			Annual Growth Rates	
		1955-72 Average	1971	1972	1955-72 Average	1972
Soybean	21.2	51.4	54.1	57.3	6.6	7.0
Cottonseed	5.1	12.5	9.5	9.9	1.4	5.6
Peanut	3.6	8.9	7.7	7.2	2.5	- 4.6
Sunflowerseed	2.7	6.6	6.2	6.3	6.3	2.4
Rapeseed	1.7	4.2	4.9	5.0	4.9	3.4
Linseed	1.4	3.3	2.9	2.3	0.7	-18.3
Copra	0.5	1.3	1.1	1.2	2.0	12.0
Palm Kernel	0.2	0.5	0.4	0.4	1.9	- 2.0
Fish	4.7	11.4	13.2	10.4	7.3	-20.4
Total	41.1	100.0	100.0	100.0	5.1	1.2

Source: Computed from Food and Agriculture Organization of the United Nations, FAO Production Yearbook, FAO Yearbook of Fishery Statistics, Soybean Bluebook and Feed Situation.

meals. About 66 percent of the expansion in production has been accounted for by soybean meal. Soybean meal output almost tripled during the period under review (from 11.3 million tons to 33.4 million tons, see Figure II-1). Most of the remaining increase was accounted for by fish meal, which rose more than three fold to reach 6 million tons, and sunflowerseed meal which more than doubled to over 3.6 million tons in 1972. In 1972 these three meals account for about 74 percent of the world total meal production.

As shown in Table II-2, soybean meal production alone now accounts for about 57 percent of the total world production. Soybean meal production grew at the annual rate of 6.6 percent during the period 1955-72.

In contrast to the rapid growth of the above commodities, production of linseed, cottonseed, and palm kernel meals has increased much more slowly at a rate less than 2 percent a year. In aggregate, the relative importance of these three protein meals have declined slightly and in 1972 accounted for only 12.6 percent of the world total against 16.3 percent during 1955-72. In addition, peanut and copra meals also showed a far below-average growth in production during the same period and a downward declining trend in their relative importance in the total production of all meals. The aggregate production of these two commodities represented only about 8.4 percent of total production in 1972 as against the average of 10.1 percent during the 1955-72 period.

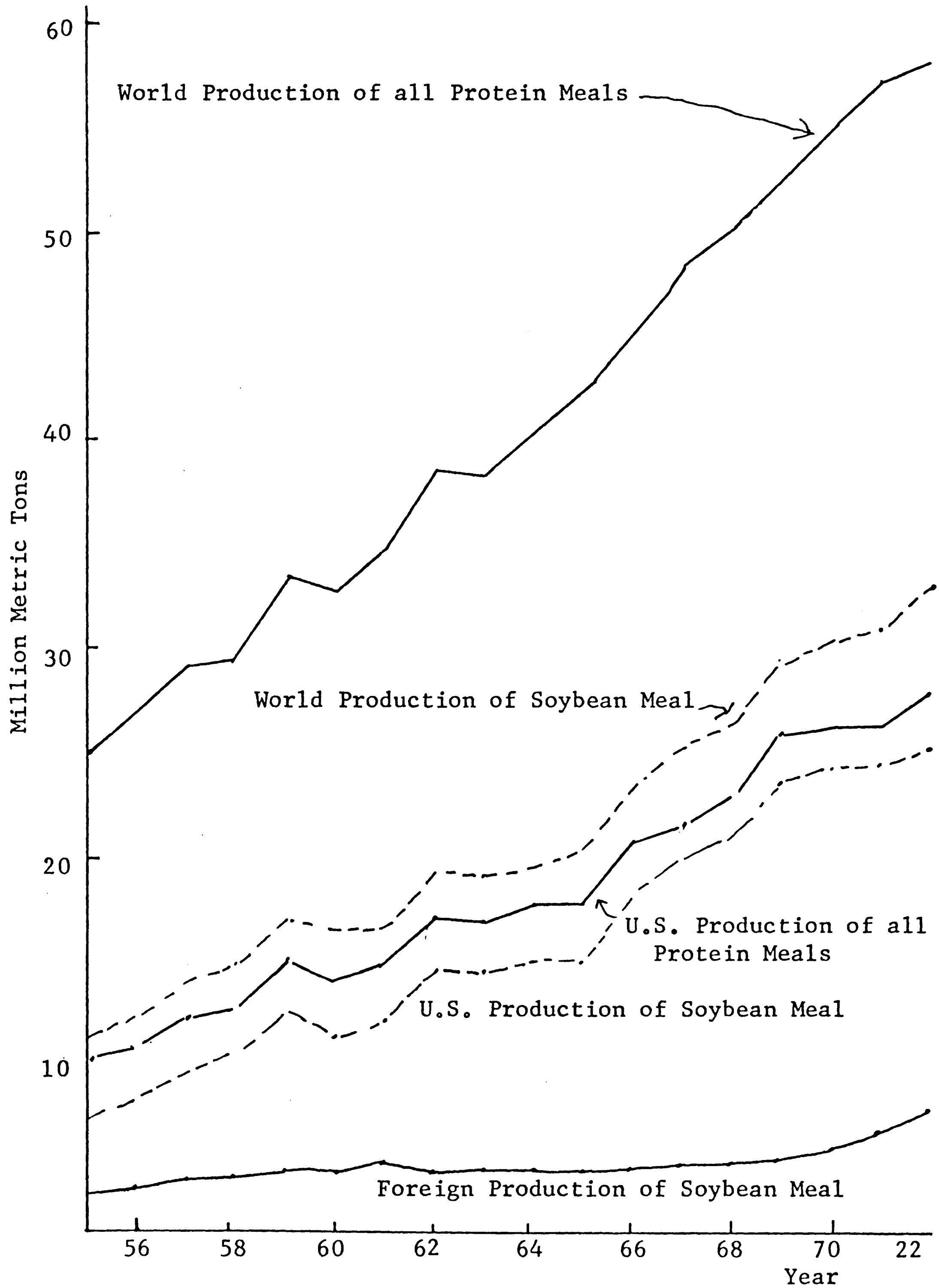

Figure II-1. World and United States Production of High Protein Meals, 1955-1972.

Regional Production of High Protein Meals

Individual major producer countries during the 1955-72 period showed wider differences in growth rates for meal production than has existed among the individual commodities for production during the same period.

Three countries showed an annual production growth rate exceeding 9 percent (Table II-3). They are Peru, Brazil and Canada. The overall average rate of increase in production for these three countries during the 1955-72 period has averaged 13.5 percent annually. They produced an average of about 8 percent of the world output.

Major producing countries with meal output increase averaging between 4.0 and 8.9 percent during the 1955-72 period accounted for roughly 70 percent of the estimated world high protein meal production and have an above-average growth rate of 5.7 percent annually. Among these countries, the United States is of most importance where about 45 percent of the world's total output was produced. The comparison between the U.S. and world total production of protein meals is also shown in Figure II-1. The average growth rate for the United States during the review period has been 6.2 percent annually.

Meal production growth rates in the remaining seven countries were less than 4.0 percent annually. These seven countries produced 17.8 percent of the world's total in 1972 compared with 22.5 percent of the total during the 1955-72 period and the aggregate production growth rate has been only 1.6 percent; substantially lower than the world average of 5.1 percent during the same period.

Table II-3. Major Producing Countries, Percentage of World Total, and Annual Growth Rates, All Meals, 1955-72.

Producing Countries by Growth Rate	% of World Production			Annual Growth Rates in Production	
	Average	1971	1972	1955-72 Average	1972
Annual Growth Rate 9.0 Percent or More					
Peru	3.7	4.8	2.2	24.6	-53.4
Brazil	2.4	3.6	5.3	14.1	48.1
Canada	1.6	2.6	2.4	9.3	- 5.9
Sub-total	7.7	11.0	9.9	13.5	- 9.1
Annual Growth Rate 4.0 to 8.9 Percent					
South Africa	0.9	0.9	0.9	7.8	- 6.8
Romania	0.5	0.5	0.5	6.2	2.7
United States	44.9	46.1	47.8	6.2	5.1
Japan	1.7	1.8	1.9	5.8	5.5
Pakistan	0.4	0.4	0.6	5.5	27.0
U.S.S.R.	7.3	6.7	6.4	4.8	- 2.3
Other Unspecified Countries	11.1	10.9	11.1	4.7	3.0
EEC	1.7	1.8	1.9	4.7	4.3
Senegal	0.8	0.4	0.6		64.8
Philippines	0.5	0.5	0.6	4.1	26.0
Sub-total	69.8	70.0	72.3	5.7	4.5

Table II-3. (Continued)

Producing Countries by Growth Rate	% of World Production			Annual Growth Rates in Production	
	Average	1971	1972	1955-72 Average	1972
Annual Growth Rate Less than 4.0 Percent					
Norway	0.9	0.9	0.9	3.6	- 2.2
West Malaysia	0.1	0.1	0.1	3.4	0.0
Argentina	1.8	1.5	1.0	2.4	-28.4
India	6.2	5.6	5.2	1.8	- 7.1
Nigeria	1.2	1.1	0.8	1.6	-25.7
Mainland China	12.0	9.5	9.5	1.3	1.7
Indonesia	0.3	0.3	0.3	0.3	0.6
Sub-total	22.5	19.0	17.8	1.6	- 5.0
World	100.0	100.0	100.0	5.1	1.2

Source: Computed from FAO Production Yearbook, FAO Yearbook of Fishery Statistics, Soybean Bluebook and Feed Situation.

Regional Production of High Protein Meals by Commodity

The percentage of world production by individual meals is shown in Table II-4. Also shown are the average annual growth rates during the period 1955-72 and for the year 1972.

Virtually all the increase in soybean meal output resulted from the rapid growth of production in the United States (Figure II-1). The United States accounts for over 75 percent of world production of soybean meal. The second largest producer of soybean meal, Mainland China, accounted for about 18 percent of the world production during the 1955-72 period. However, with the annual growth rate of only 1.5 percent, China's share of the world production of soybeans has been decreasing and accounted for only 12 percent of the world total in 1972. Brazil, on the other hand, has emerged as an important soybean producer and a potential competitor of the United States. Brazil produced about 7.5 percent of the world's total in 1972 and its growth rate in production has averaged 22.7 percent annually, almost three times faster than that of the United States.

Fish meal output in Peru rose dramatically from less than 0.2 million metric tons in 1955 to about 1.3 million tons in 1972. It accounted for almost 32 percent of the world production of fish meal during the 1955-72 period. The average annual rate of growth has been 24.6 percent which is more than three times faster than the average growth rate of 7.3 percent for the world. Other countries where fish meal production has shown a substantial increase include

Table II-4. Major Producing Countries, Percentage of World Total and Annual Growth Rates, by Commodity, 1955-72

Producing Country	Soybean Meal				Cottonseed Meal			
	% of Total		Growth Rate		% of Total		Growth Rate	
	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972
Developed Countries								
Canada	0.6	0.6	4.4	1.0				
EEC								
Japan	0.4	0.1	- 6.5	- 2.8				
Norway								
United States	75.8	76.3	7.6	4.3	32.0	24.5	-1.7	14.8
Developing Countries								
Argentina					1.2	0.8	-2.4	-36.8
Brizal	2.4	7.5	22.7	77.0	4.3	3.7	1.4	-25.9
India					5.1	5.8	1.6	31.7
Indonesia								
Nigeria								
Pakistan					3.6	5.6	5.5	27.0
Peru								
Philippines								
Senegal								
South Africa								
West Malaysia								
Centrally Planned Countries								
China	17.9	12.6	1.5	0.8	4.8	5.4	2.6	- 2.5
Romania								
U.S.S.R.					20.7	25.7	3.2	3.8
Other Countries	2.9	2.9	5.8	0.8	28.3	28.5	3.2	4.2
Total	100.0	100.0	6.6	7.0	100.0	100.0	1.4	5.6

Table II-4. (Continued)

Producing Country	Peanut Meal				Sunflowerseed Meal			
	% of Total		Growth Rate		% of Total		Growth Rate	
	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972
Developed Countries								
Canada					0.2	0.8	14.5	200.0
EEC					0.4	1.0	15.7	63.6
Japan	0.2	0.2	5.1	-12.5				
Norway								
United States	2.7	4.1	14.2	- 6.4	0.5	2.2	29.3	139.4
Developing Countries								
Argentina	3.1	2.3	4.6	-35.1	10.5	8.8	6.5	0.0
Brizal	6.2	7.7	9.4	- 5.0				
India	44.0	44.0	1.8	- 6.5				
Indonesia	0.8	0.7	1.8	0.0				
Nigeria	12.0	9.0	1.9	-29.3				
Pakistan								
Peru								
Phillippines								
Senegal								
South Africa	8.8	8.6	4.4	64.8				
West Malaysia	2.3	3.2	4.5	3.8				
Centrally Planned Countries								
China	14.4	13.7	- 0.4	1.1				
Romania					7.4	8.4	6.2	2.7
U.S.S.R.					63.6	55.5	6.6	- 7.8
Other Countries	5.5	6.5	4.7	4.6	17.4	23.3	4.9	25.3
Total	100.0	100.0	2.5	- 4.6	100.0	100.0	6.3	2.4

Table II-4. (Continued)

Producing Country	Rapeseed Meal				Linseed Meal			
	% of Total		Growth Rate		% of Total		Growth Rate	
	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972
Developed Countries								
Canada	10.0	27.8	34.8	31.8	17.5	18.0	4.3	-54.2
EEC	10.1	14.0	11.9	10.9	2.2	1.2	-4.0	23.1
Japan	3.5	0.2	-15.3	-33.3				
Norway								
United States					19.7	20.9	-2.0	51.1
Developing Countries								
Argentina					19.5	10.4	-1.5	-53.7
Brizal								
India	27.2	18.7	2.0	-26.6	13.0	16.4	1.6	7.8
Indonesia								
Nigeria								
Pakistan								
Peru								
Philippines								
Senegal								
South Africa								
West Malaysia								
Centrally Planned Countries								
China	21.9	15.5	1.3	15.4				
Romania								
U.S.S.R.					14.8	17.4	3.4	14.8
Other Countries	27.3	23.8	3.8	- 0.3	13.3	18.7	1.1	1.9
Total	100.0	100.0	4.9	3.4	100.0	100.0	0.7	-18.3

Table II-4. (Continued)

Producing Country	Copra Meal				Palm Kernel Meal			
	% of Total		Growth Rate		% of Total		Growth Rate	
	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972	1955-72 Average	1972
Developed Countries								
Canada								
EEC								
Japan								
Norway								
United States								
Developing Countries								
Argentina								
Brizal					13.1	14.2	5.4	0.0
India	8.1	7.9	2.4	0.0				
Indonesia	17.9	16.5	-0.2	0.0	3.7	4.6	1.9	10.0
Nigeria					36.4	32.1	0.0	- 1.3
Pakistan								
Peru								
Philippines	41.6	49.3	4.1	26.0				
Senegal								
South Africa								
West Malaysia	4.2	3.0	-0.5	-12.5	4.4	10.4	13.3	13.6
Centrally Planned Countries								
China								
Romania								
U.S.S.R.								
Other Countries	28.2	23.3	0.8	4.5	42.4	38.7	1.4	- 8.8
Total	100.0	100.0	2.0	12.0	100.0	100.0	1.9	- 2.0

Table II-4. (Continued)

Producing Country	Fish Meal			
	% of Total		Growth Rate	
	1955-72 Average	1972	1955-72 Average	1972
Developed Countries				
Canada	2.5	2.0	2.0	-10.3
EEC	10.1	10.4	2.8	- 1.9
Japan	11.8	17.5	10.0	6.3
Norway	8.2	8.9	3.6	- 2.2
United States	8.4	7.7	1.0	3.7
Developing Countries				
Argentina				
Brizal				
India				
Indonesia				
Nigeria				
Pakistan				
Peru	32.4	21.4	24.6	-53.4
Philippines				
Senegal				
South Africa	6.1	5.9	9.7	-10.2
West Malaysia				
Centrally Planned Countries				
China				
Romania				
U.S.S.R.				
Other Countries	20.4	26.2	9.4	- 4.3
Total	100.0	100.0	7.3	-20.4

Source: Computed from FAO Production Yearbook, FAO Yearbook of Fishery Statistics, Soybean Bluebook and Feed Situation.

Japan and South Africa with average annual growth rates of 10 and 9.7 percent, respectively.

The increase in production of sunflowerseed meal took place mainly in the U.S.S.R., where 63.6 percent of the world production was produced during the period 1955-72. The United States, EEC, and Canada together produced only about 1.0 percent of the world sunflowerseed meal, however, they had the highest annual rate of increase during the same period. The annual growth rates for these three countries have been 29.3, 15.7, and 14.5, respectively.

Historically, the United States which produced 32.0 percent of the world total production has been the major producer of cottonseed meal. The U.S.S.R. ranked second accounting for 20.7 percent of the world total. However, production of cottonseed meal in the U.S.S.R. has been increasing at about 3.2 percent annually. In contrast, the United States has had a -1.7 percent annual decrease. As a result, the U.S.S.R. was the biggest cottonseed meal producer of the world in 1972 followed by the United States.

The major rapeseed meal producers are India, China, EEC and Canada. Together they produce almost 70 percent of the world total. Among them Canada and the EEC have been growing most rapidly at an annual rate of 34.8 and 11.9 percent, respectively, while India and China have shown little growth in producing during the period 1955-72. Most of the major producers of the other types of meal, in general, have either declined or shown no upward trend in output during the period 1955-72.

International Trade in High Protein Meals

In comparing the individual meals according to their growth rates in production and exports, it is apparent that the individual meals showing the fastest growth in production are, in general, the same ones that have shown the largest growth in exports. However, the average rate of overall growth in exports far exceeds that in production. World exports of protein meals on a soybean meal equivalent basis averaged 16 million metric tons during 1955-72 (Table II-5). Trade increased 9 percent annually compared with a 5 percent annual increase in production during the same period. Between 1955 and 1972 total world exports increased more than fourfold in volume to reach approximately 28 million tons. Thus, while 26 percent of world production entered world trade in 1955, the proportion had risen to nearly 50 percent by 1972.

Among the various meals, growth rates in exports during the 1955-72 period for rapeseed, fish, sunflowerseed, and soybean meals were above the world average of 9.0 percent. These four commodities accounted for about 73.1 percent of world trade in protein meals. Though rapeseed meal has shown the largest relative rate of increase, it still represents only a minor tonnage. Soybean meal, as shown in Figure II-2, accounted for about half of the world's exports of meal, and was responsible for over two-thirds of the growth in exports.

Exports of palm kernel meal has been relatively constant in exports of cottonseed, peanut, linseed, and copra meals have been at below-average rate. The combined exports of these commodities

Table II-5

World Exports of High Protein Meals by Commodity, Percentage of World Total and Annual Growth Rates, 1955-72

Type of Meal	1955-72 Average Million Metric Tons	% of World Total			Growth Rates	
		1955-72 Average	1971	1972	1955-72 Average	1972
Soybean	8.0	50.0	60.5	62.3	10.9	10.1
Cottonseed	0.9	5.6	3.8	3.9	3.6	10.0
Peanut	2.1	13.1	7.6	7.5	3.9	5.0
Sunflowerseed	0.5	3.1	2.3	2.1	11.1	0.0
Rapeseed	0.4	2.5	3.8	3.6	14.5	0.0
Linseed	0.7	4.4	3.0	2.8	4.2	0.0
Copra	0.4	2.5	1.5	1.8	1.3	25.0
Palm Kernel	0.2	1.3	0.8	0.7	0.0	0.0
Fish	2.8	17.5	16.7	15.3	12.3	-2.3
Total	16.0	100.0	100.0	100.0	9.0	6.8

Source: Computed from FAO Commodity Review and Outlook, 1968-69, 1971-72, and 1973-74.

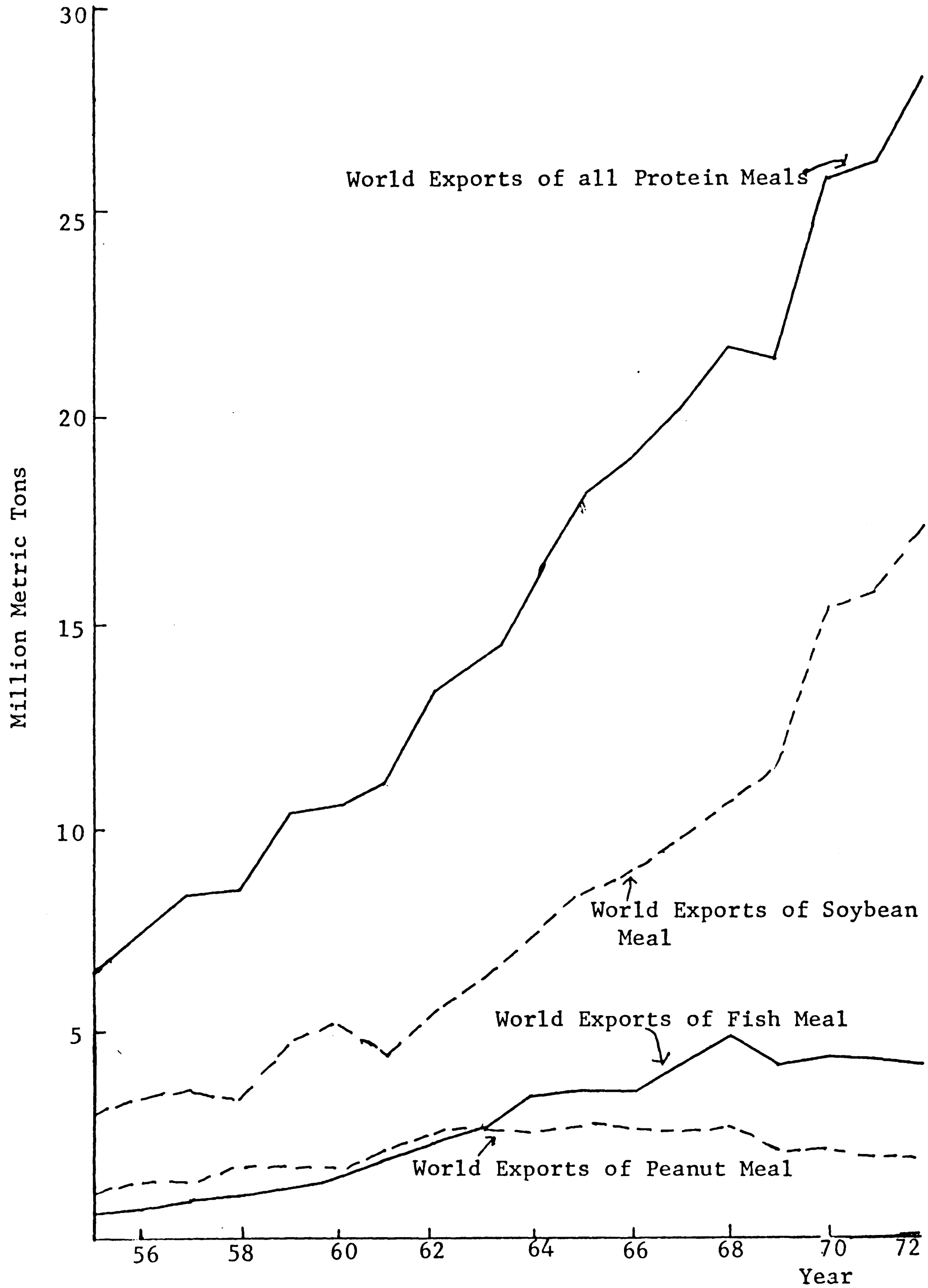

Figure II-2. World Exports of Soybean and all High Protein Meals, 1955-1972.

accounted for only 16.7 percent of the total in 1972 as comparing the average of almost 27 percent of the total between 1955 and 1972.

Consumption of High Protein Meals

Estimates of high protein meal consumption were developed from 1955 to 1972 for the major consuming regions. The estimates were developed on several assumptions which may not necessarily be true in any given year but which balance out over a series of years. During the period under review, total production of protein meals has roughly kept pace with the increase in requirements and there has been no long term build-up of stocks.[3] Regional estimates of consumption are calculated as the sum of a region's production and net trade of meal plus meal equivalent of net trade in oilseed. Changes in stocks, which are not known for most commodities and countries, are assumed negligible and therefore ignored from the calculation, except for the U.S. where changes in soybean meal stocks were taken into consideration.

Regional Consumption of High Protein Meals

Figure II-3 shows the U.S. total consumption of protein meals and soybean meal in contrast to the world total consumption. During the 1955-72 period, the United States consumed an average of 12 million metric tons of meals, accounting for about 29 percent of total world consumption (Table II-6). The EEC was the second largest con-

[3]Food and Agriculture Organization of the United Nations, "The World Market for Oilcakes and Meals," FAO Commodity Review and Outlook, 1968-1969 (Rome: CCP 69/9, 1969), p. 162.

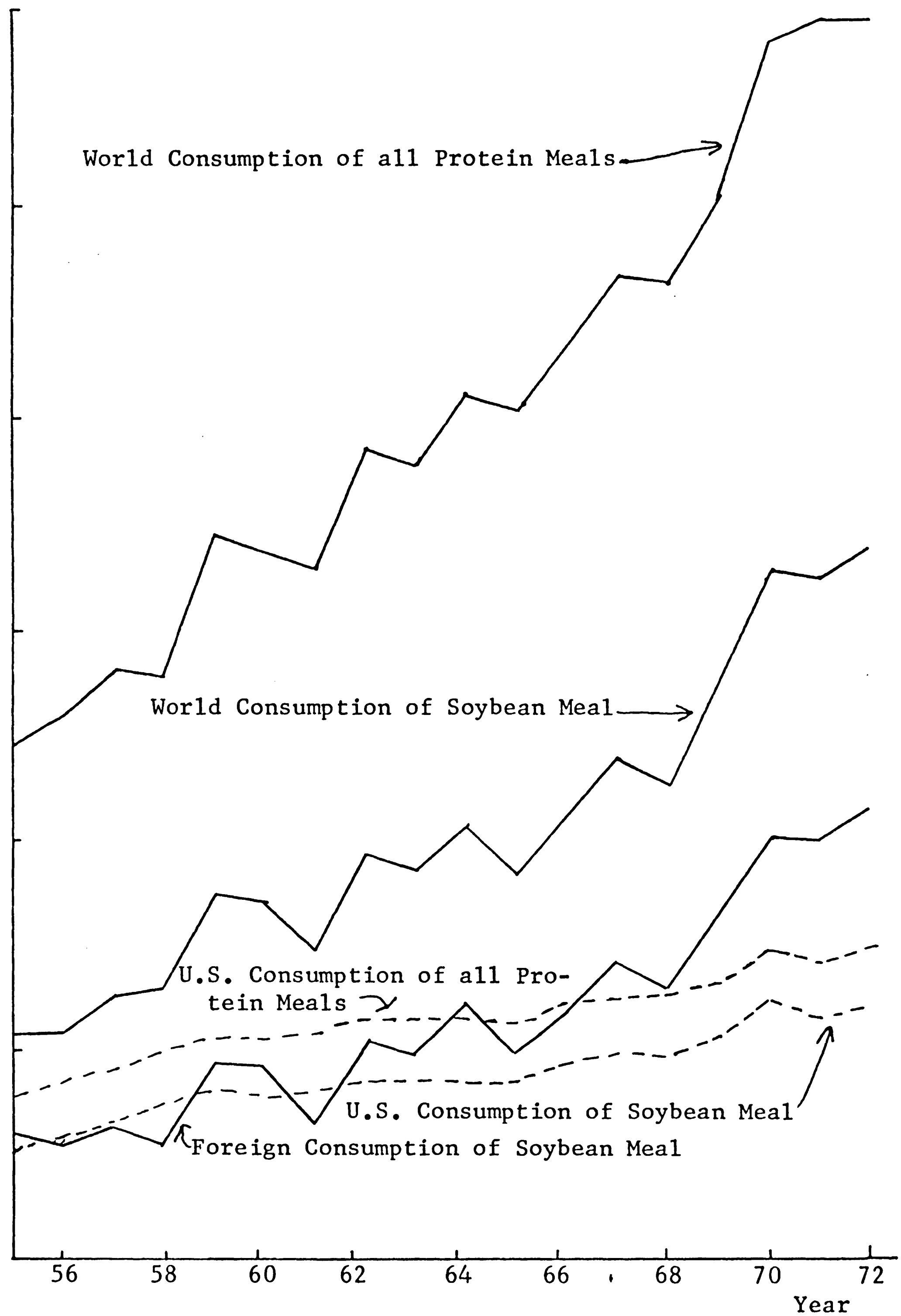

Figure II-3. World and United States Consumption of High Protein Meals, 1955-1972.

Table II-6. Estimated Apparent Consumption of High Protein Meals by Region, Percentage of World Total and Annual Growth Rates, 1955-72.

Major Consuming Region	1955-72 Average Million Metric Tons	% of World Total			Growth Rates	
		1955-72 Average	1971	1972	1955-72 Average	1972
United States	11.7	28.8	24.4	25.7	3.9	5.0
EEC	7.4	18.3	19.1	20.3	7.8	6.3
Japan	1.5	3.8	4.2	4.6	7.9	9.8
Canada	0.6	1.4	1.7	1.7	6.9	1.4
Sub-total	21.2	52.3	49.4	52.3	5.6	5.8
Other Unspecified Countries	19.3	47.7	50.6	47.7	4.9	-6.3
Total	40.5	100.0	100.0	100.0	5.3	-0.2

Source: Computed from FAO Production Yearbook, FAO Trade Yearbook, FAO Yearbook of Fishery Statistics, Soybean Bluebook and Feed Situation.

suming region accounting for about 18 percent of total protein meal consumption. Meal consumption in the United States, EEC, Japan and Canada accounts for more than half of total consumption.

Japan, with an annual increase in consumption of 7.9 percent, had the highest consumption growth rate of any region. The EEC was second, at 7.8 percent, followed by Canada, at 6.9 percent, was third. The United States, which is by far the world's largest consumer had the lowest growth rate among the regions. This is primarily because the U.S. level of concentrate feeding per animal unit has historically been quite high and since the early 1960's, the increase in demand for meals in the U.S. has moved in line with the increase in total livestock numbers. As a group, these four major consuming regions maintained an average annual growth rate of 5.3 percent during 1955-72.

Regional Consumption of High Protein Meals by Commodity

Table II-7 shows the percentages of individual meal utilized and their annual rates of increase within each major consuming region during the period 1955-72. It is apparent that the type of meal consumed within an exporting or surplus country is largely determined by the type of meal that is produced in that country. Furthermore, one would also expect that the types of meal utilized in an importing or deficit region will be more varied. This is evident from Table II-7 which shows growth rates in consumption substantially lower than the growth rates in production for both the United States and Canada. Also in these countries consumption is concentrated on

Table II-7. High Protein Meals Consumption by Region and by Commodity, Percentage of Total and Annual Growth Rates, 1955-72.

Type of Meal	United States			Canada		
	Thousand Metric Tons	% of Total	Rate of Growth	Thousand Metric Tons	% of Total	Rate of Growth
Soybean	8,850.7	75.9	5.3	393.0	68.7	6.1
Cottonseed	1,642.0	14.1	-1.3	0.8	0.1	0.0
Peanut	93.3	0.8	15.4	4.0	0.7	3.1
Sunflowerseed	14.7	0.1	29.4	4.2	0.7	14.8
Rapeseed	7.2	0.1	6.3	51.2	9.0	12.8
Linseed	217.3	1.9	-4.1	67.1	11.7	-1.8
Copra	43.9	0.4	-2.2	0.3	0.1	0.0
Palm Kernel	0.0	0.0	0.0	0.0	0.0	0.0
Fish	786.5	6.7	3.9	51.2	9.0	6.0
Total	11,655.6	100.0	3.9	571.8	100.0	6.9

Table II-7. (Continued)

Type of Meal	EEC			Japan		
	Thousand Metric Tons	% of Total	Rate of Growth	Thousand Metric Tons	% of Total	Rate of Growth
Soybean	2,514.8	34.0	15.0	619.1	40.4	6.6
Cottonseed	678.2	9.2	0.3	49.8	3.3	6.7
Peanut	907.6	12.3	4.8	60.0	3.9	24.8
Sunflowerseed	409.8	5.5	6.2	10.8	0.7	6.7
Rapeseed	269.3	3.6	10.8	120.5	7.9	4.3
Linseed	546.3	7.4	3.2	40.4	2.6	3.9
Copra	235.4	3.2	6.1	14.0	0.9	5.2
Palm Kernel	134.2	1.8	-0.5	4.9	0.3	0.0
Fish	1,696.6	23.0	6.2	612.3	40.0	10.4
Total	7,392.2	100.0	7.8	1,531.8	100.0	7.9

Source: Computed from FAO Production Yearbook, FAO Trade Yearbook, FAO Yearbook of Fishery Statistics, Soybean Bluebook and Feed Situation.

fewer types of protein supplements than in the EEC or Japan, where the growth rates in consumption have exceeded the growth rates in production.

During 1955-72, soybean meal accounted for over three-fourths of total United States meal consumption. Cottonseed meal was the second most important meal consumed followed by fish meal. In aggregate, these three meals accounted for more than 96 percent of total United States meal consumption. In the same period, sunflowerseed meal had the largest annual rate of increase, 29.4 percent. Peanut meal increased 15.4 percent annually and rapeseed meal, 6.3 percent. Soybean and fish meals ranked fourth and fifth, at annual growth rates of 5.3 and 3.9 percent, respectively. Cottonseed meal, second-ranked in quantity consumed, exhibited a negative trend as did copra and linseed meals.

Meal utilization in Canada was comprised principally of soybean meal and linseed meal. Together, they accounted for over 80 percent of total Canadian consumption during 1955-72. Rapeseed and fish meals combined accounted for another 18 percent of total meal consumption in Canada. The largest annual rate of increase occurred in sunflowerseed meal and rapeseed meal, at 14.8 and 12.8 percent, respectively. These growth rates were more than double the rates of increase for both soybean and fish meals.

Consumption of other types of meal are of minor importance in Canada. Among these commodities, peanut meal increased about 3.1 percent annually and linseed meal was declining at an annual rate of

1.8 percent while cottonseed meal and copra meal showed no increase at all.

Soybean meal is the dominant meal utilized in the EEC countries, where over 2.5 million tons were consumed annually during 1955-72. Soybean meal consumption increased 15.0 percent annually from 1955 to 1972. Fish meal consumption, with an annual rate of increase of about 6.0 percent, ranked second in terms of quantity but third in terms of growth rate. Peanut meal consumption, which averaged less than one million tons annually, was ranked third. Cottonseed meal, which accounted for 9.2 percent of total EEC meal consumption, increased only slightly over the 1955-72 period. Rapeseed meal accounted for only 3.6 percent of total consumption in EEC, however, it had a faster rate of growth at about 10.8 percent annually and ranked second in terms of rate of change.

In Japan, meal consumption of soybean meal and fish meal together accounted for over 80 percent of total meal consumption. Soybean meal consumption which averaged 0.6 million tons between 1955 and 1972 was only slightly greater than fish meal consumption. While soybean meal was ranked first in consumption, it was ranked fourth in terms of consumption growth rates. Consumption of peanut meal accounted for less than 4 percent of the total, however, it had the fastest rate of growth, at 24.8 percent annually. Fish meal had an annual consumption growth rate of 10.4 percent. Cottonseed and sunflowerseed meals, which accounted for about 4.0 percent in total

Japanese meal consumption have been increasing at an annual rate of 6.7 percent even faster than that of soybean meal.

During the period between 1955 to 1972, substantial increases in world production and consumption of high protein meals have occurred. With these increases, international trade in high protein meals has become increasingly important. Understanding basic trends in production, utilization and trade will assist in analyzing future trends and in developing economic models within which the important economic relationships among high protein meals in world markets may be studied and quantified. The economic model that is to be used as a basis for statistical estimation, given the data available, will be developed in the next chapter.

CHAPTER III

THE THEORETICAL FRAMEWORK

Econometric models have become an important tool in the study of economic behavior. In the process of developing econometric models, economic theory is conventionally used as the foundation on which the entire model may be specified. Alternatively, econometric models may be constructed on the basis of theory and knowledge of the particular characteristics of the commodity or the sector which is studied combined with systematically collected statistical data for the relevant variables.[1] More specifically, models of the first type are designed to provide insight into the properties of an actual or hypothetical economic system, but whose parameters could not be estimated from empirical data. The second approach includes models whose parameters could, conceivably, be estimated from statistical data, and which could be used as a basis for prediction or decision-making.[2] This last type of model will be used in this study. In general, the model construction of this type serves three main pur-

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[1] T. C. Koopmans, "Identification Problems in Economic Model Construction," in W. C. Hood and T. C. Koopmans, ed., Studies in Econometric Method, Cowles Commission Monograph 14, (New York: John Wiley & Sons, Inc., 1953), pp. 27-28.

[2] A. R. Bergstrom, Selected Economic Models and Their Analysis, (New York: American Elsevier Publishing Company, Inc., 1967), pp. 1-4.

poses. First, it provides a systematic approach for studying the past and specifying the interrelationships of economic variables that have prevailed over the period for which data are available. The second purpose is to provide a basis for the exercise of economic forecasting. The third main purpose of model building is to provide a framework within which to consider policy alternatives.[3]

Econometric models developed purely on the basis of economic theory and hypothetical relations are legitimate and have considerable importance in their own right, however, econometric models cannot be developed from purely empirical measurements. Empirical relationships unsupported by economic theory are speculative and may lead to invalid conclusions and policy implications.[4] Thus, without economic theory as a foundation, it is dangerous to apply statistical inference directly to the estimated economic relationships which are most relevant to analysis and to policy discussion.[5]

It is the objective of this chapter to present the theoretical considerations for the construction of an econometric model which describes the way that the world economy of high protein meal actually operates. This model will serve as a basis for quantitative

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[3]R. J. Ball, "Econometric Model Building," in Mathematical Model Building in Economics and Industry, (New York: Hafner Publishing Company, 1968), pp. 23-25.

[4]T. C. Koopmans, "Measurement Without Theory," The Review of Economics and Statistics, Vol. XXIX, No. 3 (August 1947), pp. 161-72.

[5]T. C. Koopmans, "Identification Problems in Economic Model Construction," op. cit., p. 28.

estimation and is intended to yield structural estimates that are useful information for analyzing the consequences of alternative courses of action and hence more rational decision-making.

Terminology and Assumptions

To begin with, it will be useful to provide some terminology and major assumptions to be used in the discussion of building the model for this analysis.

Definitions

The measurement of demand. Econometrics is concerned with measurement in economics. As mentioned previously, one of the objectives of the present study is to identify and measure empirically the underlying economic forces that determine and influence the world demand for high protein meals. The measurement of demand has been associated with two sorts of problems. One is that of measuring how price is related to quantity demanded when there is no change in other things which may be viewed as affecting the shift of demand. The other is the problem of measuring the shifts of demand and determining what factors are responsible for those shifts. From the standpoint of this study, the measurement of demand is concerned with both the nature of demand curve and its shifts.

Structure. In particular, economists require knowledge of "structure" which is useful and necessary for determining the most practical decision. Structure is defined as a set of conditions which might change in the future. The conditions that constitute a structure are a specific, numerical set of relationships involving, in general, the observable variables as well as a specific joint probability distribution function of the non-observable disturbances.[6]

Endogenous variables are those variables whose values are explained by the model.

Exogenous variables are the variables whose values are determined outside the model.

Predetermined variables refer to the group of lagged values of endogenous variables and exogenous variables.

Model is defined as the set of structures that are compatible with the investigator's statistical specification.[7] Moreover, within a model, one may specify which structural relations are assumed to hold exactly and which include an unexplained residual. The former are referred to as identities and the latter, as relations. At this stage, it is also useful to make a distinction between an economic model and a statistical model.

Economic model is the set of structures consistent with economic theory and some a priori knowledge of the workings of the sector of the economy being studied.[8]

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[6]Jacob Marschak, "Economic Measurements for Policy and Prediction," in W. C. Hood and T. C. Koopmans, ed., op. cit., p. 26.

[7]T. C. Koopmans, "Identification Problems in Economic Model Construction," op. cit., p. 29.

[8]C. Hildreth and F. C. Jarrett, op. cit., pp. 6-7 and Richard J. Foote, Analytical Tools for Studying Demand and Price Structures, Agricultural Handbook No. 146, USDA Agricultural Marketing Service, August 1958, p. 7.

Statistical model is the set of structures consistent with all the assumptions and specifications, both economic and statistical, that a research worker finds necessary to make for which economic considerations offer little guide.[9] For instance, the algebraic form of the relations must be specified and transformations on some variables may be performed in order to be able to obtain a statistical estimation of the parameters of the model.

Assumptions

The United States is considered as a single buying market for high protein meals. Other important buying markets for protein meals are assumed to exist outside of the United States and are aggregated into another market.

Domestic and foreign markets at wholesale and farm levels are presumed to consist of a number of utility and profit-maximizing buyers and sellers who possess no perceptible individual market power. Domestic and foreign prices of high protein meals are assumed to link together so they react directly to changes among their price levels.

With respect to commodities, the demands for high protein meals to be considered are divided into two categories, soybean meal and other high protein meal which includes cottonseed, peanut, sunflowerseed, rapeseed, linseed, copra, palm kernel, and fish meals.

There is an important difference between the production of soybean meal and other high protein meals. Namely, the production of soybeans is basically for processing into meal and oil. In con-

[9] Ibid.

trast, the production of other high protein meals comes mainly as by products from the production of their parent materials. It is, therefore, assumed that the production of other meal is predetermined for a given year. On the other hand, it seems less obvious that one can consider the production of soybean meal to be predetermined. However, it seems reasonable to argue that the production of soybean meal in a given year is also predetermined if the potential production rather than the actual production level of soybean meal is considered.[10]

The regional supply of protein meals may be regarded as exogenous or as endogenous variables which can be determined jointly within the model. More specifically, the consideration depends upon whether the region is a net exporting or importing region of a protein meal. The regional supply of a protein meal may be considered as predetermined if the region is a net exporter of that protein meal. On the other hand, it becomes endogenous if the region is a net importer of that protein meal. On the net trade basis, the United States is a net importing region of other high protein meal and a net exporting region of soybean meal. The United States imports more fish meal than it exports other oilseed meals, such as linseed meal and peanut meal. The rest of the world is a net importing region of soybean meal and a net exporting region of other meal. It is assumed that, at equilibrium, net exports and net imports of protein meal are equal between two regions.

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[10]In this study, the concept of potential production was employed. See pages 30-34.

While variations in inventory may be considered as an important factor influencing the price and demand conditions in the producing and exporting countries, it seems reasonable to assume that production and imports are to be used immediately in the consuming countries. Consequently, it is assumed that the United States does not hold any stock of other meal and the rest of the world does not hold any stock of soybean meal. The relation for the foreign demand for inventory of other high protein meal is omitted because data are not available on this variable. Therefore, only the soybean meal stock relation for the United States will be considered in the model.

The Economic Model

In order to analyze the price making forces that affect high protein meal price movements, both in the United States domestic and foreign markets, a flow diagram that depicts the conceptual structure of the demand-supply mechanism of the high protein meal economy is presented in Figure III-1. It illustrates the way in which important economic variables are believed to be related to one another. For ease of recognition, circles are used to represent prices while boxes are used to represent quantities. Solid lines indicate a causal relationship, while broken lines show quantity flows. Arrows give the directions of influence or flow.

Figure III-1, is simplified in the sense that it only describes the nature of the interdependency between one exporting country and one importing country producing one oilseed, converted into a vegetable oil product and an oilcake product. Diagrams of this kind have

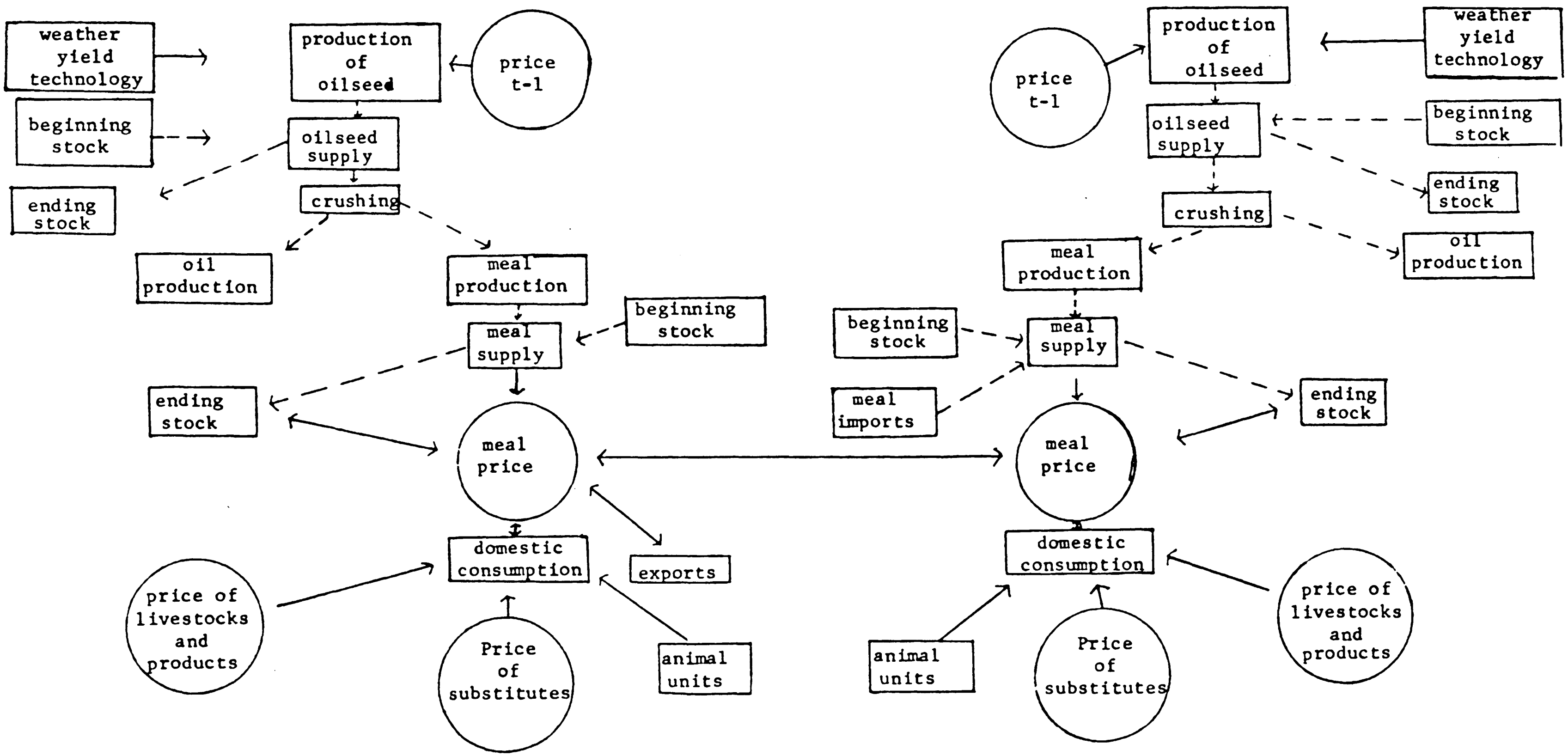

Figure III-1. Flow Chart for World Demand and Supply of High Protein Meals.

been used in a number of ways. They are used to help the analyst think through basic factors and relationships involved; to aid in the preparation of a logical write-up of the economic structure of the sector and to assist the reader in following fairly complex relationships and discussions.[11] For example, in response to adverse weather conditions, the United States soybean supply, and consequently soybean meal production in the United States declines. This decrease in supply will have an effect on stock withdrawals, domestic consumption, and export, which in turn, causes price to rise. Furthermore, a higher U.S. soybean meal price also implies a higher import price of soybean meal to those countries that import and consume U.S. soybean meal. After some adjustment lags, imports and consumption of soybean meal in the consuming countries can be expected to be reduced toward a level more in accordance with the new price level. This process will continue with the levels of inventory decreasing and prices rising until a point is reached where the rate of consumption declines below the production rate and the stocks begin to accumulate. At the same time, there will be effects on the substitute products which should not be overlooked. As consumption for soybean meal declines due to increases in prices, demand is shifted to other protein supplements. Nevertheless, if the supply level of other protein supplements remain constant, the price of other protein meal will tend to increase. The effect of these

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[11]Richard J. Foote, Analytical Tools for Studying Demand and Price Structures, p. 1.

changes, in turn, will affect both soybean meal and other meal consumption in the United States and foreign markets.

The diagram that relates to the demand and price structure for high protein meals is useful in showing the extent to which a number of economic variables are affected and interrelated to each other. It is important to note that they must be considered simultaneously. A system of equations that allows for the many aspects of simultaneity is needed to describe adequately the world economy of high protein meals and to estimate the parameters, statistically consistent, in the structural demand equations. Moreover, all the above-mentioned adjustments among the economic variables will take place over a period of time. If the time elapsed between observations of these variables is long enough, then, within a unit of time, the adjustment process might be expected to spread among all the variables and sectors considered in this price-demand mechanism. In this case, the value of all the endogenous variables included in the diagram will be simultaneously determined. Thus, a system of simultaneous equations is a justifiable approach in the present study of the world high protein meal economy.

Following the economic principles and simplifying assumptions abstracted from reality, the important economic relationships implied by the diagram can be examined and formulated even though the theoretical model is less complex than its real world counterpart. The core of the structural system is a twelve equation model of the high protein meal sector that focuses on the price making forces in U.S. and the rest of the world for soybean meal and other high protein meals.

Emphasis is placed on the demand side which encompasses both the U.S. domestic and foreign markets. Demand relationships were formulated for each region for soybean meal and other meals. In addition, the U.S. price of soybean, the U.S. demand for stocks of soybean meal (including meal equivalent of beans), demand for exports of soybean meal (including meal equivalent of beans), and the U.S. imports of other meal were also considered. The general model proposed for studying world economy of high protein meals consists of eight behavioral relations and four supply-utilization balancing equations. In summary, this model consists of twelve endogenous variables which are jointly determined in the system. Namely, for the United States, they are:

1. The price of soybeans, P_{sb}
2. The price of soybean meal, P_{sm}
3. The price of other meal, P_{om}
4. Quantity of soybean meal consumed, Q_{smc}
5. Exports of soybean meal, Q_{smx}
6. Ending stocks of soybean meal, Q_{sms}
7. Quantity of other meal consumed, Q_{omc}
8. Quantity of other meal imported, Q_{omi}

For the rest of the world, they are:

9. Price of soybean meal, P_{smf}

10. Price of other meal, P_{omf}

11. Quantity of soybean meal consumed, Q_{smf}

12. Quantity of other meal consumed, Q_{omf}

Soybean Price Relation

The price of U.S. soybeans can be expressed jointly in a function with the prices of soybean meal in the domestic and foreign markets, quantities of soybean meal stocked and other predetermined variables. Soybean meal and oil are joint products of the crushing industry. To obtain one of the products, the other must be produced. The market price of beans follows directly from the prices of meal and oil. In addition, one would also expect that this price of soybeans to be influenced by the demand conditions in the foreign market which will be reflected in their demand for the U.S. exports and the price of soybean meal in the foreign market. The U.S. inventory demand for soybeans and soybean meal are also expected to join the market demand forces to influence the price of soybeans. Thus, following Hildreth and Jarrett's notation,[12] a convenient way to summarize an economic behavioral relationship, the U.S. price of soybeans is presented as:

$$P_{sb}, P_{sm}, P_{smf}, Q_{sms}, P_{so}, \text{ some } Z\text{'s} \quad (1)$$

where P_{so} represents the price of soybean oil in the United States. A comma may be read "and:" and a semicolon may be read "appear in a relation with." The variables to the left of the semicolon are current endogenous variables and those to the right are regarded as

[12]Hildreth and Jarrett, op. cit., p. 17.

predetermined within the model. The symbol Z is used to represent some unspecified predetermined variables other than the price of soybean oil in this relation. The number of Z's included in each relation will have no effect on the basic structure of the model unless an identification problem is involved, but the number of Z's will affect the amount of work involved in fitting the system of equations and to some extent will affect the statistical reliability of the results.[13]

The first predetermined variable is the U.S. price of soybean oil which is, by assumption, an exogenous variable in the present study. Among those unspecified predetermined variables, the level of the U.S. beginning stocks of soybean meal is also expected to have an impact on the soybean price levels. On the a priori expectation, the higher the opening stock level, the lower will be the price of soybeans. In addition, the price of corn is another logical determinant. This variable may be regarded as representing the price of substitutes. Theoretically, one would expect the prices of competing products to move in the same direction.

Consumption Relations

The U.S. domestic demand for soybean meal faced by processors is an aggregated function comprised of the sum of the derived demands for livestock feeds, export and storage. The export and storage demand for soybean meal are considered separately.

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[13] Foote, Analytical Tools for Studying Demand and Price Structures, p. 12.

The domestic demand of soybean meal for feed is a derived demand for livestock and livestock products. The decision concerning the consumption of soybean meal is made by livestock producers. However, this decision is not made independently, due to the close substituability between soybean meal and other protein meals and the use of other feed stuffs in producing livestock. In addition, the decision to purchase feeds is closely related to the decision; how much livestock and livestock products to produce.

On the basis of neoclassic economic theory, the producer's input demand depends upon the input prices and the price of the product he produces.[14] Furthermore, since practically all high protein meals are traded in the international market, meal prices in foreign markets are also expected to have an impact on the domestic price levels. Thus,

$$Q_{smc},\ P_{sm},\ P_{om},\ P_{smf},\ P_{omf},\ P_{1},\ \text{some } Z\text{'s} \qquad (2)$$

where P_1^{us} represents the price level of livestock and livestock products in the United States.

The own and cross elasticities of demand for soybean meal may be defined with respect to each of the prices. Because there is no income effect in the theory of the profit-maximizing producer, those elasticities are a measure of total substitutability (own elasticity

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[14]For a mathematical derivation of the derived demand, see James M. Henderson and Richard E. Quandt, Microeconomic Theory: A Mathematical Approach, (2nd ed., New York: McGraw-Hill Book Company, 1971), p. 69. See also R. G. D. Allen, Mathematical Analysis for Economists, (London: Macmillan & Co., Ltd., 1933), pp. 369-74.

of demand) and substitutability with respect to other meal (cross elasticity). In addition, under the usual *ceteris paribus* assumptions, the slope of the producer's factor demand curve is always negative, and thus, the demand curves are always downward sloping.

To the extent that livestock producers may adjust the rate of feeding and the quantities of products marketed depending on the current price of feeds, and thus influence the current price of livestock products, it is, at least in part, doubtful that the price of livestock and livestock products may be regarded as predetermined.[15] Nevertheless, the variable P_1 may be considered as given, largely, due to the fact that the sales of livestock products at times differ considerably from their production.[16] This is more the case for cattle and hogs, which require a longer production time to attain market weight, than for poultry, which have a relatively short production period. In addition, King also argues that historically, a large proportion of the livestock products sold during the first seven months of the marketing year are produced on feed from the previous year's crop, and would be sold during the period regardless of

[15]By and large, in the most recent years, it is evident that the livestock industry responded to the rather sharply rising feed prices by cutting back on feedstuff ingredients where possible, grazing more cattle on grass, and cutting back on livestock feeding and animal units, particularly in the case of poultry and hogs.

[16]Richard J. Foote, "A Four-Equation Model of the Feed-Livestock Economy and Its Endogenous Mechanism," *Journal of Farm Economics*, Vol. XXXV, No. 1 (February 1953), p. 46.

price.[17] Although prices of livestock and livestock products are, to some extent, determined simultaneously with the prices of feeds and quantity of feed fed, for this formulation prices of livestock and livestock products are assumed to be predetermined.

Among the unspecified factors, Z's, which are expected to have some influences on the U.S. demand for soybean meal are the animal units of hogs, cattle and poultry, and consumption of feed grains in the United States.

Animal units contribute to this demand relation in a manner similar to the population effect in a retail demand equation.[18] They are the consumers of protein meals.

To the extent that there is no a priori knowledge about the relationship which may exist between the demand for soybean meal and feedgrains, it is appropriate to assume that they can be either substitutes or complements. In fact, Moe and Mohtadi found that in the EEC the relationships were competitive due to the high price of grains relative to that of meal, but in the United States, Japan,

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[17] Gordon A. King, The Demand and Price Structure for Byproduct Feeds, USDA, Technical Bulletin No. 1183, August 1958, p. 82.

[18] It should be noted that the number of animal units have some of the limitations indicated for the variable P_1, in that prices of feedstuffs may influence, to some extent, the animal units fed during the current period.

Canada and other Western Europe, a complementary relationship existed.[19]

Based on the same theoretical and logical considerations, the demand relations for other high protein meal in the United States, and the demand for soybean and other meals in the rest of the world are formulated in a similar manner as that of relation (2). The U.S. consumption of other high protein meal is formulated as:

$$Q_{omc},\ P_{om},\ P_{sm},\ P_{omf},\ P_{smf},\ \text{some } Z\text{'s} \qquad (3)$$

The foreign consumption of soybean meal is represented by relation (4). Thus,

$$Q_{smf},\ P_{smf},\ P_{omf},\ P_{sm},\ P_{om},\ \text{some } Z\text{'s} \qquad (4)$$

and relation (5) represents the consumption of other high protein meal in the rest of the world.

$$Q_{omf},\ P_{omf},\ P_{smf},\ P_{om},\ P_{sm},\ \text{some } Z\text{'s} \qquad (5)$$

International Trade Relations

The demand by exporters for U.S. domestic soybean meal is expressed as jointly determined with the prices of soybeans and other meal in the United States and the rest of the world, respectively. Thus,

$$Q_{smx},\ P_{sb},\ P_{om},\ P_{smf},\ P_{omf},\ P_{so},\ \text{some } Z\text{'s} \qquad (6)$$

It is noted that approximately 73 percent of U.S. soybean meal exports are in the form of beans. Thus, it is likely that European

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[19] L. E. Moe and Malek M. Mohtadi, World Supply and Demand Prospects for Oilseeds and Oilseed Products in 1980, with Emphasis on Trade by the Less Developed Countries, USDA, Foreign Agricultural Economic Report No. 71 (March 1971), p. 85.

and other foreign crushers will respond directly to the price of soybeans and import as much meal and oil as possible in the form of beans in any given year. Consequently, it may be expected that exports would be more responsive to the price of soybeans rather than to the price of soybean meal.

The distinguishing feature of exports of soybean meal from the U.S. domestic demand is that in any given year meal exports could be influenced through the exports of soybeans by price movements in the oil sector. The price of soybean oil, by assumption, is considered as predetermined in the present study.[20] Due to the fact that soybean oil is a more basic and much more speculative commodity than soybean meal, especially during the fifties the oil was certainly of more importance than the meal.[21] It may, therefore, be expected that in any given year soybean meal exports could be affected by the price of soybean oil. Moreover, to some extent, most of the major importing countries such as Europe and Japan may be expected to import soybeans up to the point where it is sufficient for them to cover their domestic needs for meal and oil. If this were not so, the importing countries, practically, would periodically be faced with the problem of exporting meal or oil. This is not feasible since they would not be able to meet the overwhelming competition from Public Law 480 exports and commercial exports of soybean oil

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[20]See Chapter I, p. 12.

[21]R. J. Vandenborre, "Demand Analysis of the Markets for Soybean Oil and Soybean Meal," <u>op. cit.</u>, p. 924.

from the United States.[22] Therefore, crushers in these countries were hampered by low export price of soybean oil as a result of competing with the U.S. P.L. 480 and commercial soybean oil exports. If this is the case, it is practically impossible for them to compensate the low prices of oil by higher prices for the meal. Based on these considerations, the price of soybean oil was introduced into the U.S. soybean meal exports relation.

Among some of the Z's, the animal units or per capita meat production, and the total availabilities of high protein meals and feedgrains in the rest of the world may be specified. If income continues to rise in the rest of the world, it seems quite certain that there will be substantial increases in both the consumption and the production of meat. This likelihood has important implications for the derived demand for protein feeds in the foreign countries. Thus, the demand for soybean meal will increase with expanded livestock production, and more intensive feeding practices. The exports demand for soybean meal is somewhat different from the U.S. domestic demand to the extent that soybean meal has to meet strong competition from other high protein meals which are largely produced and consumed outside of the United States. In addition, there will also be competition from the foreign produced feedgrains. Consequently, the total availabilities of high protein meals and feedgrains in the rest of the world are expected to be negatively related to the exports of U.S. soybean meal.

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[22] R. J. Vandenborre, An Econometric Analysis of the Markets for Soybean Oil and Soybean Meal, p. 17.

The analogous formulation can be extended to the net exports of other high protein meal from the rest of the world. This relation is written as:

$$Q_{omi},\ P_{om},\ P_{sm},\ P_{omf},\ P_{smf},\ \text{some Z's} \qquad (7)$$

This relation is presented in terms of the United States import demand for other meal rather than the export demand for other high protein meal in the rest of the world. In a two region economy, one region's exports are always equal to the other region's imports. The distinctions between exports and imports in the present model are trivial. Nevertheless, by specifying a U.S. importing function, the processes and work involved in the statistical fitting are substantially simplified.

Demand for Storage Relation

In addition to the demand for current consumption and exports of soybean meal, the demand for inventory is another important element of total demand. While the demand for soybean meal consumption and exports are originated by livestock producers and exporters, respectively, the demand for soybean meal inventory is forthcoming from the processors and handlers who expect to profit from holding stocks from the current period to the future. Furthermore, stocks are also carried over in a passive way from periods of seasonally high production to the periods of low production. The United States demand for ending stocks of soybean meal can be expressed as:

$$Q_{sms},\ P_{sm},\ Q_{smx},\ P_{so},\ \text{some Z's} \qquad (8)$$

The price of soybean oil was specified as one of the predetermined variables for similar reasons as discussed for the exports relation. Moreover, it should be noted that meal stocks can be either meal or whole beans, however, stocks as meal are relatively less important than bean stocks, since beans are easier and more convenient to stock than meal. More significantly, it is obvious that holding stocks in bean form provides crushers more flexibility to meet the changes in demand for soybean products. Consequently, if stocks of soybeans are held for price speculation reasons, then the incentives may be the price of soybean meal as well as the price of oil.

Since ending stocks may be varied and influenced directly by the demand and supply conditions prevailing in the domestic and foreign markets, inventory can be considered as leftover residual from the current consumption and export commitments. The behavioral relation for soybean meal stocks is much less complex than it might be in a model focusing on inventory behavior in the soybean economy. To this extent, without a more sophisticated model for the inventory demand,[23] there is no a priori basis on the behavioral relationships between the ending stocks and the price variables. In his 1967 study, Vandenborre reported that the price of soybean meal was of no importance in explaining meal stock, whereas the price of soybean oil was found to be negatively related to the amount of meal in stock. However, for the soybean oil stock relation, a positive re-

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[23]See, for example, George W. Ladd, Distributed Lag Inventory Analyses, Agricultural and Home Economics Experiment Station, Iowa State University of Science and Technology, Research Bulletin 515, April 1963.

lationship between oil stocks and price of oil was obtained. Vandenborre argues this is because that some stocks are held for speculative purposes.[24] If stocks are indeed held for price speculation, one would expect stocks to be accumulated at low rather than high price levels. In other words, if there is a demand for speculation, the logical relationship between stocks and price is expected to be negatively related. Nevertheless, if the carryout demand is for "pipeline" stocks needed for current crushing requirements and export commitments, it seems reasonable to argue that stocks tend to be built up passively during the period when domestic and foreign demands are relatively weak which may result from an increase in the current price level.

As mentioned previously, the production of soybeans or soybean meal will be a predetermined variable that can be expected to affect the stock demand for soybean meal in the United States. In addition, based on a priori reasoning, the level of soybean meal stocks at the beginning of the time period is another logical determinant. The higher the level of opening stocks at the beginning of a given year, the smaller would be the expected demand increases in total inventory over the year. These are the supply factors that were included in order to separate passive holding of stocks from active holdings stimulated by the speculative demands. Ending stocks of soybean meal were hypothesized to be positively related to these supply factors and negatively related to the prices of soybean meal and oil.

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[24] R. J. Vandenborre, An Econometric Analysis of the Markets for Soybean Oil and Soybean Meal, p. 35.

Identities

Finally, equations 9 through 12 represent a set of identities that define the total use of high protein meals to equal the total availabilities in the United States and the rest of the world, respectively. They are presented as follows:

Supply-utilization identities in the United States

Soybean: $Q_{smpu} + Q_{smsl} = Q_{smc} + Q_{smx} + Q_{sms}$ (9)

Other meal: $Q_{ompu} + Q_{omi} = Q_{omc}$ (10)

Supply-utilization identities in the rest of the world

Soybean: $Q_{smpf} + Q_{smx} = Q_{smf}$ (11)

Other meal: $Q_{ompf} = Q_{omf} + Q_{omi}$ (12)

The structural relations discussed are considered to be sufficient to formulate a complete economic model in the sense that it contains as many relationships as endogenous variables. The statistical specifications of the model will be presented in the next chapter.

CHAPTER IV

THE STATISTICAL MODEL AND RESULTS OF ESTIMATION

Whereas Chapter III focused on the theoretical framework of the relationships in the high protein feed sector, this chapter will be concerned with the statistical aspects of the empirical work. Specifically, this chapter will present the statistical model that is to be estimated, procedures of estimation and testing, and a discussion of the empirical results.

The Model

With few modifications the economic model was used as a basis for a twelve-equation statistical model of the high protein feed market. The statistical model specifies all of the *a priori* knowledge about the operation of the sector. The model sets forth the form of equations, variables appearing in each equation, the class of distributions from which disturbances arise, and other restrictions, if any, that are imposed

The form of equations was presumed linear in actual numbers. Linearity in certain definitional identities required this restriction. The statistical model includes eight stochastic equations and four definitional identities. The eight normalized behavioral equations are:

$$P^*_{sb} = a_0 + a_1 P^*_{sm} + a_2 P_{so} + a_3 Qsmsl + U_1$$

$$Q^*_{smc} = b_0 + b_1 P^*_{sm} + b_2 P^*_{om} + b_3 Hog + b_4 Broil + U_2$$

$$Q^*_{omc} = c_0 + c_1 P^*_{sm} + c_2 P^*_{om} + c_3 Q^*_{smc} + c_4 Pc + U_3$$

$$Q^*_{smf} = d_0 + d_1 P^*_{sb} + d_2 P^*_{omf} + d_3 Hpaf + U_4$$

$$Q^*_{omf} = e_0 + e_2 P^*_{om} + e_3 Hpag + U_5$$

$$Q^*_{smx} = f_0 + f_1 P^*_{sb} + f_2 P^*_{smf} + f_3 Hpaf + U_6$$

$$Q^*_{omi} = g_0 + g_1 P^*_{smf} + g_2 P^*_{omf} + g_3 Q^*_{sms} + g_4 Hpag + U_7$$

$$Q^*_{sms} = h_0 + h_1 P^*_{sm} + h_2 Q^*_{smx} + h_3 Qsmsl + U_8$$

And the four identities are:

$$Q_{smpu} + Q_{smsl} = Q^*_{smc} + Q^*_{smx} + Q^*_{sms}$$

$$Q_{ompu} + Q^*_{omi} = Q^*_{omc}$$

$$Q_{smpf} + Q^*_{smx} = Q^*_{smf}$$

$$Q_{ompf} + Q^*_{omf} + Q^*_{omi}$$

where:

P^*_{sb} = Price of soybeans, Illinois country shipping point, dollar per metric ton. (Endogenous).

P^*_{sm} = Price of soybean meal, 44% protein, Decatur, in dollar per metric ton. (Endogenous).

P_{so} = Price of soybean oil, Decatur, crude tank cars, dollar per metric ton. (Predetermined).

Q_{smsl} = U.S. beginning stocks of soybean meal at January 1, including meal equivalent of soybeans in thousand metric tons. (Predetermined).

Q^*_{smc} = U.S. domestic consumption of soybean meal, thousand metric tons. (Endogenous).

P^*_{om} = Composite average annual price of other high protein meals in the United States, dollar per metric ton. (Endogenous).

Hog = Number of hogs in the United States, thousand heads at January 1. (Predetermined).

Broil = U.S. commercial production of broilers in million heads. (Predetermined).

Q^*_{omc} = U.S. consumption of other high protein meals in terms of 44% protein soybean meal equivalent, thousand metric tons. (Endogenous).

P_c = Price of corn received by farmers, dollar per metric ton. (Predetermined).

Q^*_{smf} = Foreign consumption of soybean meal, thousand metric tons. (Endogenous).

P^*_{omf} = Composite average annual price of other high protein meals, c.i.f., European ports, dollar per metric ton. (Endogenous).

H_{paf} = High protein consuming animal units in the rest of the world, million units. (Predetermined).

Q^*_{omf} = Foreign consumption of other high protein meals, in terms of 44% soybean meal equivalent, thousand metric tons. (Endogenous).

P^*_{smf} = Price of soybean meal, Canadian 45% protein, c.i.f., European ports, dollar per metric ton. (Endogenous).

Q^*_{smx} = U.S. net exports of soybean meal, including meal equivalent of soybean exports, thousand metric tons. (Endogenous).

Q^*_{omi} = U.S. net imports of other high protein meals, in terms of 44% soybean meal equivalent, thousand metric tons. (Endogenous).

Q^*_{sms} = U.S. ending stocks of soybean meal, including meal equivalent of soybean stock, thousand metric tons. (Endogenous).

Q_{smpu} = U.S. annual production of soybean meal, thousand metric tons. (Predetermined).

Q_{ompu} = U.S. annual production of other high protein meals, in terms of 44% soybean meal equivalent, thousand metric tons. (Predetermined).

Q_{smpf} = Foreign production of soybean meal, thousand metric tons. (Predetermined).

Q_{ompf} = Foreign production of other high protein meals, in terms of 44% soybean meal equivalent, thousand metric tons. (Predetermined).

The actual but unknown values of the a's, b's, c's, d's, e's, f's, g's and h's are structural parameters. The U's are disturbances and reflect the random influences of all other unspecified variables on individual equations. All the variables included in the model are assumed observable and measured without errors. In order to draw meaningful inferences from the model, it is assumed that the disturbances are[1] (1) jointly normally distributed with zero means and a non-singular matrix of variances and covariances, (2) independent from observation to observation, i.e., there is no serial correlation in the U's, and (3) stochastically independent of each predetermined variables.

The Sample Period and Data

The sample period included the 18 annual observations beginning with 1955 and ending with 1972. The structure of the market under consideration was presumed constant in this period of time. The true relationships and parameters which underlie and full determine the operation of this high protein feeds sector are assumed unchanged during the 1955-72 time period. A further discussion of the actual data used and their sources is presented in Appendix B.

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[1] W. C. Hood and T. C. Koopmans, op. cit., p. 97.

Method of Estimation

The conventional identification criteria indicates that all the behavioral equations specified in the system are over-identified. Several estimation procedures are available for estimating structural parameters in this model. In general, they are either single-equation methods, which can be applied to each equation of the system one at a time, or complete system methods, which are applied to the system as a whole. The former approach is referred as limited-information method and the latter full-information method. If these methods of estimation are not used, persistent bias in the estimation of the structural parameters of the equations can be introduced.[2]

While two-stage least squares (2SLS) is a limited-information method, three-stage least squares (3SLS) is a full-information method. Zellner and Theil have shown that 3SLS estimator may be expected to be more efficient than 2SLS.[3] That is, 2SLS estimator, although consistent, is in general not a symptotically efficient because it does not take into account the correlation of the structural disturbances across equations. Under the circumstances that there is no such correlation, 3SLS estimates will be the same as 2SLS estimates. Specifically, there is only a gain in asymptotic

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[2] J. Johnston, Econometric Methods (2nd ed., New York: McGraw-Hill Book Company, 1972), pp. 342-44; and W. C. Hood and T. C. Koopmans, op. cit., pp. 131-35.

[3] A. Zellner and H. Theil, "Three-Stage Least Squares: Simultaneous Estimation of Simultaneous Equations," Econometrica, Vol. 30, No. 1 (January 1962), pp. 54-78.

efficiency of 3SLS over 2SLS if the structural disturbances are contemporaneously correlated across equations.

Preliminary investigations indicated that there are substantial correlation between the observed residuals of the fitted equations. In addition, preliminary analyses also suggested that an estimator of reduced form coefficients derived from 3SLS leads to a smaller forecast error than an estimator derived from 2SLS. Accordingly, in this study, the structural coefficients were obtained using 3SLS procedure.

Test of Statistical Significance and Inference

The conventional tests used in testing various regression related hypotheses are not exactly valid for 2SLS and 3SLS estimates. This is because the properties of these estimators are asymptotic properties. The estimated variances and standard errors are estimates of variances and standard errors for finite sample sizes. Since no exact tests are available, the relative magnitude of the estimated coefficient over its estimated standard error is used in this study for testing the significance of the variable and for determining which variables should be retained in the regression equation. Thus, a regression coefficient will be retained if its absolute value is greater than its estimated standard error provided its sign is theoretically correct.[4]

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[4] This criteria was used by Houthakker and Taylor in their study of consumer demand in the United States. See H. S. Houthakker and L. D. Taylor, Consumer Demand in the United States 1929-1970, (Massachusetts: Harvard University Press, 1966), p. 8.

For the case of a regression equation that belongs to a simultaneous system, the conventional Durbin-Watson (DW) statistic is also known to be biased against discovering either positive or negative serial correlation. In practice, when an over-identified structural equation, which does not include lagged endogenous variables, has been fitted by the limited-information method, such as 2SLS, Durbin has shown that the conventional DW test is a good approximate test for serial correlation.[5] Therefore, the DW statistic is also reported to serve as an approximation for measuring serial correlation in disturbances.

Although the presence of multicollinearity among the independent variables will not affect the over-all goodness of fit,[6] it does hamper the efforts of obtaining precise and stable estimates of coefficients for correlated variables. According to Klein, multicollinearity among two independent variables is harmful if the correlation between them is greater than the overall degree of multiple correlation of the regression equation.[7] This simple rule of thumb has been extended by Farrar and Glauber to considering the coefficient of multiple determination, R_i^2, between each independent variable and

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[5]J. Durbin, "Testing for Serial Correlation in Systems of Simultaneous Regression Equations," Biometrika, Vol. 44, Part 3 and 4 (December 1957), p. 377.

[6]In fact, the estimate of the sampling variance of the entire equation is not affected or biased by multicollinearity. See J. Johnston, op. cit., pp. 162-3.

[7]L. R. Klein, An Introduction to Econometrics (New Jersey: Prentice-Hall, Inc., 1962), p. 101.

the remaining variables in the independent variable set. Specifically, "a variable x_i then, would be said to be 'harmfully multicollinear' only if its multiple correlation with other members of the independent variable set, R_{xi}, were greater than the dependent variable's multiple correlation with the entire set, R_y."[8] Farrar and Glauber also developed a series of tests based on the Chi Square, F, and t distributions to identify the presence, location, and patterns of the interdependence among the independent variables, respectively. These tests were used in this study for detecting the degree of multicollinearity among the independent variables in each fitted equation.

Results of the Statistical Estimation

The results of the 3SLS estimation process are presented in this section. The standard error of each coefficient appear beneath in parentheses. The resulting estimates are examined to determine whether they are in agreement or disagreement with economic theory and other available evidence.

In general, the statistical results were satisfactory. The structural coefficients exhibited signs that were consistent with the theoretical expectations. Since much of the preliminary work was done with ordinary least squares (OLS) in specification of the model and also that the 3SLS estimator involves the 2SLS procedure in the middle step, the OLS and 2SLS estimates are presented for comparison

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[8] D. E. Farrar and R. R. Glauber, "Multicollinearity in Regression Analysis: The Problem Revisited," The Review of Economics and Statistics, Vol. 49, No. 1 (February 1967), p. 98.

in Appendix C and Appendix D, respectively. As shown in Appendix C, fairly good fits were obtained by the OLS procedure. For the OLS equations, the coefficient of multiple determination (R^2) ranged from 0.81 to 0.98. With regard to serial correlation, the DW test was inconclusive for two estimated structural relations, namely, the U.S. demand for other high protein meals and the U.S. imports of other high protein meals. The DW statistic for the OLS and the 2SLS equations is reported in Appendix C and Appendix D, respectively,

The existence of multicollinearity appears, however, likely to be a serious problem in each fitted regression equation. Particularly, a high degree of interdependence between the endogenous variables and between the endogenous and some of the predetermined variables are the most common patterns detected. In spite of the presence of a high degree of collinearity, most of the explanatory variables appear to have sufficiently strong influence so that the estimated coefficients are substantially greater than their estimated standard errors. However, the presence of multicollinearity may have obscured the presence of some other less strong effects. Consequently, it may not be surprising to find out that one is caught in the complexity of multicollinearity intermingled with serial correlation. Indeed, the DW test was inconclusive for the two estimated relations where the presence of multicollinearity was considered to be most severe. These results suggest that they do not happen merely by coincident. This assertion implies only that the presence of multicollinearity may also, but not necessarily, complicate the estimation problem with serial correlation. The reverse, however, is not true. The resulting estimates of each individual structural equation are presented below.

U.S. Soybean Price Relationship

The price of U.S. soybeans was estimated as a function of U.S. prices of soybean meal and soybean oil, and the beginning stocks of soybean meal. Thus,

$$3SLS\ P^{*}_{sb} = -3.549 + .9508P^{*}_{sm} + .1627P_{so} - .0007705Q_{smsl}$$
$$(.1073) \qquad (.0254) \qquad (.0003093)$$

All the coefficients display the expected sign and are relatively larger than their standard errors. The coefficients obtained for the price of soybean oil and the beginning stock of soybean meal are relatively more stable than those for the price of soybean meal. In fact, the Farrar-Glauber test indicates that there is a signiticant correlation between the price of soybean meal and the stock variable. However, this may not be serious because this correlation is significantly lower than the overall coefficient of correlation for the entire equation. The actual values and the computed values obtained from 3SLS are presented in Figure IV-1. The fitted equation explains adequately most of the important turning points in the price of soybeans. However, in 1957, the equation wrongly predicted a turning point for the price of soybeans.

Using the results obtained from 3SLS, the coefficients implied that a 1% change in the price of soybean meal or oil was associated with a .75% or .39% change in the price of soybeans; and a 1% change

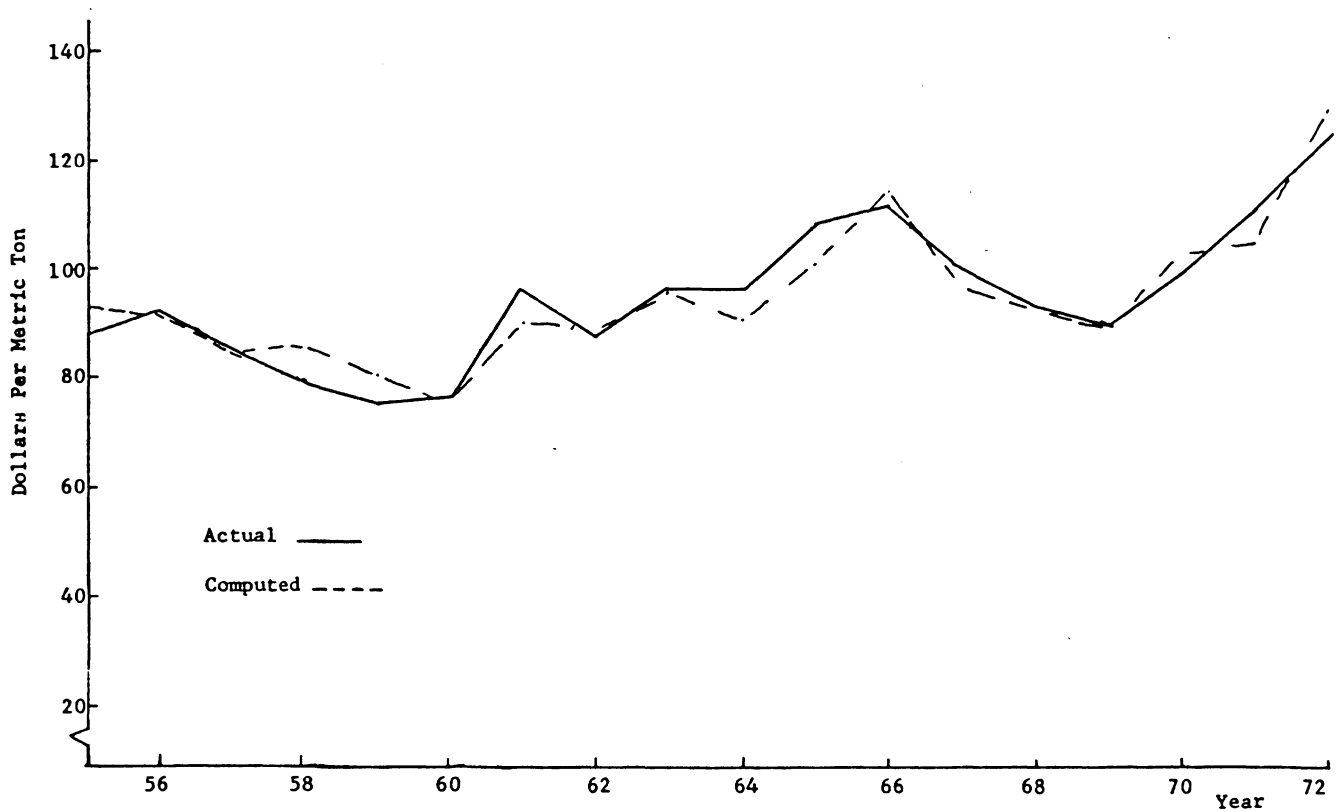

Figure IV-1. Average Wholesale Price of Soybeans, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

in the beginning stock of soybean meal affects the price of soybeans by 0.1% in opposite direction. The corresponaing measures implied by Vandenborre (1970) for the period of marketing years 1948-1964 were .65 and .11 percent for soybean meal price and oil price, respectively.

U.S. Domestic Demand for Soybean Meal

The estimated U.S. domestic consumption of soybean meal does not incorporate all the variables included in its theoretical counterpart. Foreign prices of soybean meal and other high protein meals were not included since the domestic and foreign prices are strongly correlated, so there is no gain in including both series. In addition, preliminary investigations also indicated that the price of livestock and livestock products and the price of corn were not significant in explaining the variation of the U.S. consumption of soybean meal during the period 1955-1972. However, the animal units of hogs and broilers were found to be highly related to the consumption of soybean meal in the United States during the same period of time. The fitted regression equation is presented as:

$$\text{3SLS} \quad Q^*_{smc} = -.3080. - \underset{(19.94)}{85.57}P^*_{sm} + \underset{(17.3)}{84.51}P^*_{om} + \underset{(.0109)}{.0534}Hog + \underset{(.283)}{3.499}Broil$$

The overall goodness of fit for the United States domestic consumption of soybean meal can be observed from Figure IV-2. In general, the predicted values traced the actual values quite well during

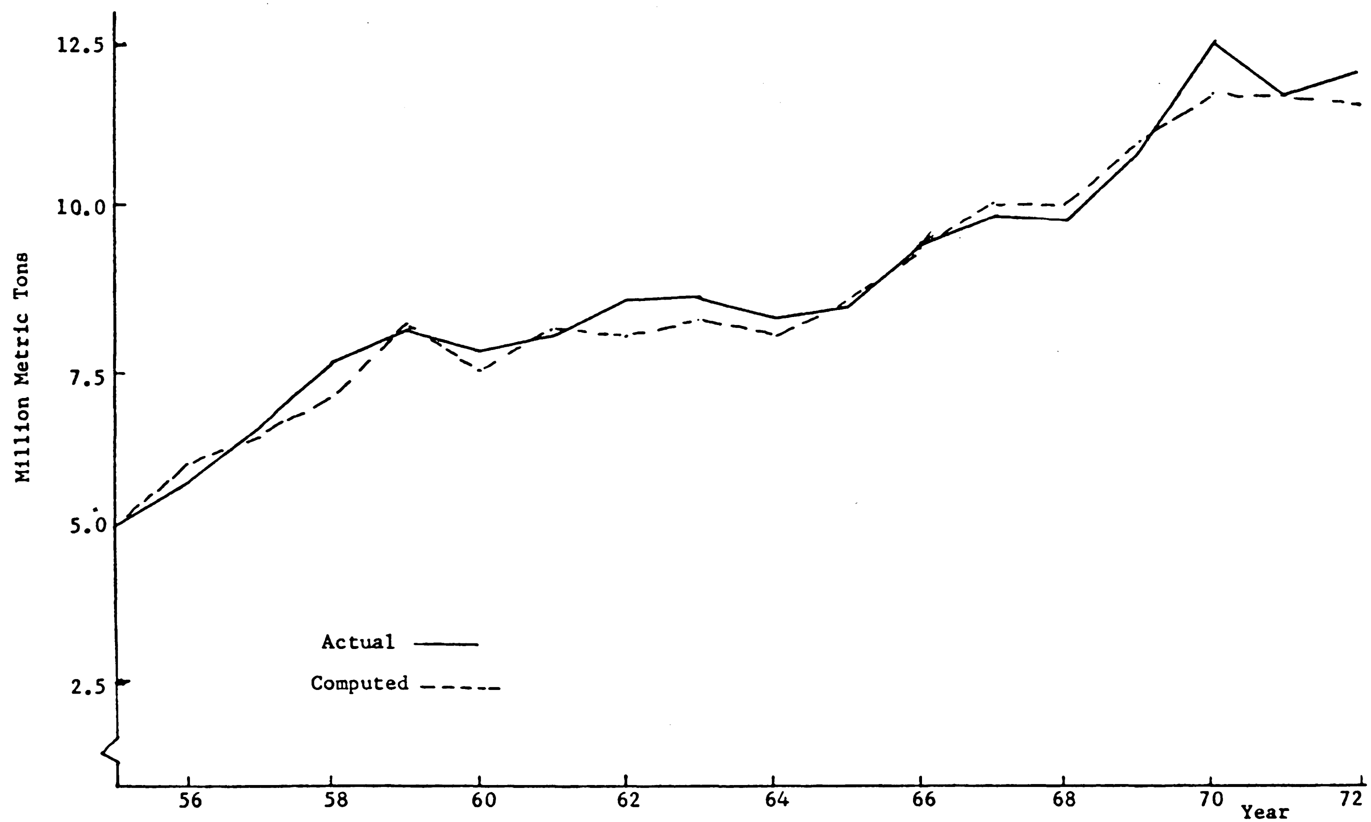

Figure IV-2. U.S. Consumption of Soybean Meal, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

the period from 1955 to 1972. There were only two years, in 1961 and 1971, that the estimated equation produced the opposite directions as compared with the actual change of directions.

The Farrar-Glauber test indicates the collinearity between the price of soybean meal and the price of other high protein meal may be serious. The overall coefficient of correlation is only slightly greater than the correlation between these two prices. Thus, the precision of the estimated coefficients for these variables may be seriously reduced by the presence of multicollinearity.

According to the resulting estimates, the elasticities calculated at the means were -.73 for own price elasticity and .88 for cross elasticity with respect to the price of other meals. The price flexibility coefficients for soybean meal obtained by G. A. King[9] for the interwar and immediate postwar period were -.48 and -.58. These flexibilities implied price elasticities of -2.08 and -1.72, respectively. Houck (1963) in his study computed elasticities from price flexibility coefficients of -.89 to -.93 for the marketing years 1940-60 period. Another recent study by Houck (1968) indicates an elasticity of -.33 for the period 1946-64. Vandenborre (1967) obtained an elasticity of -.28 for the 1948-63 period and -.44 for the 1948-64 period in his 1970's study. Price elasticity implied in the soybean meal analyses publised in Feed Situation for the 1950-64 period was -.56.[10]

[9] G. A. King, op. cit., p. 113.

[10] Malcolm Clough, "Major Factors Influencing High-Proten Feed Prices," Feed Situation, Fds-213, ERS, USDA, April 1966, p. 26.

Direct comparisons of the cross elasticity of soybean meal demand with respect to the price of other high protein meal are not available. However, Houck's study in 1963 indicated that a 1% increase in the quantity of high protein feed available for feeding (excluding soybean meal) decreases the price of soybean meal by .68 percent, or an elasticity of approximately -1.47. Vandenborre (1967) indicated that a 1% increase in other high protein feed availabilities decreases soybean meal consumption by .38% Vandenborre's study in 1970 indicated that the cross elasticity with respect to supply of other high protein feeds was -.88.

U.S. Demand for Other High Protein Meals

The U.S. demand for other high protein meals is an aggregated demand for all high protein meals specified in this study, except for soybean meal. Although demand for various kinds of protein feeds may have fluctuated substantially from year to year, it is likely that on the average, variations associated with individual high protein feeds were balanced out in the process of aggregation. Such a high degree of aggregation, to some extent, may have hampered the attainment of good economic and statistical analyses. In contrast to the *a priori* expectation, preliminary analyses suggested that animal units in the United States were negatively related to the consumption of other high protein meals. The animal units, therefore, were not included in the regression equation. The results of the 3SLS procedure in estimating the U.S. consumption of other high protein meals are presented below:

$$3SLS \quad Q^*_{omc} = 5283. + \underset{(9.45)}{54.8P^*_{sm}} - \underset{(11.44)}{49.07P^*_{om}} - \underset{(.03283)}{.09538Q^*_{smc}} - \underset{(8.32)}{28.07P_c}$$

The degree of multicollinearity detected among the prices of soybean meal and other meal, and quantity of soybean meal consumed is considered to be harmful, since the interdependency among these three variables were found to be greater than the dependent variable's multiple correlation with the entire set. The estimated relationships appears to be the weakest among the fitted equations within the system. As shown in Figure IV-3, a common pattern of an overestimation of the actual value has always associated with an underestimation of the actual value or vice versa. In general, as represented in Figure IV-3, the estimated equation traced the annual fluctuations in the consumption of other high protein meal quite well since 1961 to 1972. However, it failed to predict most of the turning points correctly during the 1955-63 period.

To the extent that there is no a priori expectation concerning the relationship between the demand for high protein meals and feed grains, it is appropriate to assume that they can be either of competitive or complementary relations. This study indicates that other high protein meals and corn tend to have a strong complementary relationship. This is in agreement with a recent study by Moe and Mohtadi.[11] They suggest that the complementary relationship existed in

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[11] L. E. Moe and Malek M. Mohtadi, op. cit., p. 85.

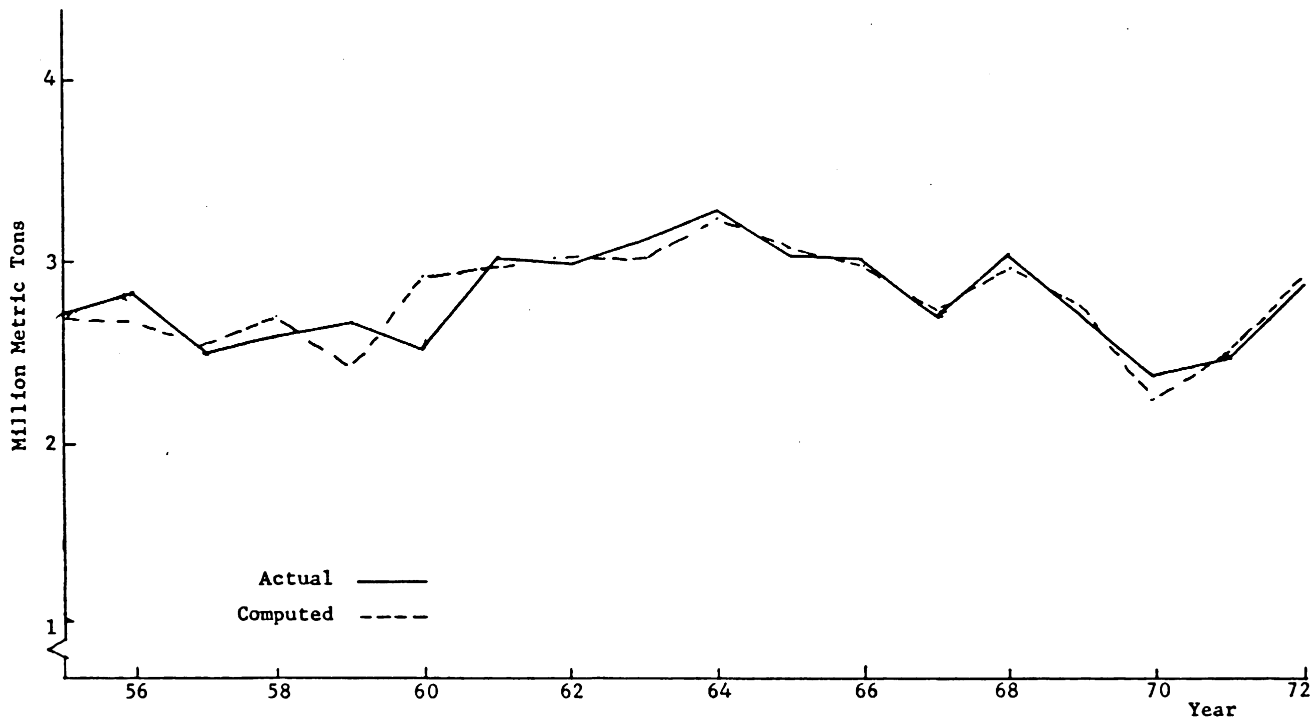

Figure IV-3. U.S. Consumption of Other High Protein Meal, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

the U.S., Japan, Canada and other Western European countries. On the other hand, G. A. King suggests that feed grains in general were strongly competing with high protein feeds.[12] In addition, Hildreth and Jarrett found that results obtained by limited information estimation methods imply that feed grains and protein feeds were technical complements, whereas the results obtained by least squares imply that they were substitutes. Therefore, Hildreth and Jarrett concluded that "our _a priori_ knowledge in this case is probably insufficient for us to regard either outcome as implausible.[13] Moreover, the tendency toward the increased use of formula feeds in the United States livestock industry could also result in complementarity between high-carbohydrate and high protein feeds.

The direct price elasticity was computed to be -1.6 and cross elasticity with respect to the price of soybean meal was 1.47 and -.45 with respect to price of corn.

Direct comparisons of these elasticities are not available. In a study of the aggregated demand for all high protein feeds, King estimated a direct price elasticity of -1.65 with cross elasticity of 0.68 for the price of feed grains.[14] For the limited information estimates of the Hildreth and Jarrett study, the elasticity of quan-

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[12] G. A. King, _op. cit._, p. 93.

[13] C. Hildreth and F. G. Jarrett, _op. cit._, p. 74.

[14] G. A. King, _op. cit._, p. 85.

tity of protein feeds fet with respect to the price of protein feeds is -1.84 and -.09 with respect to the price of feed grains.[15]

Results obtained from the present study and that of previous studies are less in agreement as to the demand interrelationship between protein meals and non-protein feeds. Statements as to these demand interrelationships must be tentative since study of the aggregate of all high protein feeds tends to average out the demand structure of the individual feeds.

Foreign Demand for Soybean Meal

The foreign price of livestock and livestock products is not included in the statistical estimation of foreign demand for soybean meal because data are not available on this variable. However, one would expect very little to be gained by including this variable in the estimated equation since the three variables, prices of soybeans and other high protein meal, and high protein consuming animal units in the foreign countries accounted for almost all of the variations in the consumption of soybean meal during 1955-72. The presence of a linear time trend is apparent. The reason that time is not incorporated is because it is highly intercorrelated with high protein consuming animal units. In fact, the influence of time may be reflected in the coefficient on the animal units variable which is found to be the most significant variable among the explanatory variables that accounted for soybean meal consumption in the rest of the

[15] C. Hildreth and F. G. Jarrett, *op. cit.*, p. 72.

world. The statistical relation for consumption of soybean meal in the rest of the world is shown below.

$$\text{3SLS} \quad Q^*_{smf} = -35870. - \underset{(32.96)}{91.32P^*_{sb}} + \underset{(27.89)}{123.4P^*_{omf}} + \underset{(2.42)}{36.27H_{paf}}$$

The Farrar-Glauber test indicates that the collinearity is located between the prices of soybeans and other high protein meals, and to a lesser extent between the price of soybeans and high protein consuming animal units. Since the multiple correlation coefficients for these variables are considerably less than the overall coefficient of correlation, the results seem to be reliable.

Preliminary investigations suggested that instead of foreign price of soybean meal, the U.S. price of soybeans was more significant in explaining the foreign consumption of soybean meal. This appears reasonable since the U.S. is the most important producer and exporter of soybeans of the world, and to a considerable extent, most of the major consuming countries in the rest of the world are also the major importing countries of U.S. soybeans. The elasticities with respect to price of soybean and price of other meal, c.i.f., European ports, were computed as -.76 and 1.13, respectively.

Annual estimates of the foreign consumption of soybean meal are compared with actual values in Figure IV-4. As shown in Figure IV-4, computed values of soybean meal consumption fitted the actual data fairly well. The general level and movement of soybean meal consumptions were also indicated by the estimated structure, but some short-term variations were not accounted for. Specifically, in the years

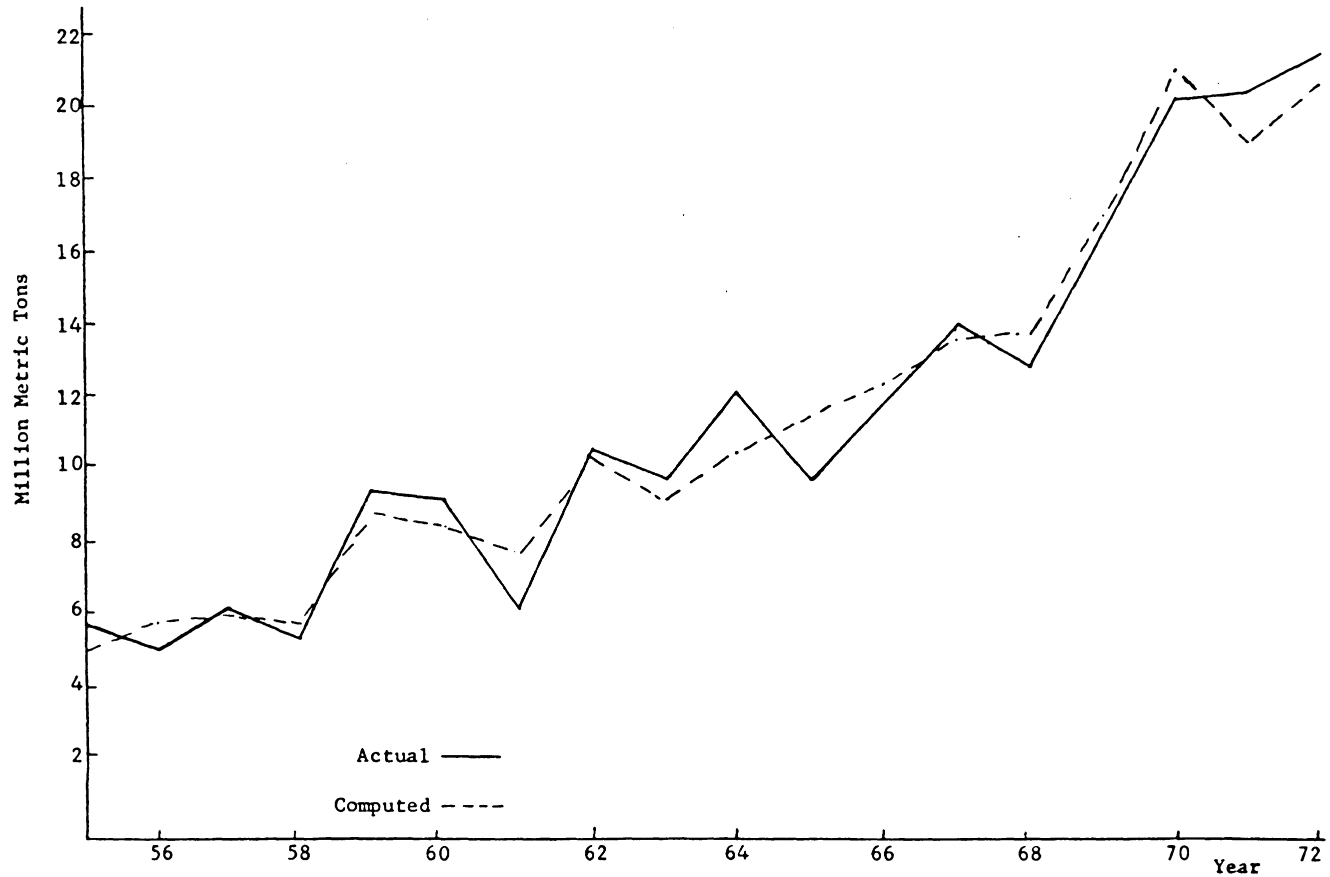

Figure IV-4. Foreign Consumption of Soybean Meal, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

of 1955, 1964, 1967 and 1970, the fitted equations wrongly indicated the change of directions.

Foreign Demand for Other High Protein Meals

The number of high protein consuming animal units again were found to be the most significant variable in explaining foreign consumption of protein feeds. Preliminary analyses suggested that foreign consumption of other high protein meals was more responsive to the U.S. price of other protein meals than the price of other meals, c.i.f. European ports. Since international trade in these protein feeds is hampered only to a very limited extent by restrictions, one would expect the two price series to be highly correlated. Consequently, it is justified to use the U.S. price of other high protein meal in substitution of the European price. The estimated statistical relationship is:

$$\text{3SLS} \quad Q^*_{omf} = -19040. + \underset{(38.03)}{184.1P^*_{smf}} - \underset{(37.38)}{146.1P^*_{om}} + \underset{(2.95)}{24.71H_{paf}}$$

Although certain degree of collinearity exists between the prices and the animal units, it does not appear to be harmful as the reliability of the estimates are concerned. As represented in Figure IV-5, during the sample period, the estimated values fitted to the actual data reasonably close. In terms of turning points, the fitted structural equation had only incorrectly predicted the change of directions three times, i.e., in 1958, 1959, and 1968, during the 18 year period.

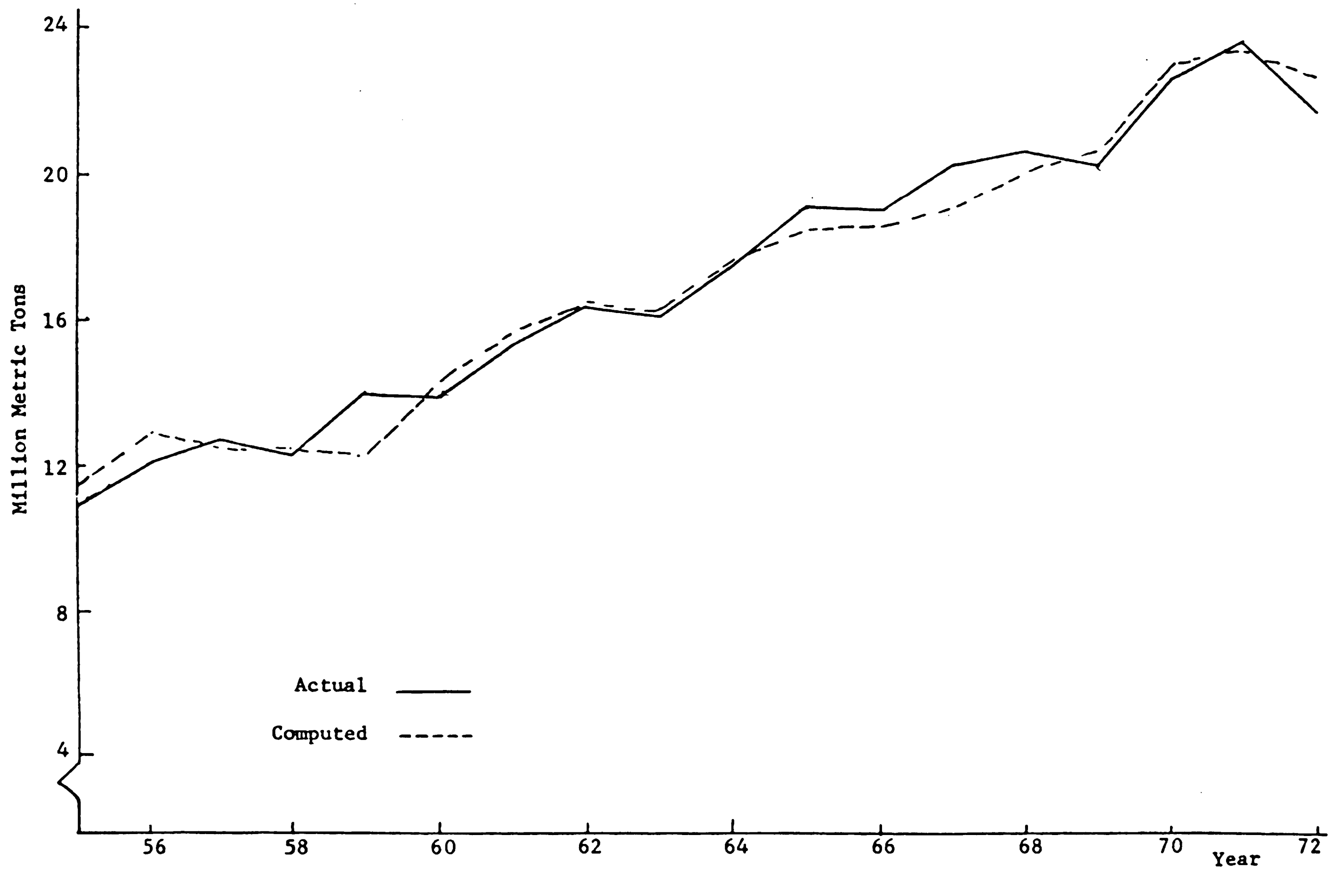

Figure IV-5. Foreign Consumption of Other High Protein Meal, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

The estimated relationship implies the elasticities of -.78 and 1.18 with respect to own price and price of soybean meal, respectively.

It should be noted that the present study indicates that price response of demand for other high protein meals in the United States is approximately twice as elastic as that in the rest of the world. In view of the easy availability of soybean meal in the United States, it appears reasonable to expect that for the same time dimension of observations, the demand elasticity would be higher in the U.S. than the rest of the world.

U.S. Exports of Soybean Meal

The three variables, prices of soybeans and soybean meal, and high protein consuming animal units, were found to be the most important variables in explaining variations in the U.S. exports of soybean meal. The price of soybean oil, as expected, is also significant in explaining the U.S. exports of soybean meal. However, it is omitted from the empirical equation because the sign for the coefficient on price of oil is unacceptable on *a priori* ground. Not surprisingly, the estimated standard error of regression reduced substantially and the predicted values fitted much better to the actual observations with the incorporation of price of soybean oil than without it. Nevertheless, in terms of turning points, preliminary analyses indicated that the estimated structural relation, when price of soybean oil was excluded, provided a more accurate prediction on the short-term variations of soybean meal exports than when it was included. Based on these considerations, the price of soybean oil was deleted from the statistical analyses. The statistically estimated export relation is presented below:

$$\text{3SLS} \quad Q^{*}_{smx} = -28210. - \underset{(49.61)}{99.08P^{*}_{sb}} + \underset{(72.14)}{159.6P^{*}_{smf}} + \underset{(5.16)}{22.39H_{paf}}$$

The test for multicollinearity suggests that the problem is located between the prices of soybeans and soybean meal. However, according to the rule of thumb employed in this study, it does not appear to be serious. The actual versus estimated values computed from 3SLS structural estimates are presented in Figure IV-6. The fitted regression explains the general movement of the soybean meal exports satisfactorily during the time period of observations. With regard to turning points, the performance of the estimated relation does not seem to be very well, particularly, for some year-to-year variation during the 1960's.

The estimated coefficients suggest that a 1% increase in the soybean price decreases U.S. exports of soybean meal by -1.47%; a 1% increase in the price of soybean meal, c.i.f., European ports, increases the U.S. exports by 2.72%. Elasticity of soybean exports implied by Houck (1963) was -.89. In his 1968 study, Houck obtained elasticity estimates of -.60 to -1.13. In the same study, the price elasticities with respect to price of soybean meal were .51 to 1.04. The elasticity of European demand for U.S. soybean meal exports with respect to the ratio of price of European and Canadian livestock to price of soybean meal reported by Vandenborre (1970) was 1.21. As noted earlier, approximately 73% of U.S. soybean meal exports are in

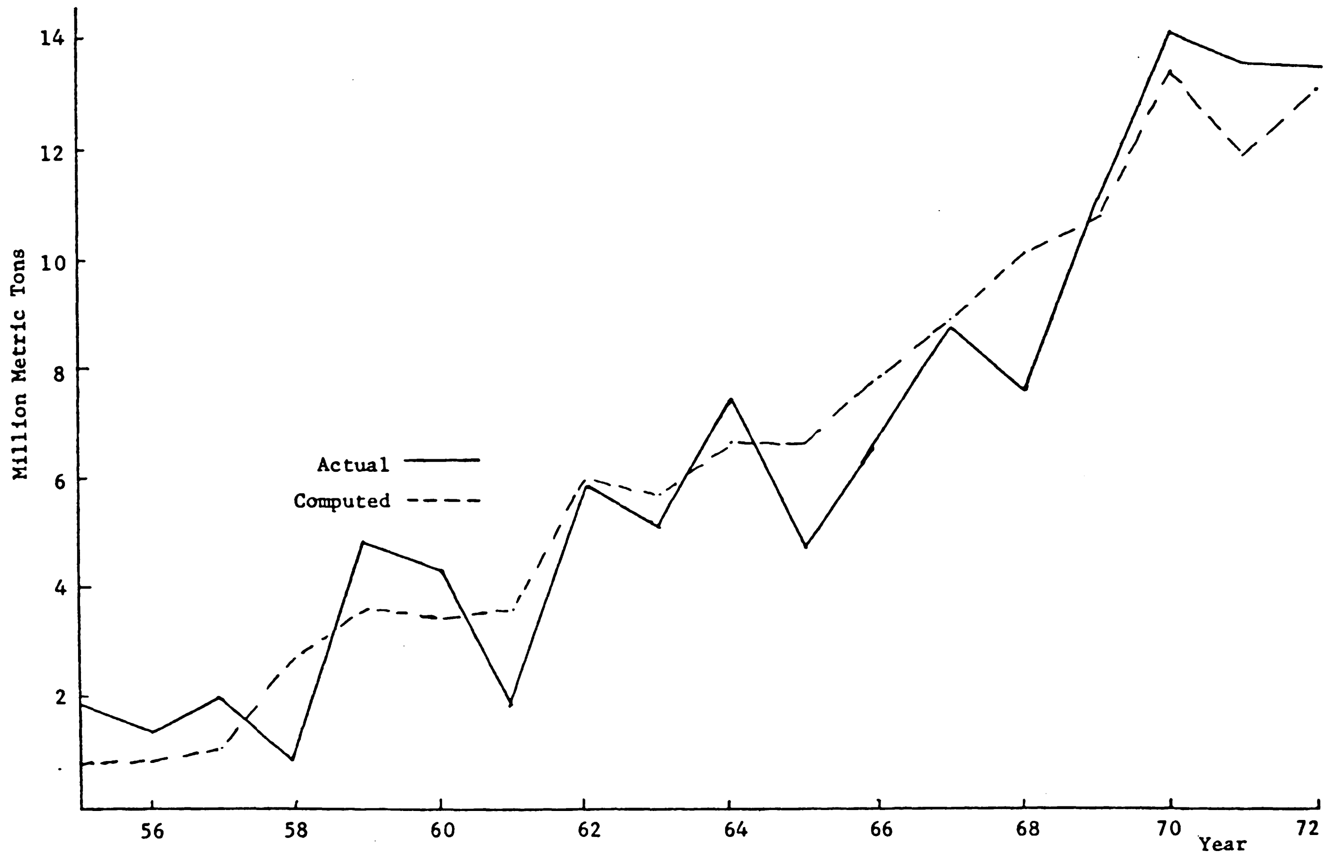

Figure IV-6. U.S. Exports of Soybean Meal, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

the form of beans. Thus, it is likely that European and other foreign crushers will respond directly to the price of soybeans and import as much meal and oil as possible in the form of beans in any given year. This study suggests tht on the average U.S. soybeans and meal compete in foreign outlets as livestock feed sources.

U.S. Imports of Other High Protein Meals

As mentioned in the previous section, strong aggregation may average out the demand structure for individual protein feed. It was not possible to establish an acceptable empirical relationship between U.S. meal import and number of animal units. However, high protein consuming animal units in the rest of the world was found to be one of the significant variables that explained the variation of U.S. imports of other high protein meals. To the extent that U.S. imports are exports from the rest of the world and without inventory adjustments in the rest of the world, one would expect exports to be decreased as protein consuming animal units and consumption of protein meals increased in the rest of the world. In addition, for any given year, stocks of soybean meal may be accumulated due to increasing supply of soybean meal. If this is the case, imports of other protein meals may be expected to be reduced. On the other hand, stocks of soybean meal may be increased because of increases in the demand for other protein meal and thus reduced the consumption of soybean meal. Since there is no clear *a priori* ground for the behavioral relationship between U.S. imports and stocks of soybean meal, either outcomes may be considered as possible. The estimated structural relation for U.S. imports of other high protein meals is:

$$3SLS \quad Q^*_{omi} = 845.9 + \underset{(7.04)}{40.11P^*_{smf}} - \underset{(4.23)}{30.19P^*_{omf}} + \underset{(.0172)}{.0215Q^*_{sms}}$$

$$- \underset{(.621)}{1.648H_{paf}}$$

In terms of turning points, it is seen from Figure IV-7 that the estimated relation predicts most of the directions correctly, except for four years, i.e., 1955, 1959, 1963 and 1971, where the overestimate (underestimate) of actual value causes the predicted value of the following year to appear to move in the wrong direction. Furthermore, the Farrar-Glauber test also suggests that the estimated structural parameters may be seriously distorted.

According to the results obtained, the U.S. import elasticity with respect to the European price of other protein meals was computed to be -8.2, and 11.29 with respect to the European price of soybean meal. These elasticity measures suggest that the United States demand for imports of other high protein meals is highly price elastic. This is probably the case, since the U.S. is primarily an exporter of protein meals. Most of the U.S. imports are imports of fish meal. The fact that the U.S. is the world's largest producer of soybean meal would lead one to the *a priori* expectation that U.S. imports of other protein meal will be price elastic, due to the easy availability of soybean meal. A recent study of the fish meal industry also suggests that U.S. demand for imports is

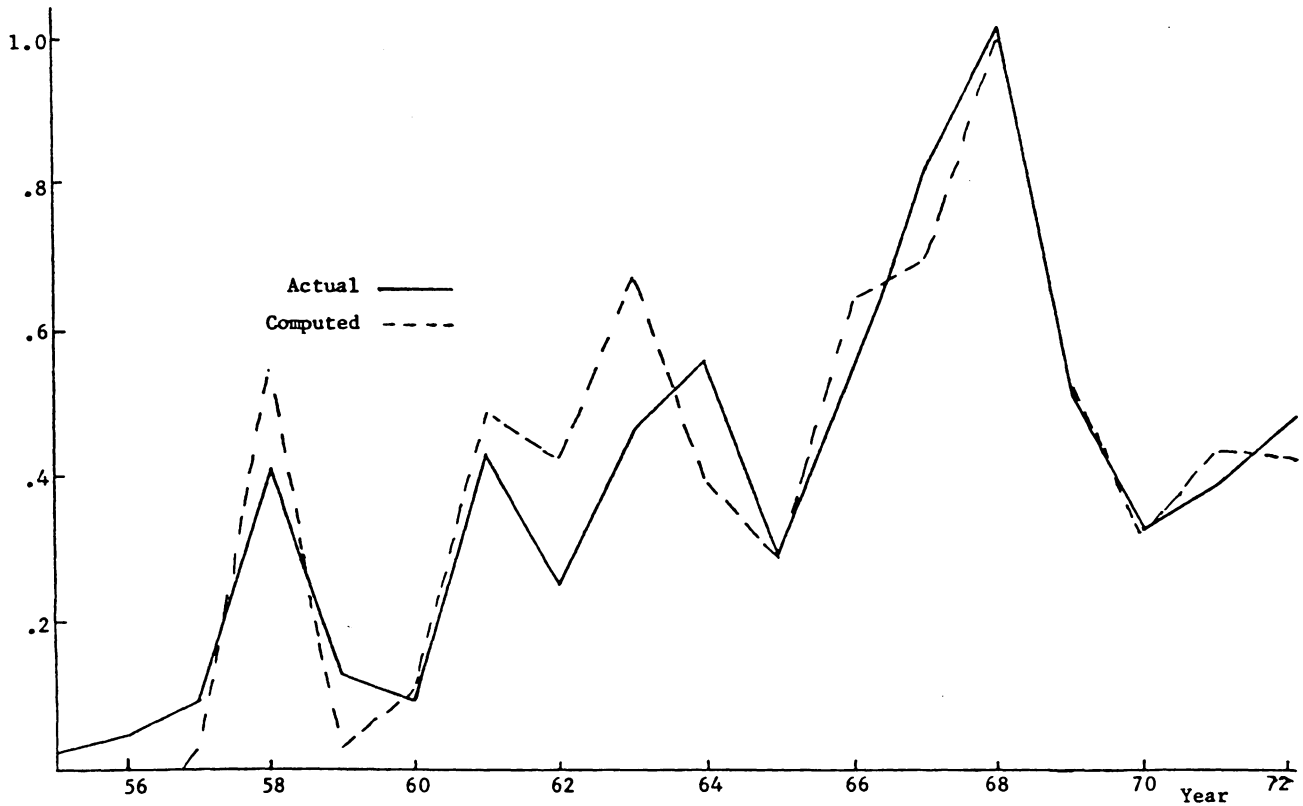

Figure IV-7, U.S. Imports of Other High Protein Meal, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

highly responsive to price changes. The elasticity of U.S. import demand for Peruvian fish meal with respect to fish meal price is computed to be -3.25 from estimates of indirect least squares and -1.29 from 2SLS estimates.[16]

U.S. Ending Stocks of Soybean Meal

While the demand for consumption and exports are originated primarily by livestock producers and exporters, the demand for inventory of soybean meal is forthcoming from the processors and handlers who expect to profit from holding stocks from the current period to the future. As in the export equation, the U.S. demand for ending stocks of soybean meal includes meal as well as meal equivalent in soybeans. Consequently, soybeans may be held for price speculation reasons, on the expectation that the price of soybean meal and/or price of soybean oil is going to improve. Attempts to establish an acceptable empirical relationship between the ending stocks of soybean meal and price of soybean oil that was specified in the theoretical model was unsuccessful. The price of soybean oil was then dropped from this structural equation. The results of the statistical estimates for the stock relation are presented. Thus,

$$\text{3SLS} \quad Q^*_{sms} = -6351. + \underset{(20.12)}{86.4P^*_{sm}} - \underset{(.144)}{1.103Q^*_{smx}} + \underset{(.117)}{1.594Q_{sms1}}$$

The Farrar-Glauber test indicates a higher degree of collinearity between the price of soybean meal and the beginning stocks of

[16] E. L. Segura, An Econometric Study of the Fish Meal Industry, FAO Fisheries Technical Paper No. 119 (Rome: Food and Agriculture Organization of the United Nations, 1973), pp. 155-6.

soybean meal. The multicollinearity, although present, is not considered to cause a harmful effect for the estimates according to the rule used in this study. As shown in Figure IV-8, the fitted regression explains the variations in U.S. ending stocks of soybean meal during the 1955-72 period fairly well. Except for the year of 1961, 1969 and 1971, the estimated equation gave predicted values which moved in the wrong direction.

In his 1963 and 1968 studies, Houck indicated that coefficients on the price of soybeans were positive in soybean storage equation but were not large relative to their standard errors. This study also shows that there is a positive relationship between ending stocks and the price of soybean meal. This may have reflected the influence of factors such as price anticipations and, to a considerable extent, trend.

Price response of ending stocks was calculated to be .48 with respect to soybean meal price during the observation period. In his 1970 study, Vandenborre reported that demand elasticity of soybean meal stocks with respect to price of soybean meal was .70. Conclusions reached from the present study and that of Vandenborre tend to indicate that stock of soybean meal was price inelastic.

In this chapter, the empirical results of the statistical model were presented and discussed. In most of the cases, the results were satisfactory and seemed to agree with *a priori* expectations and findings obtained by previous studies. In what follows, a further analyis on these empirical results and the implications of reduced form estimates will be presented.

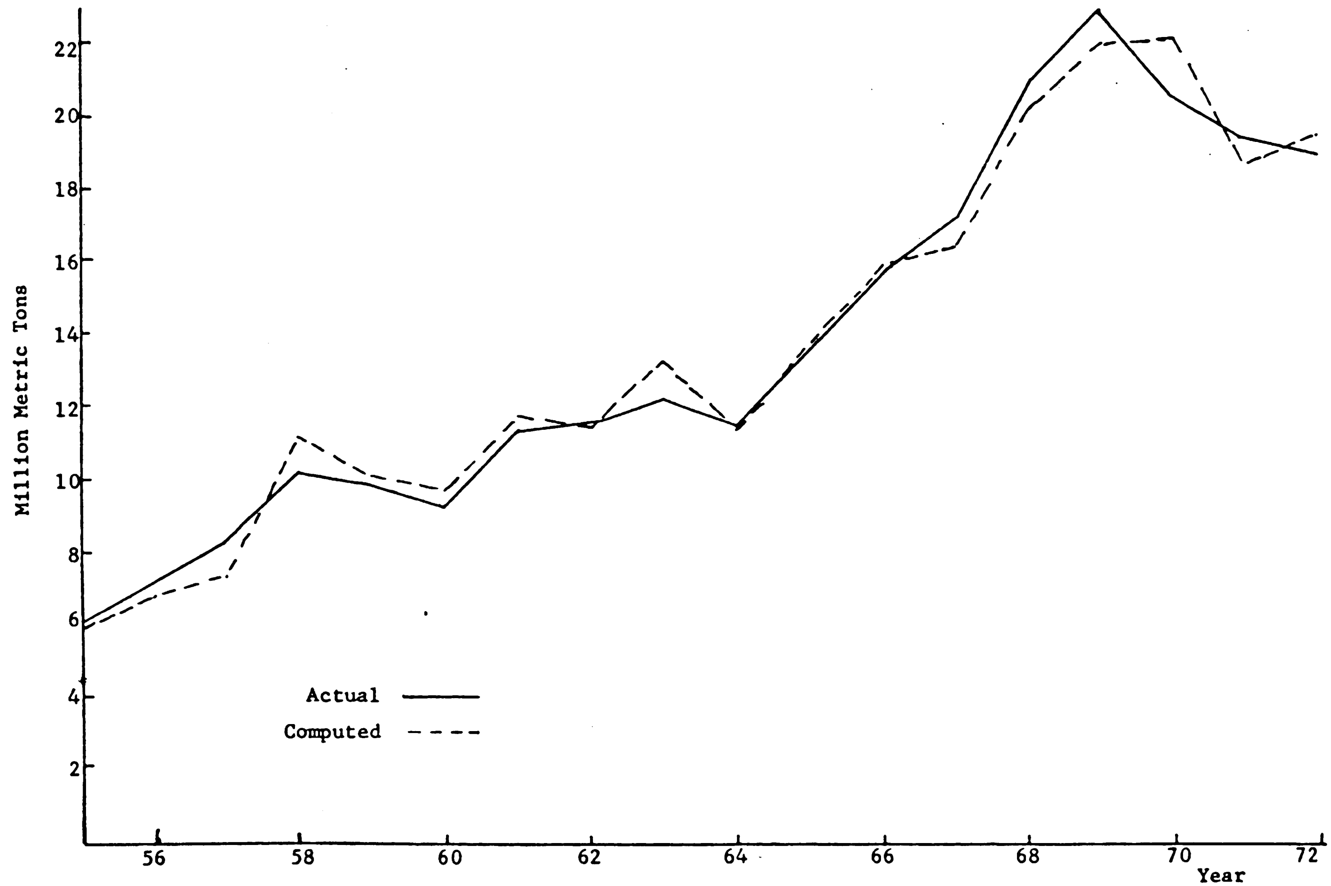

Figure IV-8. U.S. Ending Stocks of Soybean Meal, Actual and Computed from 3SLS Structural Estimates, 1955-1972.

CHAPTER V

ECONOMIC ANALYSES AND IMPLICATIONS OF THE STATISTICAL RESULTS

The previous chapter was devoted to the statistical estimation of the structural parameters of the model for the world economy of high protein feeds. In this chapter a further check on these statistical results and the implications of these results for policy considerations will be discussed.

Reduced Forms

In a fundamental economic sense, the property that characterizes a structural system is the assertion that it accurately describes the precise economic mechanism in which all the endogenous and predetermined variables mutually interact within the specified economic system. A reduced form system, on the other hand, describes the way in which the predetermined variables serve to influence the behavior of the current endogenous variables, after all interactions among jointly dependent variables have been allowed for. Thus, a reduced form coefficient measures the "total" effect, direct and indirect, of a change in the predetermined variable on the endogenous variables, after taking account of the interdependences among the jointly determined variables; whereas a structural parameter indicates only the direct effect within a single sector of the economy.[1]

The reduced form of a structural model is the model in which the endogenous variables are expressed as a function of all the predetermined variables. The estimates of the reduced form coefficients may be obtained in two ways. The first is to express the endogenous variables as functions of all the predetermined variables of the system and proceed with the estimation by applying OLS to these functions. This method of obtaining the reduced form coefficients is referred to as least-squares no-restrictions (LSNR), because it does not take into account any restrictions imposed by the form of the structural system. Thus, it does not require complete knowledge of the structural system, but only knowledge of the predetermined variables appearing in the whole system.

The second method for obtaining the reduced form coefficients of a structural model is to solve the structural system of endogenous variables in terms of predetermined variables, the structural parameters and the disturbances. The reduced form coefficients obtained by this method are often called the "derive" or "solved" reduced form coefficients. Goldberger has shown that reduced form coefficients derived from any consistent structural estimates will also be consistent.[2] In addition, there is also an invariance property asso-

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[1]Arthur S. Goldberger, Econometric Theory (New York: John Wiley & Sons, Inc., 1964), p. 369.

[2]Ibid., pp. 370-71.

ciated with asymptotic efficiency, that is, the reduced form estimates derived from the efficient structural estimates are also efficient. Nevertheless, small sampling errors in individual structural coefficients may be accumulated into large sampling errors in the derived reduced form coefficients rather than cancelling out. The minimum variance property does not carry over from the structural to the derived reduced form coefficients.[3]

Since the reduced form suffices for several important applications, there seems to be less agreement about the relative merits of LSNR and of derived reduced form estimates. Klein argues that "the best forecasts should be made from the best estimate of the structure of the economic system."[4] Generally, it is believed that derived reduced form estimates have several advantages over the direct estimation of LSNR. (1) The deriviation of reduced form coefficients from the structural coefficients is more efficient, at least asymptotically, because it takes into account all the information incorporated into the structural models. (2) Structural changes occur continuously over time. LSNR estimates give no structural information and are, thus, of limited use from the very moment a structural change takes place. However, if structural estimates are available, they may be modified appropriately and recomputed reduced form estimates derived from them. (3) Extraneous information on

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[3] Ibid., p. 379.

[4] L. R. Klein, A Textbook of Econometrics (New York: Row, Peterson and Company, 1953), p. 255.

some structural parameters may become available; without structural estimates, such information again will be of limited use.[5]

On the other hand, it is argued that the best unbiased forecasts are obtained from LSNR, and thus the complexities involved first in estimating the structural parameters and then in deriving reduced form estimates from them are not necessary and can be avoided. This is the position of T. C. Liu,[6] who argues that econometric models are much more likely to be underidentified rather than overidentified and structural estimation is generally not possible in simultaneous systems. The most one can do is to estimate reduced forms without a priori restrictions. Restricting the reduced form by a priori restrictions, Liu advances, not only adds no more information, it is positively harmful, as it adds misinformation. Forecasting should therefore always be done with the LSNR which has the smallest error variance for the sample observations and there is no reason to expect mistakenly oversimplified and restricted models to do as well or better. Moreover, he argues that most of the structural changes can be included in the structure as exogenous variables if one has past experience with them. Forecasting under changed structure then becomes forecasting under an unchanged structure with changed magnitudes for exogenous variables.[7] In what follows, both

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[5] Ibid., pp. 379-80.

[6] T. C. Liu, "Underidentification, Structural Estimation and Forecasting," Econometrica, Vol. 28, No. 4 (October 1960), pp. 855-65.

[7] Ibid., pp. 360-62.

partial equilibrium analyses using three-stage least squares reduced form (3SLSRF) estimates and annual forecasts for 1973 using 3SLSRF and LSNR estimates are presented. The objective is to illustrate the applications of the model in studying questions with economic and policy considerations.

Partial Equilibrium Analysis--
Reduced Form Estimates

As indicated previously, unrestricted estimates of the parameters of the reduced form were estimated directly by least-squares. In the derived reduced form equations, each jointly determined variable was expressed as a function of all predetermined variables in the system. The derived reduced form coefficients preserve all of the structural restrictions and the definitional identities built into the system. The complete set of 3SLSRF and LSNR estimates for every endogenous variable is given in Appendix E. In addition, both 3SLSRF and LSNR estimates were compared with their actual values and presented graphically in Appendix E, in Figure E-1 through Figure E-12. Excellent fits were obtained from the LSNR for most of jointly determined variables. In contrast, 3SLSRF performed much less satisfactorily and generally provided unduely large errors and less accurate estimates of the endogenous variables. For predictive purposes, therefore, the LSNR appeared to be superior than structural estimates.[8]

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[8]Hildreth and Jarrett also pointed out that the simultaneous-equations approach, although internally consistent with existing theory and knowledge of institutional arrangements, does not necessarily produce the useful predictions. See Hildreth and Jarrett, *op. cit.*, pp. 119-20.

The estimated structure indicated the general movements in the actual price series during the 1955-1972 sample period (Figure E-1 through Figure E-5). However, much of the short-term price variations were not accounted for by the 3SLSRF. These are most evident for the 1969-70 period. The model consistently indicated a price decline for 1969-70 which did not occur. In fact, 1969 was a turning point where the prices of high protein meals began to increase after several years of decline. The failure of the system to predict this upward trend in the prices of protein meals may be a result of a sudden shift in the demand for protein meals in 1970 caused by the increases of animal units both in the U.S. and in the foreign countries, and an advance in price of soybean oil and price of corn in the U.S. Although the productions of protein meals were also increased generally from 1969 to 1970, the shifts in the supply function were relatively less than the shifts in the demand function during that period.

The general movements in the jointly determined quantity variables were also indicated by the 3SLSRF estimates, as with prices the estimated structure did not account for some yearly variations (Figure E-6 through Figure E-12). In general, estimates of the U.S. domestic consumption of soybean meal (Figure E-6) and foreign consumption of other meals (Figure E-9) were more accurate than estimates of other quantity variables close to the actual quantities. Strong trends in these two quantity variables, especially foreign consumption of other protein meals, partially accounted for this better performance.

The structural model, reflected in the 3SLSRF, is used in this section to provide a partial equilibrium analysis in tracing the consequences of specific changes in predetermined variables on the jointly determined variables.

The effects of a specific change in the predetermined variables on each of the endogenous variables are summarized in Table V-1. The structure of the model assumes that the equilibrium prices of protein meals are established implicitly within the system. More specifically, those identities included in the model define the equilibrium prices when the demand for and supply of protein meals are equal. Therefore, the effects of changes in predetermined variables on the prices can be viewed as changes in the direction of new equilibrium prices. For instance, Table V-1 shows that increasing the number of hogs or broilers in the United States, after all simultaneous relationships have worked themselves out with all other exogenous variables remaining constant, will have a negative effect on the various protein meal prices. Moreover, Table V-1 also indicates the adjustment process among the quantity variables. It shows the net effects on the resource reallocation at new.equilibrium levels, given an initial change in the predetermined variables. Thus, if there is a one million unit increase in the number of hogs in the U.S., the U.S. soybean meal consumption will increase 44.4 thousand metric tons and the exports of soybean meal and ending stock of soybean meal will decrease by 30.59 and 13.81 thousand metric tons, respectively. The effects of changes in number of broilers in the U.S. on the meal consumption are much less than that of changes in the

Table. V-1. The Impact on Endogenous Variables of an Increase in Predetermined Variables

Effect on	Hog million units	Broil million units	P_c dollar metric tons	H_{paf} million units	Q_{sms1} 1000 metric tons
P_{sb} ($/m.t.)	- 0.81	-0.03	0.40	0.02	-0.01
P_{sm} ($/m.t.)	- 0.55	-0.04	0.43	0.02	-0.01
P_{om} ($/m.t.)	- 0.66	-0.04	-0.07	-0.004	-0.01
P_{smf} ($/m.t.)	- 0.51	-0.03	-0.07	-0.15	-0.01
P_{omf} ($/m.t.)	- 0.63	-0.04	-0.11	-0.30	-0.01
Q_{smc} (1000 m.t.)	44.40	2.91	-42.29	-2.42	-0.062
Q_{omc} (1000 m.t.)	- 1.84	-0.12	2.71	1.76	0.009
Q_{smf} (1000 m.t.)	-30.59	-2.01	-51.14	-3.37	-0.243
Q_{omf} (1000 m.t.)	1.84	0.12	- 2.71	-1.76	-0.009
Q_{smx} (1000 m.t.)	-30.59	-2.01	-51.14	-3.37	-0.243
Q_{omi} (1000 m.t.)	- 1.84	-0.12	2.71	1.76	0.009
Q_{sms} (1000 m.t.)	-13.81	-0.90	93.43	5.79	1.31

Table V-1. (Continued)

Effect on	Positive Change In				
	P_{so} dollar metric tons	Q_{smpu}	Q_{ompu}	Q_{smpf}	Q_{ompf}
		1000 metric tons			
P_{sb} ($/m.t.)	0.15	0.01	0.01	-0.003	0.001
P_{sm} ($/m.t.)	- 0.01	0.01	0.02	-0.004	0.001
P_{om} ($/m.t.)	- 0.02	0.01	-0.002	0.001	0.001
P_{smf} ($/m.t.)	- 0.02	0.01	-0.002	0.002	0.01
P_{omf} ($/m.t.)	- 0.04	0.01	-0.004	0.01	0.01
Q_{smc} (1000 m.t.)	- 1.10	0.024	-1.51	0.375	0.025
Q_{omc} (1000 m.t.)	0.693	0.044	1.096	-0.271	-0.012
Q_{smf} (1000 m.t.)	-18.69	0.40	-1.82	1.676	0.943
Q_{omf} (1000 m.t.)	-0.693	-0.044	-0.096	0.271	1.012
Q_{smx} (1000 m.t.)	-18.69	0.40	-1.82	0.676	0.943
Q_{omi} (1000 m.t.)	0.693	0.044	0.096	-0.271	-0.012
Q_{sms} (1000 m.t.)	19.79	0.576	3.33	-1.051	-0.968

hogs. If there is an increase of one million broilers, soybean meal consumption in the U.S. will increase only 2.91 thousand metric tons and exports and ending stock of soybean meal will decrease approximately 2 thousand metric tons and 900 metric tons, respectively.

The effects of changes in the price of corn and animal units in the foreign countries on the endogenous variables as shown in Table V-1 are similar. In addition, Table V-1 shows that corn appears to be complimentary to other protein meal but substitutes for soybean meal in the United States. For example, a one dollar increase in the price of corn will increase the price of soybean meal by 43 cents and decrease U.S. soybean meal consumption by 42.29 thousand metric tons. On the other hand, for each dollar increase in the price of corn, the price of other meal in the U.S. will decrease by 7 cents and consumption of other meal will increase 2.71 thousand metric tons.

These effects can also be traced from the structional equation. The direct effect of a one dollar increase in the price of corn as shown by the structural coefficient on the price of corn[9] is a reduction in the consumption of other meal by 28.07 thousand metric tons. However, indirectly the prices of other meal and soybean meal, as well as the quantity of soybean meal consumed, will also be affected. Specifically, the equilibrium price of other meal declined by 7 cents and price of soybean meal increased 43 cents and quantities of soybean meal consumed decreased 42.29 thousand metric

[9]The structural equation of the U.S. consumption of other meal is presented here for convenience. Thus, $Q^*_{omc} = 5283. - 49.07P^*_{om} - .09538Q^*_{smc} - 28.07P_c$.

tons. From the structural coefficients, it can be seen that these changes induce an increase in the consumption of other meal by 3.43, 23.56, and 4.03 thousand metric tons, respectively. The combined indirect effects represent a total of 31.02 thousand metric ton increase in the consumption of other meal. Therefore, the new effect, combining the direct and indirect effects, is a 2.95 (= 31.02 - 28.07) thousand metric ton increase in the consumption of other meal. Note this is different only slightly from the 2.71 thousand metric tons increases as shown in Table V-1.

The influence of the beginning stock of soybean meal does not seem to be in agreement with _a priori_ expectation. Table V-1 indicates that the effect of one thousand metric ton increase in the beginning stocks of soybean meal will depress all the protein meal prices by about one cent per metric ton. However, the consumption and the exports of soybean meal, instead of increasing, have declined by 62 metric tons and 243 metric tons, respectively, since the price of other protein meal is more responsive to the changes in the beginning stocks than the price of soybean meal. Thus, when the price of soybean meal decreases, consumption of soybean meal increases and consumption of other protein meal decreases. At the same time, price of other meal also decreases which causes the consumption of other meal to increase and consumption of soybean meal to decrease. The combined effect after these simultaneous adjustments is that more other protein meals have been substituted for soybean meal in livestock feeding. Therefore, the net effect is that soybean meal consumption decreases 62 metric tons and consumption of other meals increases by 9 metric tons. The same phenomena are also observed on the impacts of change in soybean oil price on the consumption of high protein meals.

As shown in Table V-1, the price variables are not very responsive to changes in the production of high protein meals. Generally, the various protein meals prices are more responsive to the U.S. production of soybean meal than foreign production of soybean meal. Furthermore, foreign prices of protein meals are also more responsive to foreign production of other meals than the U.S. production of other meals. This is probably so because the U.S. is the major producer of soybean meal and the rest of the world is the major producer of high protein meals other than soybean meal. According to Table V-1, most of the increase in the soybean meal production in the United States is allocated between ending stocks and exports to foreign countries, and only a very small portion of the increased production is consumed domestically. Specifically, it is shown in Table V-1 that if the U.S. increases soybean meal production by one thousand metric tons, domestic consumption will increase by 24 metric tons and exports of soybean meal will increase by 400 metric tons and the ending stocks of soybean meal will increase 576 metric tons. These figures may not appear to be very realistic. For instance, the relative increase in the domestic consumption seems to be too low and the increase in the ending stocks seems to be overestimated.

However, as previously noted in Chapter II, during the 1955-72 period, the U.S. which was by far the world's largest consumer of soybean meal had a lowest growth rate among the consuming regions. In addition, it is also shown that during the same period the growth rate of consumption in the U.S. was substantially lower than the rate of growth in production. Moreover, the level of concentrate feeding per animal unit has historically been quite high in the U.S. and since the early 1960's, the increase in demand for meals in the United States has moved in line with the increase in total livestock numbers. This can be verified from Table V-1 which shows that in response to a one unit increase in hog numbers, the U.S. consumption of soybean meal will increase 44.4 thousand metric tons. In view of these considerations, it seems, after all, not totally unrealistic to assert that a given change in the U.S. production of soybean meal, holding other exogenous variables constant, appears to have no effects on the U.S. domestic consumption of soybean meal. Table V-1 also shows that the net effects of a one thousand metric ton increase in the United States production of other meals will increase United States imports of other meals by 96 metric tons and the United States consumption of other high protein meals will increase as a total of 1096 metric tons. Consumption of soybean meal will decrease by 1510 metric tons. When soybean meal prices increase and the price of other high protein meals declines, more other high protein meals are demanded and substituted for soybean meal. As a result of these increases in both domestic consumption and exports, the U.S. ending stocks of soybean meal will be reduced by 1051 metric tons. Finally, the consequences of changes in the production of other meals in foreign countries can also be traced from Table V-1. If the foreign production of other meals increase by one thousand metric tons, the net effect will be that all prices will be adjusted upward. Since the price effects are greater in the foreign market than in the United States, the U.S. imports of other protein meals will decrease by 12 metric tons and hence the U.S. consumption of other protein meals. Furthermore, because U.S. consumption of soybean meal is responsive to prices of other protein meal, a net increase of 25 metric tons of soybean meal are demanded as a result of the substitution effects being greater than the own price effects.

This section has been concerned with the analyses of the total effect which measures the direct and indirect effects of a particular predetermined variable on a particular endogenous variable (or all the endogenous variables). Some of the results do not seem to be consistent with the *a priori* reasoning. This is partly due to the fact that there were no clear *a priori* grounds on which to base the theoretical and statistical analyses of this study. In addition, some simplifying assumptions of the theoretical framework were obviously abstractions. The lack of the *a priori* information is especially true with respect to reduced form coefficients. Although the 3SLSRF equations incorporate more *a priori* information, note that the impacts of the changes in the foreign production of soybean meal on the endogenous variables are in the opposite direction compared with the effects of changes in U.S. production of other meals.

As shown in Table V-1, the results of a one thousand metric ton increase in the foreign production of soybean meal are that both soybean and soybean meal prices in the U.S. will decrease and consumption of soybean meal in the U.S. and foreign countries will increase by 375 metric tons and 1676 metric tons, respectively. The increase in the U.S. consumption of soybean meal are re-enforced by the increases in the prices of other meals in the U.S. and in the foreign market which reduce the U.S. consumption of other meals by 271 metric tons. The increase in foreign consumption of soybean meal is accounted for by the decline of soybean and soybean meal prices and hence the increases of the U.S. exports than the LSNR, they do not represent either a demand or a supply curve but rather a mixture of both. Therefore, when the total effects are observed, it becomes quite difficult to evaluate and to make judgments based on the *a priori* expectation. Furthermore, the results of this section also imply that the shifts in the demand (both domestic and foreign) curves for the high protein meals are large; this may account for some of the upward influence on prices when the production of protein meals are assumed increasing. In the following section, both the LSNR and 3SLSRF reduced form equations are used to forecast the values of jointly determined variables outside the sample period.

Forecasting with Reduced Form Estimates

Another important application of an estimated structural model is for economic forecasting. Since the main objective of this study is to investigate the market structure of the demand for high protein meal, both domestic and foreign, economic forecasting presented in this section is only to serve the purpose of illustration. The actual and forecasted values of endogenous variables for 1973 are shown in Table V-2. As shown in Table V-2, there is no distinct superiority of LSNR over 3SLSRF in 1973 forecasting. With respect to prices both models have indicated the right direction, however, the predicted price levels are far below the actual prices. With respect to quantity variables, the predicted values are generally more accurate than those of the price variables. In terms of direction of changes, 3SLSRF was wrong two times and LSNR was wrong three times. Specifically, 3SLSRF indicated a decrease in foreign consumption of soybean meal and an increase in the U.S. imports of other meals for 1973 while foreign consumption of soybean meal was actually increasing and the U.S. imports of other protein meals were reduced to a very low level. On the other hand, the LSNR has wrongly predicted a decrease in the U.S. consumption of other meal and ending stocks of soybean meal and wrongly predicted an increase in the U.S. exports of soybean meal.

Note that Table V-2 also provides actual observations of endogenous variables for 1972. In almost every case, the prices of high protein meals were more than doubled, with the only exception of U.S. price of other protein meals, in 1973 comparing with 1972. Not surprisingly, this extraordinary price explosion of 1973 appeared to undermine the model's predictive power and indeed was a poor year for testing this model. However, the generally good fit in the sample period suggests structural change as a strong possibility

Table V-2. Actual and Forecasted 1973 Values of Jointly Determined Variables by LSNR and 3SLSRF

Variable	Units	Actual		1973 Forecasted	
		1972	1973	LSNR	3SLSRF
P^*_{sb}	dollar per metric ton	126.40	255.00	182.72	197.35
P^*_{sm}		116.65	262.75	148.78	151.93
P^*_{om}		128.58	229.16	163.84	152.27
P^*_{smf}		137.01	319.25	171.25	141.02
P^*_{omf}		131.22	284.36	199.02	144.48
Q^*_{smc}	1000 metric tons	12,174.30	10,650.80	11,326.40	10,468.30
Q^*_{omc}		2,888.80	2,962.40	2,346.10	3,047.00
Q^*_{smf}		21,585.10	24,338.80	27,858.30	16,622.90

Table V-2. (Continued)

Variable	Units	Actual		1973 Forecasted	
		1972	1973	LSNR	3SLSRF
Q^*_{omf}		21,989.40	20,923.40	21,270.50	20,568.80
Q^*_{smx}		13,679.10	10,519.10	18,506.80	7,266.70
Q^*_{omi}		473.60	13.90	-332.40	368.50
Q^*_{sms}		18,956.50	25,544.80	16,842.90	28,979.60

to account for the model's poor performance in economic forecasting. Unfortunately, forecasts for years beyond 1973 are not possible because the values of predetermined variables for the year 1974 and beyond are not known for most of the foreign countries. This data limitation imposes serious restrictions on the practical application of this study.

In summary, this chapter focused on some of the applications that are often the ultimate interest of economists studying the structure of a particular economic sector. The relative success of the empirical estimation suggests that this particular theoretical framework is a useful way to understand the operation of the high protein meal economy. It appears that most of the difficulties encountered in the present study emerge from some of the simplifying assumptions in the theoretical model. It is obvious that the assumption of predetermined soybean oil price was not realistic. Similarly, neither the linear form of the structural equations nor the assumptions of the predetermined supplies of protein meals were completely realistic.

To conclude this study, the major findings and conclusions obtained from the present study and also recommendations regarding future research are summarized in the next chapter.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study has been concerned with the underlying economic forces, interrelationships, and processes which determine and influence the price behavior of the world high protein meal market. The objectives of the present study are essentially two-fold. One is to develop and estimate a complete econometric model of world protein meal economy which isolates components of foreign and domestic demands. The other objective is to provide a basis for short-term economic forecasting for high protein meal prices and utilization.

Using a set of simplifying assumptions, the world economy of high protein meal was expressed and formulated in a theoretical framework. The core of the analysis is a twelve equation model of the high protein meal sector that focuses on the price making forces in the United States and the rest of the world for soybean meal and other high protein meals. Emphasis is placed on the demand side which encompasses both the United States and foreign markets. Demand relationships were formulated for each region for soybean meal and other high protein meals. The theoretical model provided a basis for the statistical estimation of economic interrelationships between soybean and other high protein meals.

The structure included eight linear stochastic behavioral equations and four linear identities in actual numbers. The behavioral relations represented the wholesale price relationship for U.S. soybeans, the U.S. and foreign demands for soybean meal and other high protein meals, the U.S. net exports and imports of soybean meal and other high protein meals, respectively, and the U.S. ending stocks of soybean meal. The four identities defined the utilization and supply relationship for soybean meal and other high protein meals, both in the United States and the rest of the world.

The sample period included eighteen annual observations for each variable specified in the model during the period from 1955 to 1972. Crop year data were adjusted to calendar year basis so that production, trade and consumption throughout the world could be measured in the same time dimension.

The unknown parameters of the statistical model were estimated by 3SLS (three-stage least squares) procedure. The derived reduced form parameters were computed from 3SLS estimated structural coefficients. OLS (ordinary least squares) estimates of the reduced form parameters were also obtained for the model.

Statistical fits on most of the structural equations were quite satisfactory. Most estimated structural coefficients displayed correct signs as might be expected and they were large relative to their standard errors.

Elasticity measures were estimated for the structural relations. Elasticities of U.S. soybean price with respect to prices of soybean meal and oil were .75 and .39, respectively. The wholesale price elasticities of U.S. demand for soybean meal were -.73 and .88 with respect to price of soybean meal and price of other high protein meals, respectively. The U.S. demand for other high protein meals were estimated at -1.6 for own price elasticity and 1.47 for cross elasticity with respect to price of soybean meal and -.45 with respect to corn price. For the rest of the world, the computed price elasticities of demand for soybean meal were of -.76 and 1.13 with respect to prices of soybeans and other high protein meals, c.i.f. European ports, respectively. Foreign demand elasticities were estimated to be -.78 and 1.18 with respect to U.S. and European prices of other high protein meals and soybean meal, respectively. The estimated elasticity of U.S. soybean meal demanded for exports, in all forms, was -1.47 with respect to price of soybeans. The elasticities of U.S. import demand for other high protein meals were -8.2 and 11.29 for direct and cross price elasticities with respect to European prices of soybean and other protein meals, respectively. The elasticity of U.S. ending stocks of soybean meal, in all forms, with respect to price of soybean meal was computed at .48.

Derived reduced form equations were computed from 3SLS structural estimates of the statistical model. Effects of a specific change in the predetermined variables on all the jointly determined variables were examined using the 3SLSRF (three-stage least squares reduced form) estimates. For example, in the absence of other changes, an increase of one million units of hogs in the United States would increase U.S. consumption of soybean meal by 44.4 thoussand metric tons and reduced soybean meal exports and stocks by 30.59 and 13.81 thousand metric tons, respectively. Several illustrations of this type are provided in the text. The 3SLSRF and LSNR (least squares no-restrictions) equations were used to compute estimated values for the twelve endogenous variables in the 1955-72 sample period. When compared with actual observations, LSNR equations tend to predict more accurately and appear to be superior than 3SLSRF equations in the sample period. However, in terms of forecasting test for 1973, the distinct superiority of LSNR over 3SLSRF estimates was not as pronounced.

The major contributions of this study relate to the quantification of demand interrelationships between soybean meal and other high protein feeds, and to demand relationships between the United States and foreign markets. The empirical analyses suggest that domestic as well as foreign demand for soybean meal during the 1955-72 period were price inelastic. Previous studies seem to agree on this point. However, elasticity measures obtained by this study were generally higher than those reported in previous studies. This tends to suggest that demand for soybean meal has become more elastic in the recent years. In view of the recent development in the utilizations of urea and synthetic supplements in livestock feeding practice, the market for high protein meals would be expected to be more competitive. In addition, this study indicates that demand for other high protein meals in the U.S. was approximately twice as elastic as that in the rest of the world.

Judging from the cross price elasticities, soybean meal and other high protein meals appear to be very close substitutes and strongly compete as livestock feeds during the period 1955-72. Furthermore, this study suggests that a technical complementary relationship existed between corn and other high protein meals in the United States. The increasing tendency towards the production and utilization of prepared feeds in the United States livestock industry could be the major factor accounting for this complementarity between corn and other high protein meals.

For the trade relations, the results obtained by this study, which confirm a priori expectations, suggest both export and import demands for protein meals were price elastic. Particularly, the U.S. demand for imports of other protein meals which was estimated to be highly price elastic. Observations on the historical movements of the U.S. imports and the easy availability of soybean meal in the U.S. seem to support this finding.

Shifts in the demand curves for high protein meals, in both domestic and foreign markets, have been large; and this may account for some of the upward influence on prices when production of protein meals are increased. Historically, the expansion of production was paralleled by expanding world markets for protein feeds, so that prices remained stable or even increased.

This study shows that an increase in the U.S. production of soybean meal, other things being constant, would be allocated mainly between exports and ending stocks. In fact, the U.S. level of concentrate feeding per animal unit has historically been quite high, and since the early 1960's the increase in demand for protein feeds has moved in line with the increase in total livestock numbers. This result, however, seems agreeable. In addition, the price of corn was found to have a great impact on the U.S. consumption of soybean meal. Note also that the rate of increase in soybean utilization has slowed down somewhat in recent years. The potential development of substitutes, such as modified-protein corn and cereal crops, and synthetic amino acids and urea supplements, suggest possible long-term problems in the utilization area for policy considerations.

It is conceivable that a purely empirical relation, unsupported or unrelated to any consistent theory, could attain considerable success in prediction. On the other hand, structures or equations that are internally consistent do not necessarily lead to useful predictions. The more direct tests of predictive usefulness presented in this study involve the use of observations for the year 1973. These data became available while the statistical analyses for the study already reported were in progress. The estimated relations do not fit data outside the sample period as well as they fit during the sample period. To the extent that this study may provide a basis for successful predictions, the conclusions reached from the present study suggest that a structural change might have occurred in recent years. Parameter estimates of the statistical model using data for the period 1955-73 were also obtained by 3SLS procedure and are presented in Appendix F.

One of the limitations to the study was obviously imposed by the data availability, especially in foreign countries. Unfortunately, this limitation on data availability involves the limited sources of data as well as, generally, a two year lag in data reporting. In addition, some simplifying assumptions in the theoretical framework were obviously abstractions and thus only approach reality. Most significantly, the study was designed to study the world demand for high protein meal in a simultaneous system, however, the system was simultaneous only to the extent that demands for soybean and other high protein meals are interrelated in the livestock feed economy. Omitting the simultaneous adjustment processes of the livestock and non-protein feed sectors, particularly the fat and oil sector, appear to undermine the model's usefulness as providing a basis for policy considerations and economic forecasting. To the extent that meal and oil are joint products of the crushing industry, allowing only one product in the adjustment process is obviously unrealistic and may obscure the attainment of reliable and useful information. Moreover, aggregations of various kinds of high protein meals into two main categories and aggregations of various kinds of high protein meals into two main categories and aggregations of different consuming regions into two markets, may have caused difficulties in obtaining good statistical estimations. Furthermore, such a strong aggregation may also present additional barriers to the attainment of successful predictions and for identifying the relevant economic factors that underlie the behavior of individual commodity markets and demand structures. Thus, other formulations which may quantify the interdependent and simultaneous relationships among protein meals, fat and oil, and livestock and livestock product sectors are suggested for further studies. In addition, research based on regional and commodity disaggregations would also seem to be necessary and appropriate for future studies.

It is believed that the relative success of the empirical estimation suggests that this particular framework is a useful approach for understanding the basic structure and general nature of the operation of the high protein meal economy. The value of this study is its ability to provide useful information on the structure of the high protein meal economy, its possible application in other areas, and its contributions in isolating the need for, and problems of, additional studies of this kind.

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APPENDIX A

Table A-1. Year of Oilseed Crops to be Processed Oil and Meal Production

Type of Oilseed	Country	Production Year of Harvest	Assigned to Year Following Harvest
Copra	All countries	x	
Cottonseed	All countries		x
Flaxseed	India, Pakistan		
	New Zealand	x	
	Others		x
Palm Kernel	All countries	x	
Peanut	Argentina, Bolivia, Brazil Ecuador, Paraguay, Peru, Uruguay, Indonesia, South Africa, Rhodesia, Zambia, Tanzania, Congo, Angola, Malawi, Gabon, Mozambique, Liberia, Australia	x	
	Others		x
Rapeseed	Canada		x
	Others	x	
Soybean	Argentina, Brazil, Paraguay, Peru, Uganda, Thailand	x	
	Others		x
Sunflowerseed	Argentina, Brazil, Chile, Uruguay, South Africa, Australia	x	
	Others		x

Table A-2. Percentage of Oilseed Crops Assumed Crushed for Oil and Meal by Countries

Type of Oilseed	Country	% of the Crop Assumed Crushed
Copra	All countries	100
Cottonseed	United States	95
	EEC, Argentina	90
	Brazil	65
	China	25
	India	35
	Pakistan	60
	U.S.S.R.	85
	Others	75
Flaxseed	United States	93
	EEC	85
	Argentina, Mexico, Uruguay	92
	Others	90
Palm Kernel	All countries	100
Peanut (in shell)	United States	28
	Argentina, Brazil, Nigeria	80
	Senegal	77
	South Africa, India	75
	China	50
	Others	15
Rapeseed	All countries	90
Soybean	United States	94
	Japan	35
	Brazil	90
	Canada	92
	China	45
	Others	50
Sunflowerseed	U.S.S.R.	95
	Others	92

Table A-3. Conversion Rates for Oilseeds to Meal Equivalent, by Countries

Country	Copra	Cotton-seed	Lin-seed	Palm Kernel	Peanut (in shell)	Rape-seed	Soy-bean	Sunflower-seed
	yield percentage							
United States	35.0	45.0	62.0	51.0	39.5	60.0	79.5	45.0
EEC	35.0	42.5	62.0	51.0	38.5	60.0	80.5	45.0
Canada	35.0	46.5	62.0	51.0	38.5	60.0	80.5	45.0
Japan	35.0	46.5	63.0	51.0	38.5	60.0	82.5	45.0
Argentina	35.0	38.5	63.0	51.0	42.5	60.0	80.5	45.0
Brazil	35.0	42.5	63.0	51.9	42.5	60.0	80.5	45.0
Mexico	35.0	46.5	65.0	51.0	38.5	60.0	80.5	45.0
China	35.0	45.5	63.0	51.0	39.5	60.0	80.5	45.0
U.S.S.R.	35.0	45.5	63.0	51.0	38.5	60.0	80.5	40.0
Others	35.0	46.5	63.0	51.0	38.5	60.0	80.5	45.0

Table A-4. Conversion Rates for Protein Meals Soybean Meal Equivalent

Type of Meal	% of Crude Protein Content	% of Digestable Protein	Adjustment Factor
Soybean	44	92	1.0000
Fish	65	90	1.4402
Cottonseed	41	80	0.8103
Peanut	50	91	1.1240
Sunflowerseed	42	91	0.9442
Rapeseed	35	80	0.6917
Linseed	35	88	0.7609
Copra	21	85	0.4515
Palm Kernel	18	80	0.3557

APPENDIX B

APPENDIX B

THE DATA

The purposes of this section are to describe the measurements, to present some rationalization of the choices measurements, and to indicate the sources of the data that were used in this study. The observations used are tabulated at the end of this section.

Some of the variables do not correspond very closely to any regularly compiled data. It is necessary to construct from the available data measurements that will correspond as closely as possible to the concepts employed in the model. The data sources, rationales, and methods used for constructing the quantity variables with respect to production, trade and consumption of protein meals were discussed and presented in Chapter III.

With respect to stock variable of soybean meal, it has two components. The actual annual stocks of soybean meal were obtained by aggregating monthly data from various issues of The Soybean Blue Book published by American Soybean Association. The second component is the meal equivalent of soybean stocks which were converted from the stocks of soybean to meal equivalent. Data on the annual observations of soybean stocks included those stocked on farms and off farms were obtained from the U.S. Department of Agriculture, Agriculture Statistics.

Animal units (cattle, hogs and chicken) in foreign countries were compiled from various issues of Agriculture Statistics. Since the different classes of livestocks are not of equal importance in consumption of protein meals, the following weights were assigned, 1.0 for cattle, 0.4 for hogs, and 0.025 for chicken. These weights were based on the feeding ratios in Western Europe. It is impossible to use different ratios for different countries because the lack of information on the feeding practices in other nations. Nevertheless, Western Europe is the most important and major market in the world economy of high protein feeds, these ratios are considered as an appropriate and reasonable proxies for all foreign countries.

With regard to animal units (hogs and broilers) in the United States, actual number of annual observations were used. The number of hogs in January 1 were obtained from Agriculture Statistics. Data on commercial broiler production from 1955-59 and 1960-72 were obtained from U.S. Department of Agriculture, Selected Statistical Series for Poultry and Eggs through 1965, ERS 232, Revised May 1966, and Poultry and Egg Statistics through 1972, USDA, Statistical Bulletin No. 525, respectively.

Price series for soybean, soybean oil and corn have all been taken from Feed Situation. Annual observations were obtained by simple average of the monthly prices. As the metric system is seldom used for the quotations of these prices in the U.S. official sources, the price series were converted to a metric-ton basis as the relevant quantity variables were expressed in these units in the study.

U.S. price of soybean meal were obtained from The Soybean Blue Book. The annual observations were compiled from monthly prices of soybean meal weighted by monthly production of soybean meal. Soybean meal price, c.i.f., European ports, were taken from the U.S. Department of Agriculture, Foreign Agriculture Circular, Oilseeds and Products, various issues.

The composite prices of other protein supplements are weighted price series. The weights used are the production of each protein meal adjusted to 44% protein, soybean meal equivalent basis. This is in a simple attempt to standardize the relative fluctuations in costs per unit of protein among them. Although such adjustment cannot, of course, explain all of the differences in nutritional value, it does provide a common base for comparing the differences in cost of protein supplements. Furthermore, this is also in accordance with the relevant quantity variables which are all expressed in terms of 44% protein, soybean meal equivalent. The general formula used to construct the composite prices of other protein meals can be written as:

$$P = \frac{P_i Q_i}{Q_i}$$

where:

P is the composite average price of other protein meals, P_i is the actual prices of the ith protein meal, q_i is the actual production figures of the ith protein meal, and Q_i represents the adjusted production of the ith meal, in terms of 44% soybean meal equivalent. Thus, the above formula gave a weighted value per unit of other meals on 44% protein content basis.

For the United States, the composite price includes price of cottonseed meal, 41% Memphis, peanut meal, 50% f.o.b. southeastern mills, linseed meal, 34% Minneapolis, and fish meal, 65% New York. All these price series were taken from Feed Situation. The procedure employed is first to obtain the total annual values of production by multiplying monthly prices to monthly productions of each protein meal summed over 12 months and over each different kinds of protein meal. The total annual values of production is then divided by the total production of other meal on the 44% meal equivalent basis. The total production on the meal equivalent basis is obtained by converting monthly actual production figures into soybean meal equivalent, then summed over 12 months and over various meals included.

Foreign price of other meal is constructed in the similar manner, except the annual observations on the prices and quantities were used instead of monthly figures. The composite average price for other meal in the foreign market includes soybean meal, Canadian 45%, cottonseed meal, Argentine 44/45%, peanut meal, Nigerian 54%, linseed meal, Argentine 37/38%, copra, Indian, 30%, and fish meal, Peruvian 65%. Data on these price series are all prices c.i.f., European ports and were obtained from Foreign Agriculture Circular, Oilseeds and Products. It should be noted that price series on cottonseed meal are not available for the year 1955. The price of copra meal are not available for 1963 and for the period 1968-72. For fish meal price, there are no available data prior to 1960. The production figures that were used as the weights were, therefore, adjusted for those years accordingly.

The following tables present the observations that were actually used in the statistical analysis of this study. The symbols that were used to represent the variables in the model have been defined in Chapter V, there is no need to repeat here.

Table B-1. Endogenous Variables: Data Used in the Simultaneous Equations Model, 1955-1972

Year	P_{sb}	P_{sm}	P_{om}	P_{smf}	P_{omf}	Q_{smc}
	----------- dollars per metric ton -----------					1000 metric tons
1955	89.29	62.32	82.62	102.28	115.61	5082.90
1956	93.33	56.30	75.65	98.50	110.65	5742.90
1957	84.14	51.78	74.06	89.86	95.55	6536.80
1958	79.37	61.73	82.50	93.78	83.58	7558.90
1959	77.90	62.38	88.08	94.56	100.80	8109.20
1960	76.79	58.41	72.87	90.58	91.21	7873.00
1961	96.27	63.37	80.16	99.65	90.13	8022.20
1962	88.92	73.14	86.94	105.75	98.89	8570.80
1963	95.53	79.92	92.62	112.82	102.02	8587.80
1964	95.53	76.07	84.67	112.31	109.76	8362.90
1965	109.50	78.65	88.93	115.55	116.65	8451.30
1966	112.07	91.85	105.31	123.81	115.65	9413.10
1967	101.05	84.15	102.09	119.01	106.23	9870.90
1968	94.43	85.08	99.57	120.41	97.51	9816.60
1969	92.59	82.32	97.93	116.30	109.09	10769.50
1970	99.21	87.17	107.16	125.11	121.43	12529.10
1971	112.07	85.91	100.39	123.83	115.05	11839.60
1972	126.40	116.65	128.58	137.01	131.22	12174.30

Table B-1. (Continued)

Year	Q^*_{omc}	Q^*_{smf}	Q^*_{omf}	Q^*_{smx}	Q^*_{omi}	Q^*_{sms}
	---------------- 1000 metric tons					----------------
1955	2727.9	5845.89	10892.7	1944.89	16.30	6005.21
1956	2825.4	5196.50	12076.5	1205.51	44.50	7141.95
1957	2515.7	6368.30	12697.9	1991.30	91.10	8334.31
1958	2580.3	5420.86	12276.3	989.87	411.70	10245.40
1959	2665.6	9423.34	13976.9	4846.34	129.10	9844.45
1960	2588.3	9273.56	13939.7	4289.56	90.30	9211.77
1961	3030.7	6374.34	15390.0	1862.34	438.00	11342.10
1962	2991.9	10680.80	16395.2	5937.80	253.80	11537.00
1963	3125.2	9903.04	16156.1	5201.04	463.90	12227.50
1964	3264.5	12220.10	17440.4	7515.13	559.60	11481.50
1965	3049.5	9835.72	19095.9	4718.72	291.10	13764.90
1966	3016.4	11804.40	19071.6	6627.39	548.40	15732.50
1967	2642.3	14161.20	20274.4	8812.25	822.60	17139.00
1968	3029.3	12869.60	20699.3	7480.61	1178.70	20960.20
1969	2678.9	16717.40	20361.0	11102.40	517.00	22956.60
1970	2361.0	20229.90	22651.2	14233.90	325.80	20563.50
1971	2504.7	20522.40	23877.6	13745.40	384.40	19365.10
1972	2888.8	21585.10	21989.4	13679.10	473.60	18956.50

Table B-2. Predetermined Variables: Data Used in the Simultaneous Equations Model, 1955-72

Year	Hog 1000 Units	Broil Million Units	P_c Dollars Per Metric Ton	H_{paf} Million Units	Q_{smsl} 1000 Metric Tons
1955	50474.0	1092.0	51.31	959.5	5653.01
1956	55173.0	1344.0	51.18	1008.7	6005.21
1957	51703.0	1448.0	45.66	1044.7	7141.95
1958	50980.0	1660.0	42.13	1065.4	8334.31
1959	58045.0	1737.0	42.28	1085.8	10245.40
1960	59026.0	1795.0	43.80	1107.3	9844.45
1961	55506.0	1991.0	39.84	1139.8	9211.77
1962	57000.0	2023.0	40.24	1165.9	11342.10
1963	58883.0	2102.0	44.19	1140.0	11537.00
1964	58119.0	2161.0	44.65	1149.1	12227.50
1965	50792.0	2334.0	46.52	1188.1	11481.50
1966	47414.0	2571.0	45.17	1223.6	13476.90
1967	53249.0	2592.0	46.18	1260.7	15732.50
1968	58777.0	2620.0	40.90	1278.8	17139.00
1969	60632.0	2789.0	44.42	1321.0	20960.20
1970	57046.0	2987.0	48.59	1407.1	22956.60
1971	67433.0	2945.0	49.91	1406.0	20563.50
1972	62507.0	3075.0	45.96	1432.5	19365.10

Table B-2. (Continued)

Year	P_{so} Dollars Per Metric Ton	Q_{smpu}	Q_{ompu}	Q_{smpf}	Q_{ompf}
		-------------	1000 metric tons	-------------	
1955	255.74	7379.98	2711.6	3901.0	10909.0
1956	291.01	8085.14	2780.9	3991.0	12121.0
1957	268.96	9720.46	2424.6	4377.0	12789.0
1958	231.49	10459.80	2168.6	4431.0	12688.0
1959	198.42	12554.60	2536.5	4577.0	14106.0
1960	194.01	11529.90	2498.0	4984.0	14030.0
1961	253.53	12014.80	2592.7	4512.0	15828.0
1962	198.42	14703.50	2738.1	4743.0	16649.0
1963	196.21	14479.30	2661.3	4702.0	16620.0
1964	202.83	15132.00	2704.0	4705.0	18000.0
1965	246.92	15165.40	2758.4	5117.0	19387.0
1966	257.94	18296.10	2468.0	5177.0	19620.0
1967	211.64	20089.60	1819.7	5349.0	21097.0
1968	180.78	21118.40	1850.6	5389.0	21878.0
1969	200.62	23868.30	2161.9	5615.0	20878.0
1970	264.55	24369.90	2035.2	5996.0	22977.0
1971	277.78	24386.60	2120.3	6777.0	24262.0
1972	233.69	25444.80	2415.2	7906.0	22463.0

APPENDIX C

APPENDIX C

OLS STRUCTURAL ESTIMATES

The following are the parameter estimates of the statistical model using OLS (ordinary least squares) procedure. The standard error of each coefficient appears beneath in parentheses. The estimated standard error of regression for each fitted equation is denoted by SE. The Durbin-Watson statistic for measuring serial correlation in disturbances is denoted as DW. If the symbol (a) follows the statistic, the DW test indicates absence of serial correlation for the 0.05 significant level of a two-tailed test; the symbol (i) indicates the test was inconclusive. The coefficient of multiple determination is shown as R^2. The fitted regression equations are:

$$\text{OLS} \quad P^*_{sb} = -.312 + \underset{(.101)}{.894P^*_{sm}} + \underset{(.03)}{.16P_{so}} - \underset{(.0003049)}{.0006409Q_{smsl}}$$

$$SE = 4.12 \quad DW = 2.09\ (a) \quad R^2 = .92$$

$$\text{OLS} \quad Q^*_{smc} = -3357.4 - \underset{(22.62)}{76.33P^*_{sm}} + \underset{(23.23)}{81.06P^*_{om}} + \underset{(.0205)}{.0588Hog}$$

$$+ \underset{(.33)}{3.31Broil}$$

$$SE = 358.45 \quad DW = 1.96\ (a) \quad R^2 = .98$$

OLS $Q^*_{omc} = 4777.1 + 43.51P^*_{sm} - 32.54P^*_{om} - .115Q^*_{smc}$

(7.25) (8.56) (.028)

$-27.73P_c$

(9.1)

SE = 125.17 DW = 2.89 (i) $R^2 = .81$

OLS $Q^*_{smf} = - 36967.2 - 124.5P^*_{sb} + 157.59P^*_{omf} + 36.82H_{paf}$

(35.17) (32.03) (2.44)

SE = 1016.52 DW = 2.18 (a) $R^2 = .97$

OLS $Q^*_{omf} = - 18519.1 + 157.54P^*_{smf} - 119.37P^*_{om} + 24.67H_{paf}$

(34.92) (32.93) (2.52)

SE = 707.74 DW = 1.64 (a) $R^2 = .97$

OLS $Q^*_{smx} = - 28115.1 - 95.03P^*_{sb} + 127.01P^*_{smf} + 24.996H_{paf}$

(56.7) (76.39 (5.034)

SE = 1428.15 DW = 2.06 (a) $R^2 = .91$

OLS $Q^*_{omi} = 991.64 + 33.79P^*_{smf} - 23.74P^*_{omf} + .0366Q^*_{sms}$

(5.79) (4.06) (.0158)

$-1.936H_{paf}$

(.602)

SE = 110.61 DW = 2.28 (i) $R^2 = .89$

OLS $Q^*_{sms} = - 5774.1 + 73.15P^*_{sm} - 1.103Q^*_{smx} + 1.627Q_{sms1}$

(20.84) (.166) (.128)

SE = 792.48 DW = 2.17 (a) $R^2 = .98$

APPENDIX D

APPENDIX D

2SLS STRUCTURAL ESTIMATES

The results of the estimation process using 2SLS (two-stage least squares) procedure are presented below. The standard error of each coefficient appears beneath in parentheses. The estimated standard error of regression is represented by SE. The Durbin-Watson statistic is denoted as DW. If the symbol (a) follows the statistic, the DW test indicates absence of serial correlation for the 0.05 significant level of a two-tailed test; the symbol (n) indicates a negative serial correlation; and the symbol (i) relations of the statistical model are:

$$\text{2 SLS} \quad P^*_{sb} = -\ 3.281 + \underset{(.1114)}{.9577P^*_{sm}} + \underset{(.03)}{.1605P_{so}} - \underset{(.0003254)}{.0007912Q_{sms1}}$$

$$SE = 4.18 \qquad DW = 2.28\ (a)$$

$$\text{2SLS} \quad Q^*_{smc} = -\ 3377.4 - \underset{(26.92}{83.52P^*_{sm}} + \underset{(29.19}{85.74P^*_{om}} + \underset{(.0208)}{.0582Hog}$$

$$+ \underset{(.374)}{3.388Broil}$$

$$SE = 360.12 \qquad DW = 1.99\ (a)$$

2SLS $Q^*_{omc} = 5073.1 + 53.82P^*_{sm} - 48.67P^*_{om} - .09116Q^*_{smc}$

(10.08) (12.4) (.03466)

$- 23.42P_c$

(10.54)

SE = 142.43 DW = 3.28 (n)

2SLS $Q^*_{smf} = - 37172.6 - 124.12P^*_{sb} + 161.48P^*_{omf} + 36.61H_{paf}$

(37.1) (33.67) (2.48

SE = 1017.62 DW = 2.2 (a)

2SLS $Q^*_{omf} = - 19265.6 + 200.76P^*_{smf} - 152.05P^*_{om} + 23.81H_{paf}$

(40.63) (40.55) (3.04)

SE = 746.04 DW = 1.67 (a)

2SLS $Q^*_{smx} = - 28294.6 - 108.01P^*_{sb} + 172.83P^*_{smf} + 21.95H_{paf}$

(61.19) (91.25) (5.87)

SE = 1452.67 DW = 2.09 (a)

2SLS $Q^*_{omi} = 1088.1 + 38.89P^*_{smf} - 27.55P^*_{omf} + .0348Q^*_{sms}$

(7.86) (5.0) (.0194)

$- 2.129H_{paf}$

(.70)

SE = 115.16 DW = 2.33 (i)

2SLS $Q^*_{sms} = - 6514 + 88.52P^*_{sm} - 1.117Q^*_{smx} + 1.60Q_{sms1}$

(24.43) (.217) (.157)

SE = 808.71 DW = 2.34 (a)

APPENDIX E

APPENDIX E

REDUCED FORM ESTIMATES

The following are reduced form equations of the statistical model. The derived reduced form equations obtained from three-stage least squares are denoted as 3SLSRF (three-stage least squares reduced form). The unrestricted least squares estimates of reduced form equations of the model were estimated by ordinary least squares procedure. They are denoted as LSNR (least squares no-restrictions). The estimated standard error of regression (SE) and the coefficient of multiple determination (R^2) are reported for each LSNR reduced form. In addition, both 3SLSRF and LSNR estimates were compared with the actual observations and presented graphically in Figure E-1 through Figure E-12. The reduced form equations are:

3 SLSRF $$P^*_{sb} = -2.917799 - .000523Hog - .0343044Broil + .4073765P_c + .0228158H_{paf} - .0069038Q_{smsl} + .1535962P_{so} + .0111883Q_{smpu} + .0145129Q_{ompu} - .0033557Q_{smpf} + .0007967Q_{ompf}$$

LSNR $$P^*_{sb} = -68.5 - .00149Hog + .01306Broil + 1.108P_c + .0449H_{paf} - .006001Q_{smsl} + .05986P_{so} + .004617Q_{smpu} + .01051Q_{ompu} - .000634Q_{smpf} + .0004871Q_{ompf}$$

$SE = 3.86$ $\qquad R^2 = .96$

3SLSRF P^*_{sm} = .6638324 - .0005503Hog - .0360795Broil +
+ .4284565P_c + .0239965H_{paf} - .0064507Q_{smsl} -
.009575P_{so} + .0117672Q_{smpu} + .0152639Q_{ompu} -
.0035293Q_{smpf} + .0008379Q_{ompf}

LSNR P^*_{sm} = - 54.72 - .0006956Hog + .009152Broil + 1.282P_c
+ .08723H_{paf} - .00508Q_{smsl} - .132P_{so} +
.005733Q_{smpu} + .01038Q_{ompu} + .0003055Q_{smpf}
- .001961Q_{ompf}

SE = 5.89 R^2 = .94

3SLSRF P^*_{om} = 116.8274994 - .0006634Hog - .043493Broil -
- .0665326P_c - .0043385H_{paf} - .0072619Q_{smsl}
- .0226887P_{so} + .0122041Q_{smpu} - .0023702Q_{ompu}
+ .0008592Q_{smpf} + .0011415Q_{ompf}

LSNR P^*_{om} = 6.194 - .0008013Hog - .003862Broil + .8846P_c
+ .09055H_{paf} - .004238Q_{smsl} - .07217P_{so}
+ .006453Q_{smpu} + .003888Q_{ompu} + .0002716Q_{smpf}
- .002916Q_{ompf}

SE = 6.56 R^2 = .91

3SLSRF P^*_{smf} = 201.8703156 - .0005165Hog - .0338606Broil -
.0675057P_c - .1472164H_{paf} - .0058104Q_{smsl} -
.0217718P_{so} + .0094479Q_{smpu} - .0024049Q_{ompu} +
.0021555Q_{smpf} + .0064054Q_{ompf}

LSNR $P^*_{smf} = -31.73 - .0005098Hog - .002136Broil + 1.445P_c + .08248H_{paf} - .003902Q_{sms1} - .07717P_{so} + .004602Q_{smpu} + .009071Q_{ompu} - .00431Q_{smpf} + .0003798Q_{ompf}$

SE = 5.38 $R^2 = .94$

3SLSRF $P^*_{omf} = 323.3474121 - .0006351Hog - .0416366Broil - .112927P_c - .3043174H_{paf} - .0070808Q_{sms1} - .0378177P_{so} + .0115159Q_{smpu} - .0040231Q_{ompu} + .0111025Q_{smpf} + .0082344Q_{ompf}$

LSNR $P^*_{omf} = -8.314 - .00103Hog - .02257Broil + 1.849P_c - .01238H_{paf} + .000007259Q_{sms1} - .03303P_{so} + .003298Q_{smpu} + .0254Q_{ompu} + .004843Q_{smpf} + .001167Q_{ompf}$

SE = 4.04 $R^2 = .96$

3SLSRF $Q^*_{smc} = 6736.2890625 + .0443971Hog + 2.9107285Broil - 42.2857056P_c - 2.420042H_{paf} - 0617207Q_{sms1} - 1.0980968P_{so} + .0244413Q_{smpu} + 1.5064383Q_{ompu} + .3746126Q_{smpf} + .0247718Q_{ompf}$

LSNR $Q^*_{smc} = -3687 + .00341Hog + 2.028Broil - 22.58P_c + 10.03H_{paf} + .2145Q_{sms1} - 1.01P_{so} - .203Q_{smpu} - .1205Q_{ompu} + .1578Q_{smpf} - .1585Q_{ompf}$

SE = 360.14 $R^2 = .99$

3SLSRF $Q^*_{omc} = -1055.8586426 - .0018392Hog - .1205811Broil + 2.7073898P_c + 1.758729H_{paf} + .0087322Q_{sms1} + .6933649P_{so} + .0436612Q_{smpu} + 1.964508Q_{ompu} - .2712969Q_{smpf} - .0124606Q_{ompf}$

$$\text{LSNR} \quad Q^{*}_{omc} = 2956 + .009569Hog + .4291Broil - 8.265P_{c}$$
$$+ 2.7073898P_{c} + 1.758729H_{paf} + .0087322Q_{sms1}$$
$$+ .6933649P_{so} + .0436612Q_{smpu} + 1.964508Q_{ompu}$$
$$- .27129690Q_{smpf} - .0124606Q_{ompf}$$

$$\text{LSNR} \quad Q^{*}_{omc} = 2956 + .009569Hog + .4291Broil - 8.265P_{c}$$
$$-2.033H_{paf} - .1105Q_{sms1} - 1.061P_{so} + .09836Q_{smpu}$$
$$+ .4891Q_{ompu} - .147Q_{smpf} + .04754Q_{ompf}$$

SE = 157.29 $\qquad$ $R^2 = .84$

$$\text{3SLSRF} \quad Q^{*}_{smf} = 4297.6328125 - .0305864Hog - 2.0052834Broil$$
$$- 51.1368103P_{c} - 3.3663731H_{paf} - .2433163Q_{sms1}$$
$$- 18.6930847P_{so} + .3993421Q_{smpu} - 1.8217611Q_{ompu}$$
$$+ 1.6764936Q_{smpf} + .9433712Q_{ompf}$$

$$\text{LSNR} \quad Q^{*}_{smf} = - 30540 - .0148Hog - 4.562Broil + 231.4P_{c}$$
$$+ 19.56H_{paf} + .4849Q_{sms1} - 18.98P_{so} + .1916Q_{smpu}$$
$$+ 2.089Q_{ompu} + 1.401Q_{smpf} + .1146Q_{ompf}$$

SE = 1078.89 $\qquad$ $R^2 = .98$

$$\text{3SLSRF} \quad Q^{*}_{omf} = 1055.8583984 + .0018392Hog + .1205813Broil$$
$$- 2.7073927P_{c} - 1.7587309H_{paf} - .0087323Q_{sms1}$$
$$- .693365P_{so} - .0436612Q_{smpu} - .09645150Q_{ompu}$$
$$+ .271297Q_{smpf} + 1.0124607Q_{ompf}$$

$$\text{LSNR} \quad Q^{*}_{omf} = - 2956 - .009569Hog - .4291Broil + 8.265P_{c}$$
$$+ 2.033H_{paf} + .1105Q_{sms1} + 1.061P_{so} - .09836Q_{smpu}$$
$$+ .5109Q_{ompu} + .147Q_{smpf} + .9525Q_{ompf}$$

SE = 161.55 $\qquad$ $R^2 = .99$

3SLSRF $Q^{*}_{smx} = 4297.625 - .0305864Hog - 2.0052824Broil$

$- 51.1367798P_{c} - 3.3663578H_{paf} - .24331630Q_{sms1}$

$- 18.693084P_{so} + .3993421Q_{smpu} - 1.8217602Q_{ompu}$

$+ .6764936Q_{smpf} + .9433712Q_{ompf}$

LSNR $Q^{*}_{smx} = -30540 - .0148Hog - 4.562Broil + 231.4P_{c}$

$+ 19.56H_{paf} + .4849Q_{sms1} - 18.98P_{so} + .1916Q_{smpu}$

$+ 2.089Q_{ompu} + .4015Q_{smpf} + .1146Q_{ompf}$

SE = 1079.35 $R^2 = .98$

3SLSRF $Q^{*}_{omi} = - 1055.8586426 - .0018392Hog - .1205811Broil$

$+ 2.7073898P_{c} + 1.758729H_{paf} + .0087322Q_{sms1}$

$+ .6933649P_{so} + .0436612Q_{smpu} + .0964514Q_{ompu}$

$- .2712969Q_{smpf} - .0124606Q_{ompf}$

LSNR $Q^{*}_{omi} = 2956 + .009569Hog + .4291Broil - 8.265P_{c}$

$- 2.033H_{paf} - .1105Q_{sms1} - 1.061P_{so} + .09836Q_{smpu}$

$- .5109Q_{ompu} - .147Q_{smpf} + .04754Q_{ompf}$

SE = 159.26 $R^2 = .88$

3SLSRF $Q^{*}_{sms} = - 11033.9101563 - .0138107Hog - .9054471Broil$

$+ 93.4224701P_{c} + 5.7863646H_{paf} + 1.3050365Q_{sms1}$

$+ 19.7911682P_{so} + .576217Q_{smpu} + 3.3281975Q_{ompu}$

$- 1.0511036Q_{smpf} - .9681422Q_{ompf}$

LSNR $Q^{*}_{sms} = 34220 + .01139Hog + 2.534Broil - 208.9P_{c}$

$- 29.6H_{paf} + .3006Q_{sms1} + 19.99P_{so} + 1.011Q_{smpu}$

$- 1.969Q_{ompu} - .5593Q_{smpf} + .04396Q_{ompf}$

SE = 1351.67 $R^2 = .97$

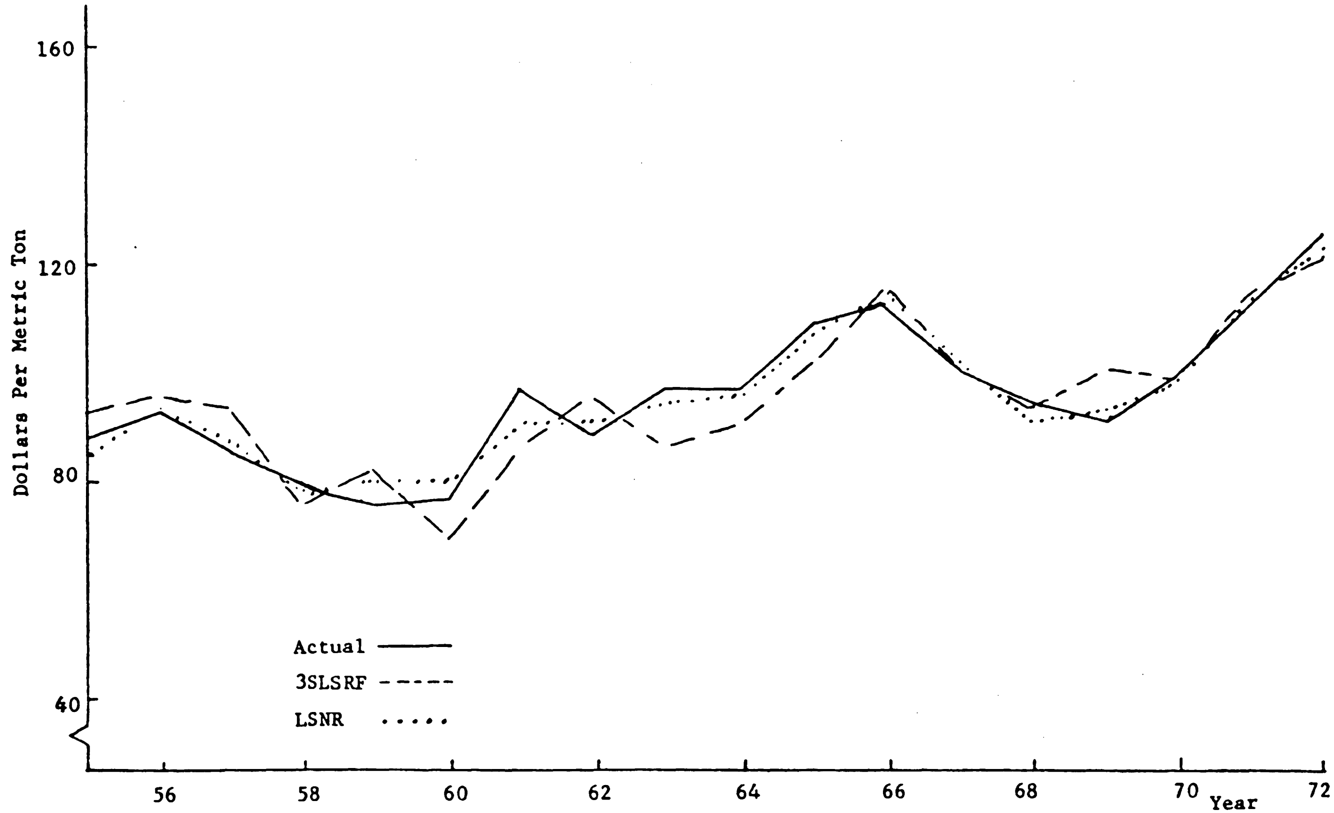

Figure E-1. Average Wholesale Price of Soybeans, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

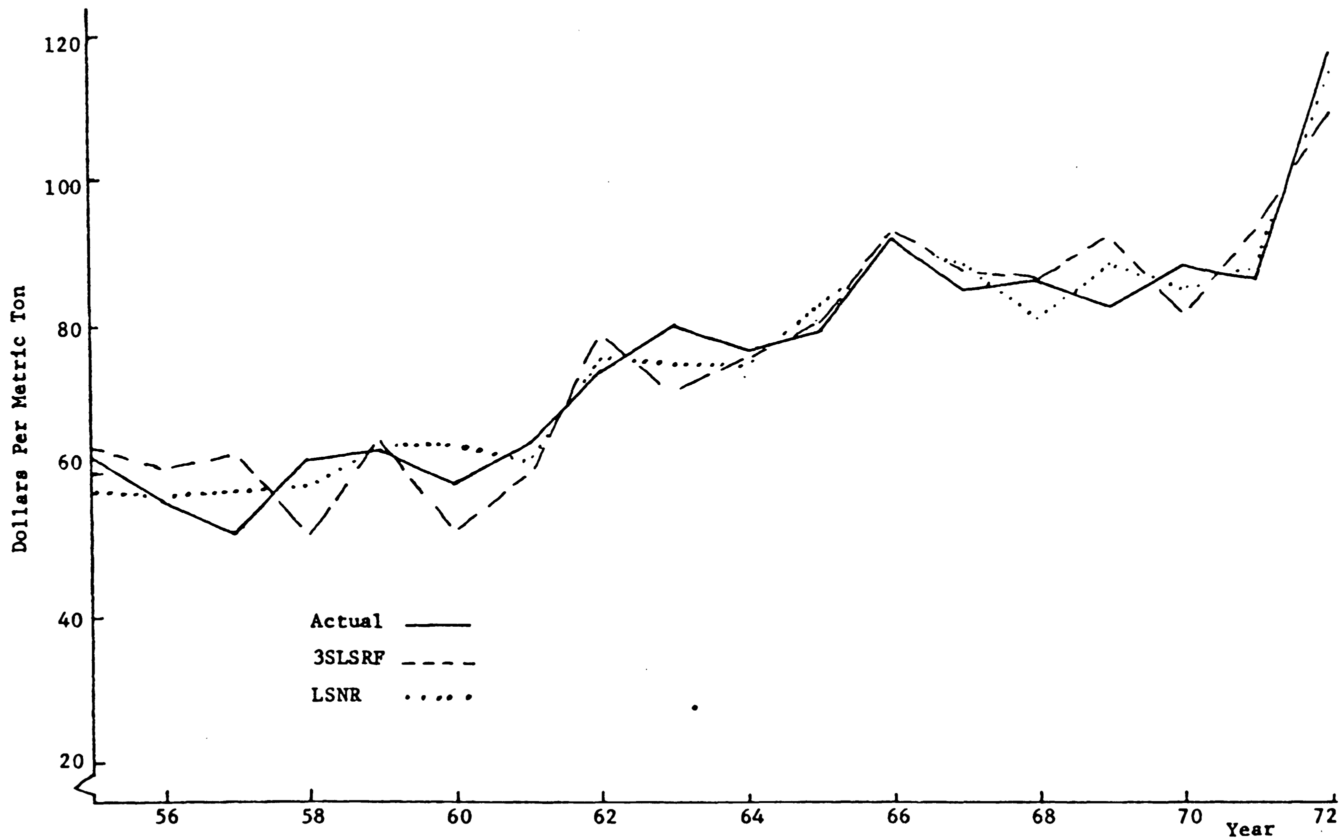

Figure E-2. U.S. Price of Soybean Meal, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

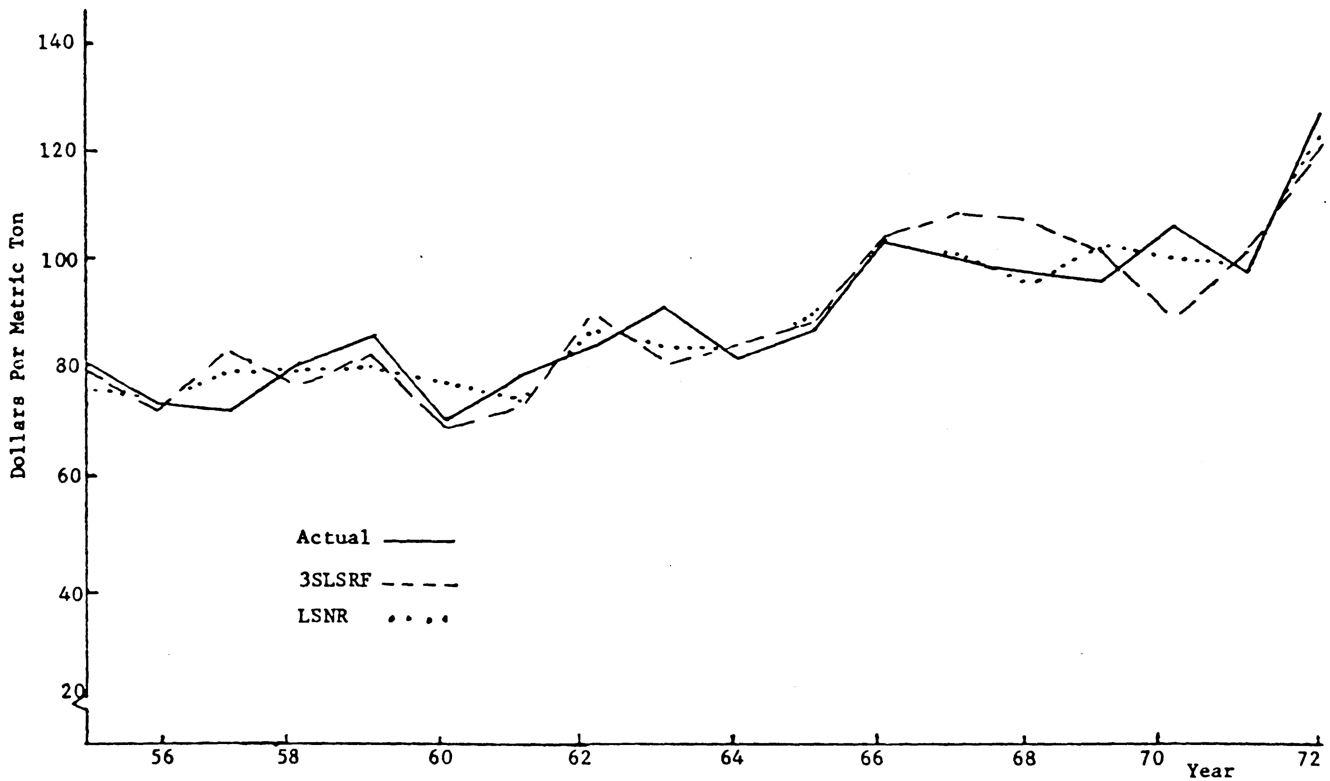

Figure E-3. U.S. Price of Other High Protein Meals, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

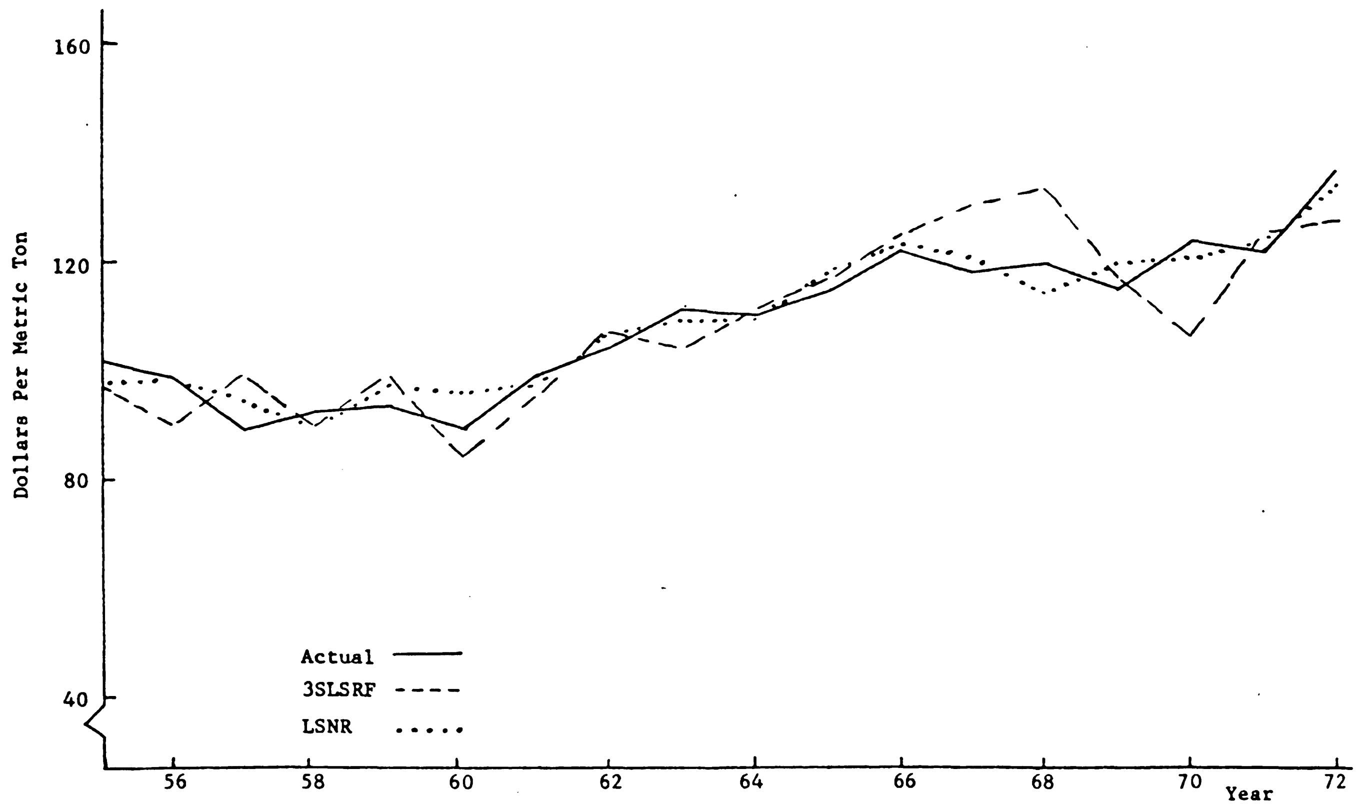

Figure E-4. European Price of Soybean Meal, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

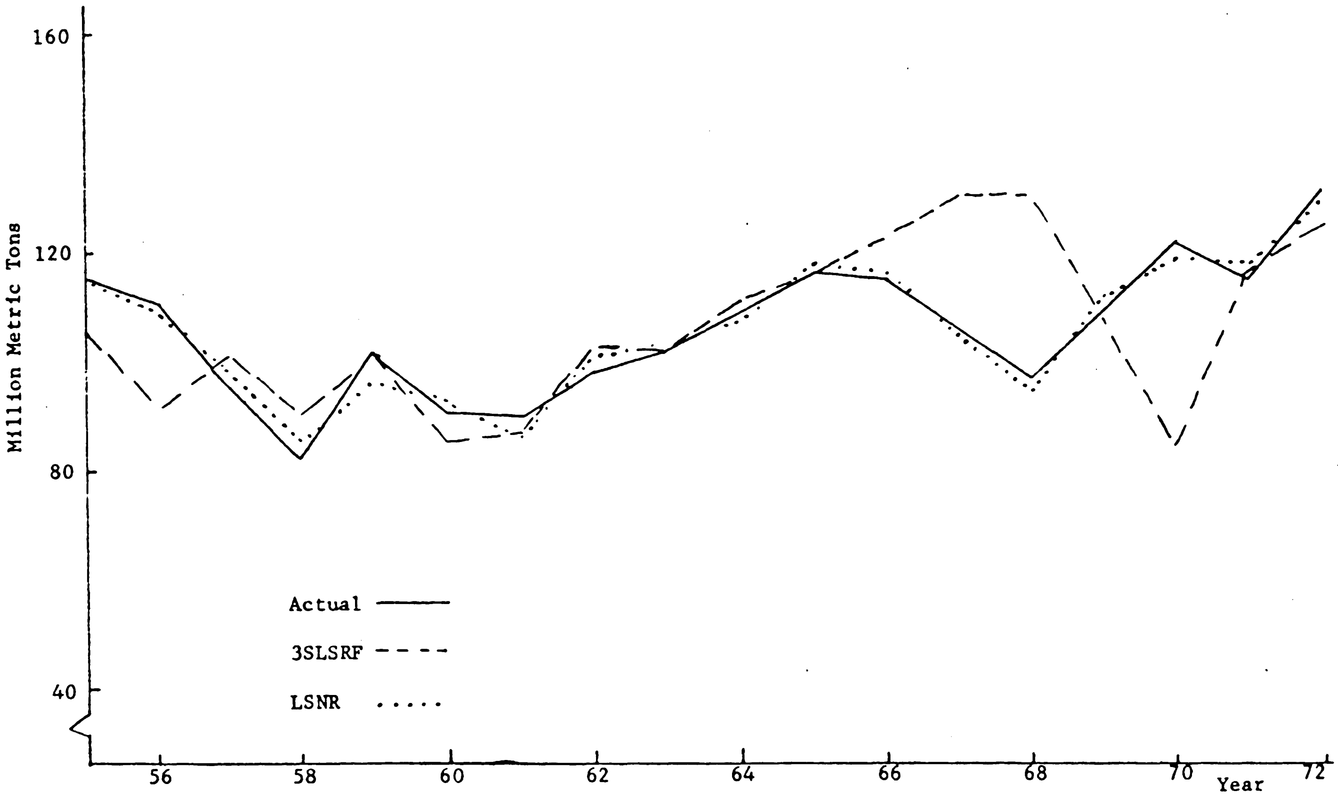

Figure E-5. European Price of Other High Protein Meals, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

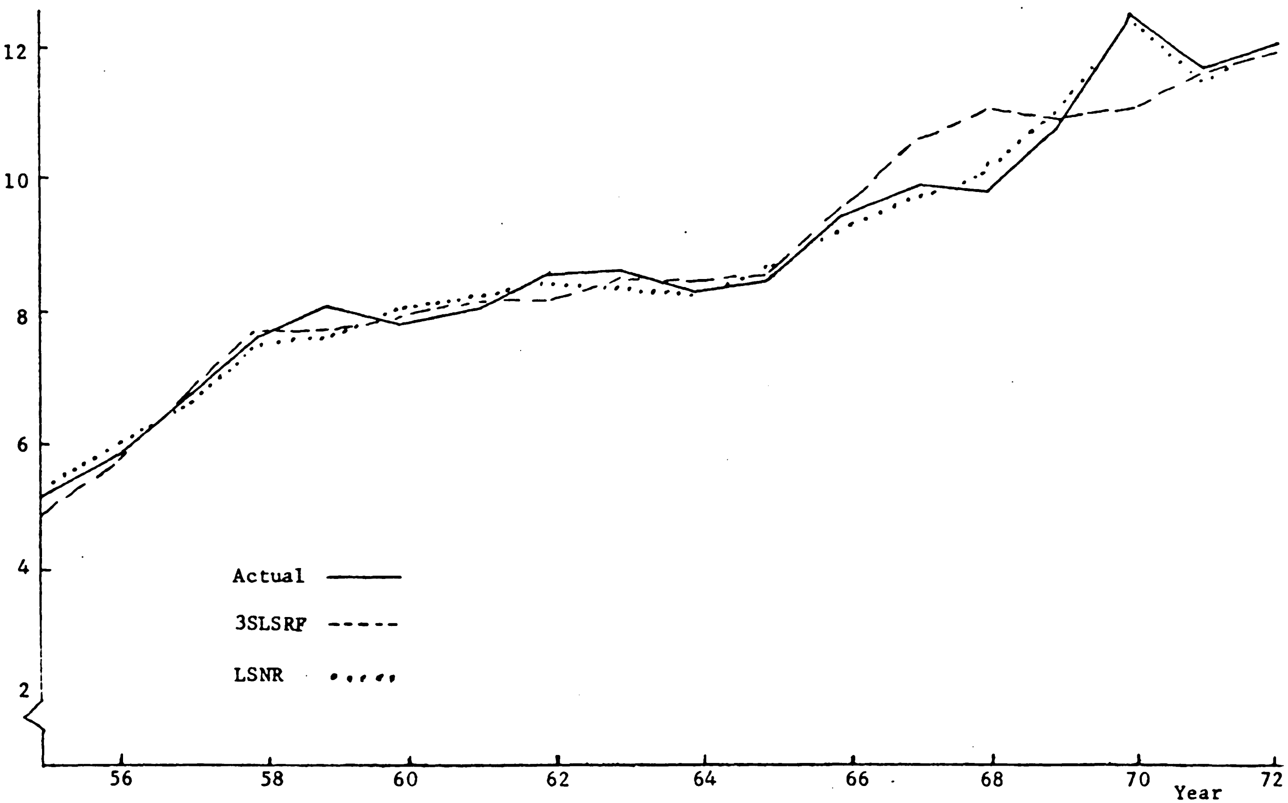

Figure E-6. U.S. Consumption of Soybean Meal, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

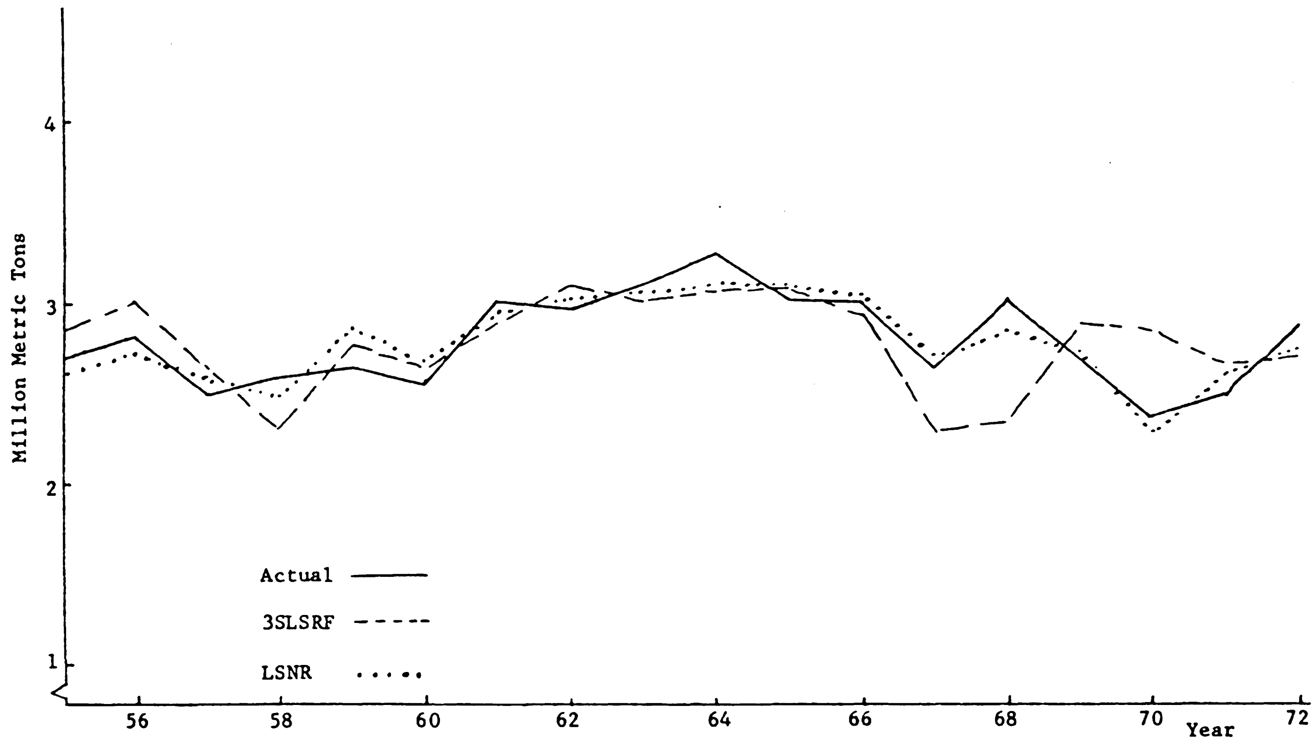

Figure E-7. U.S. Consumption of Other High Protein Meals, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

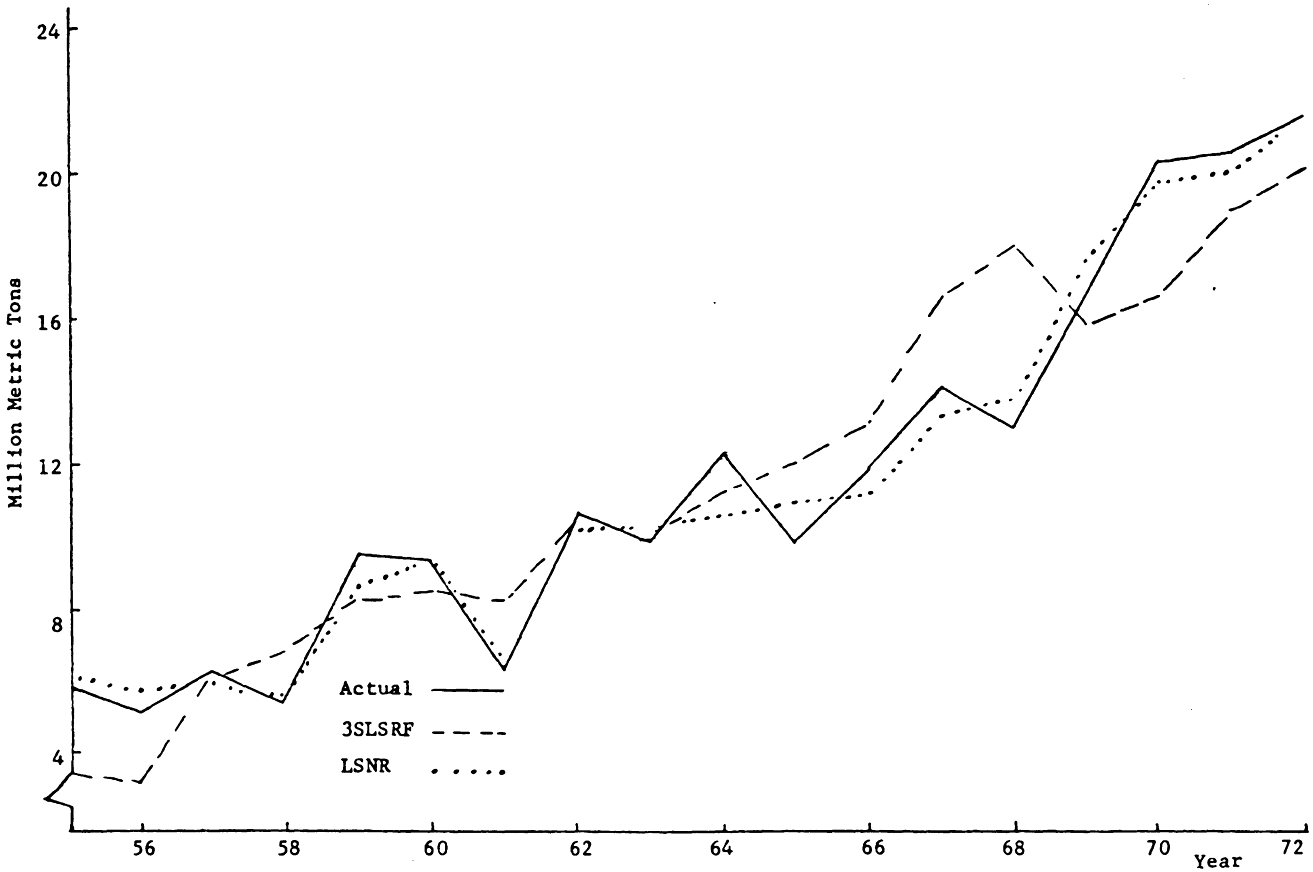

Figure E-8. Foreign Consumption of Soybean Meal, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

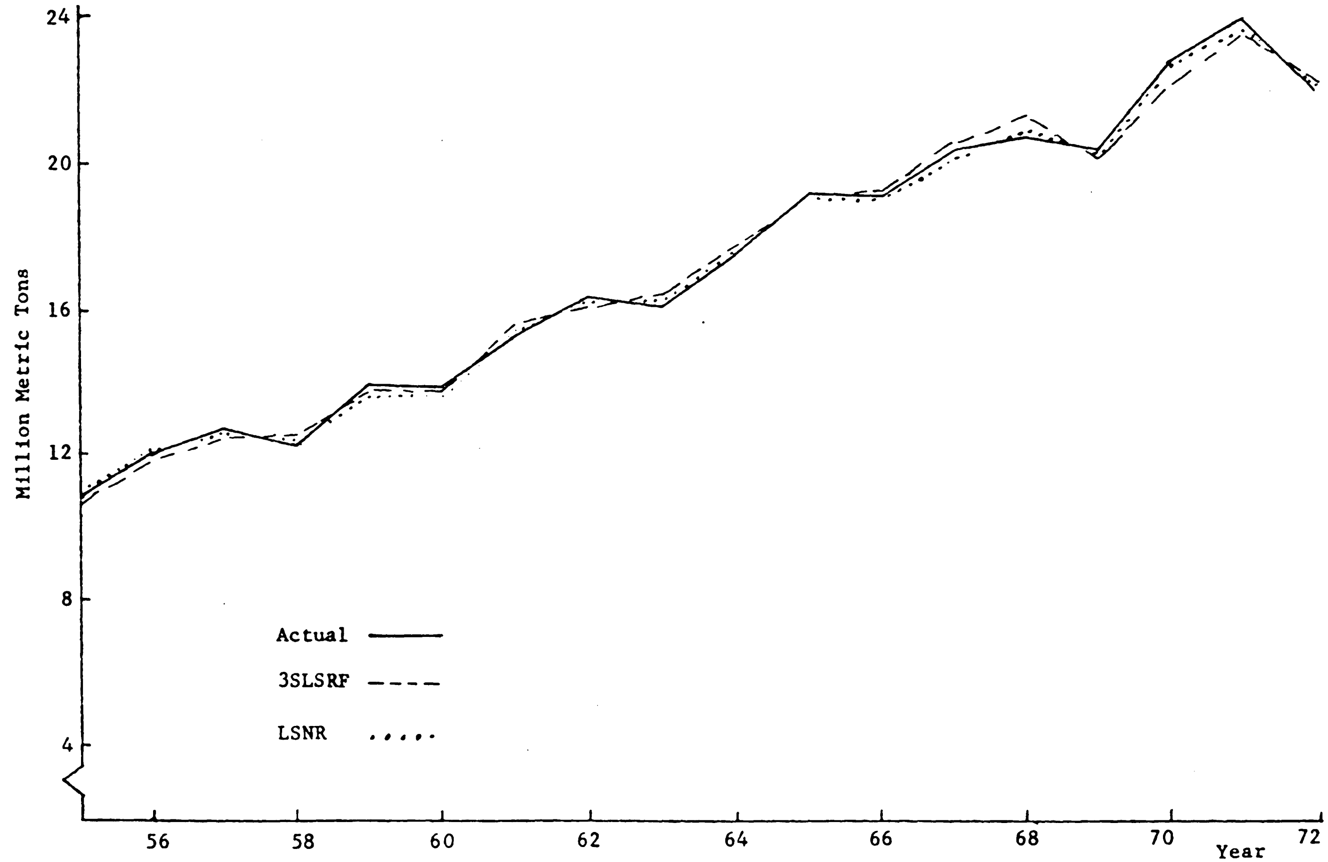

Figure E-9. Foreign Consumption of Other High Protein Meals, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

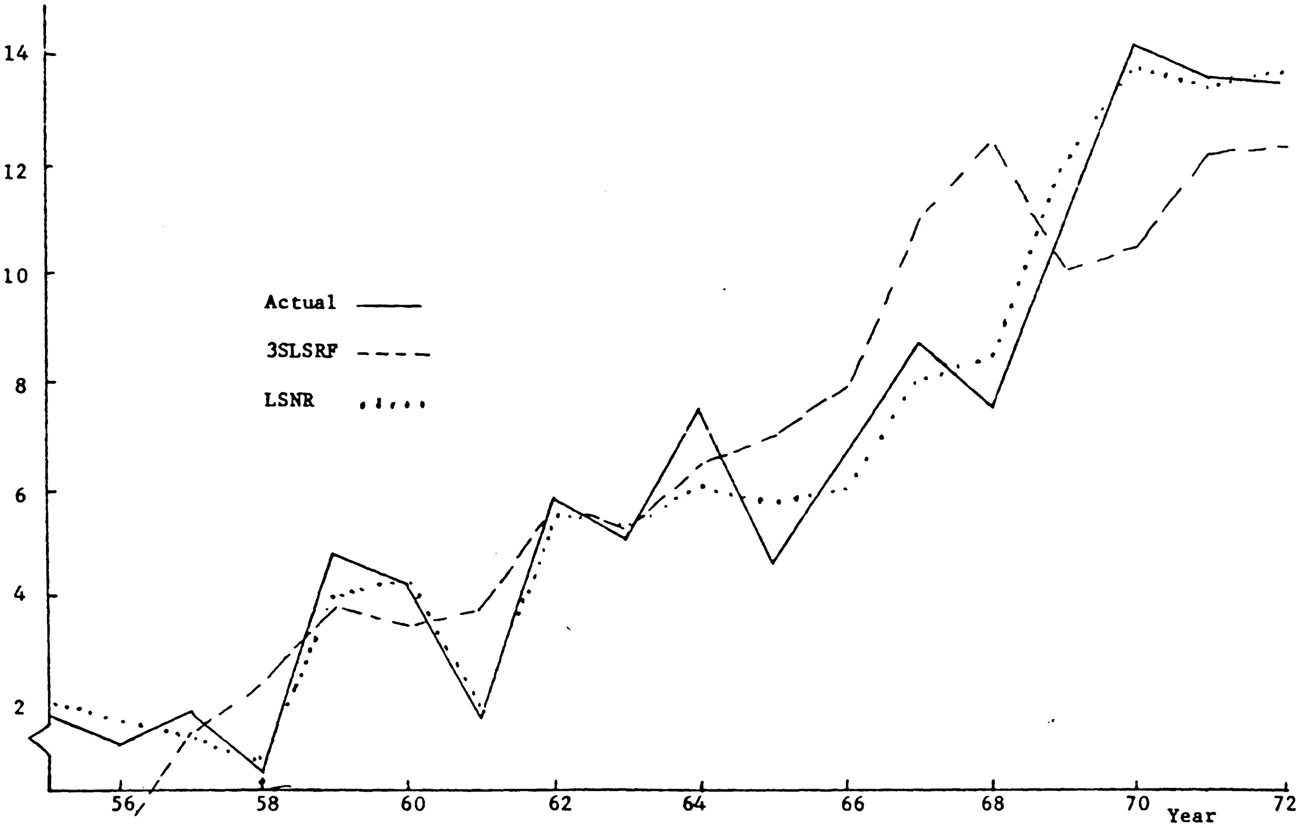

Figure E-10. U.S. Exports of Soybean Meal, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

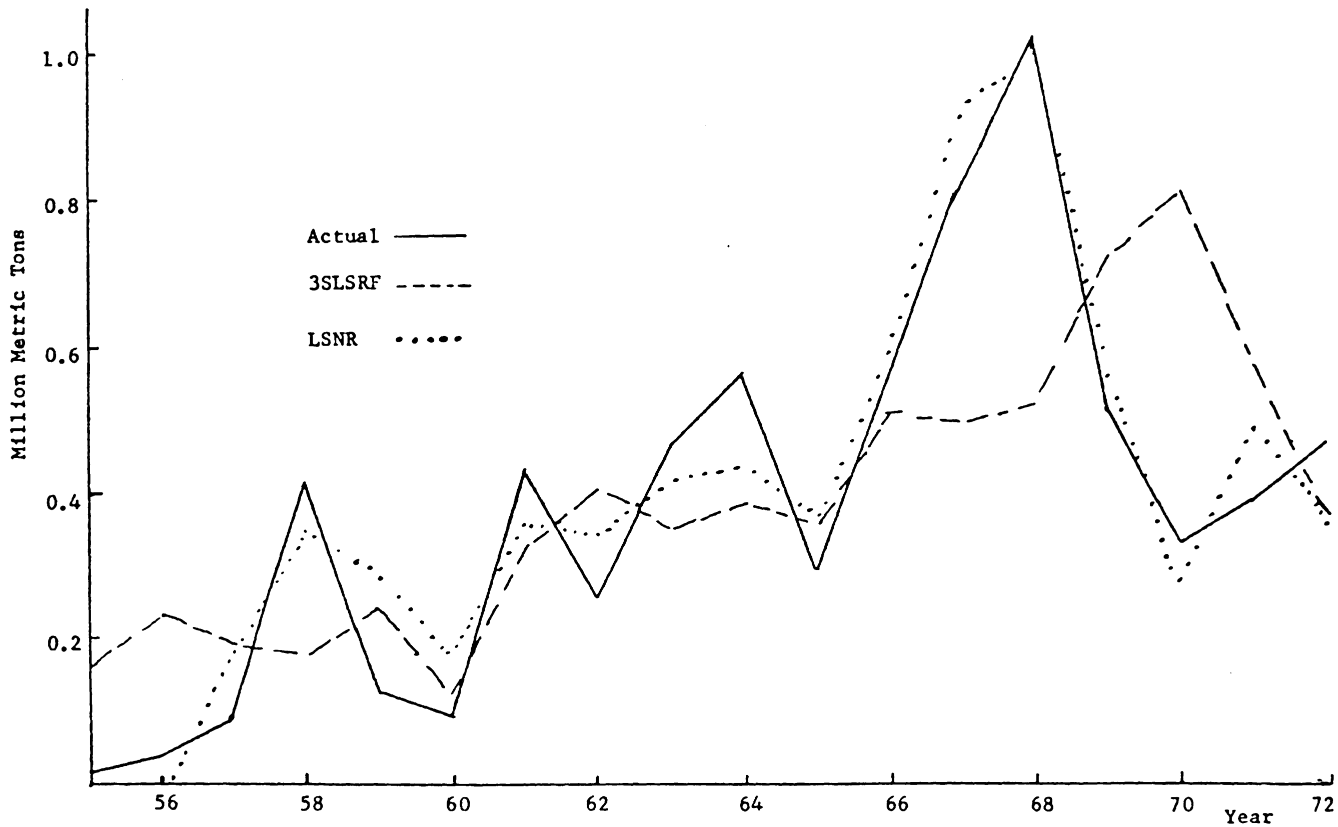

Figure E-11. U.S. Imports of Other High Protein Meals, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

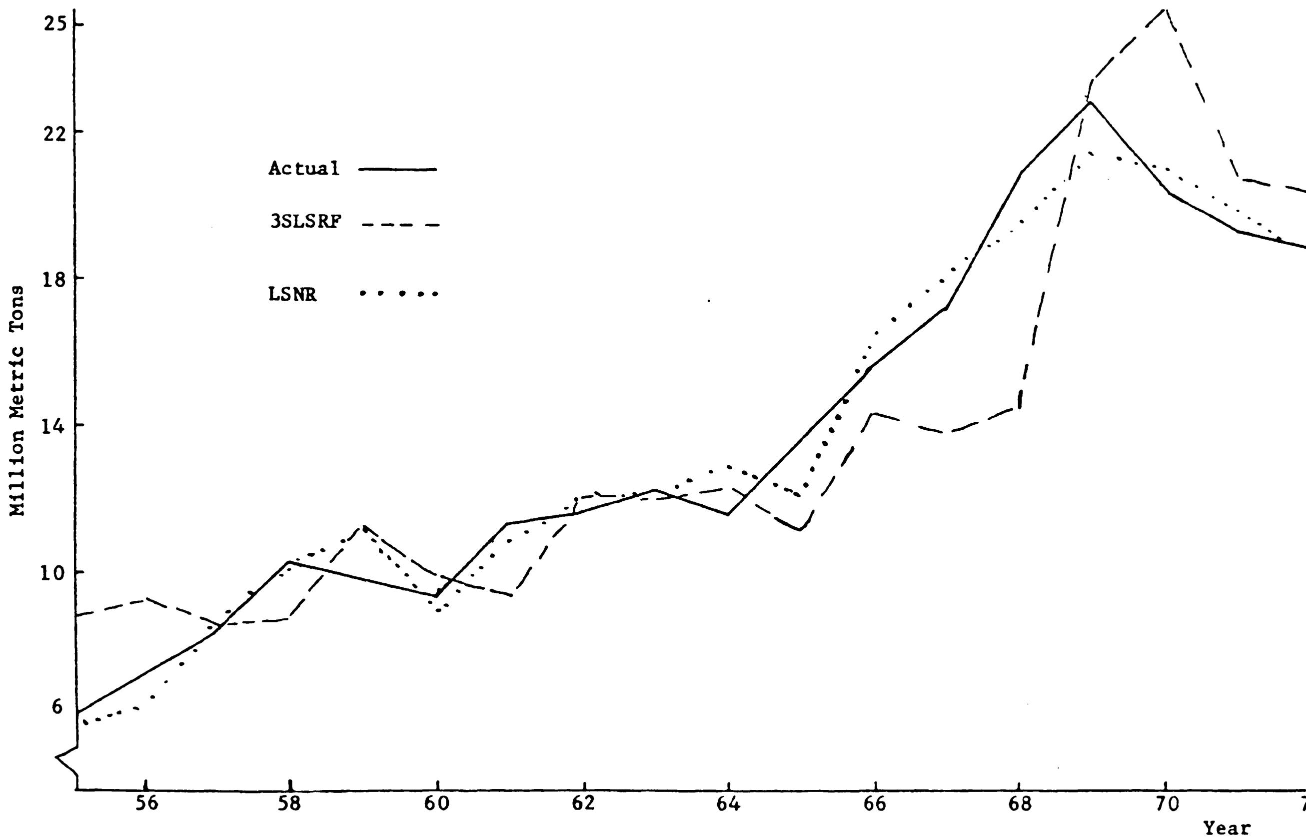

Figure E-12. U.S. Ending Stocks of Soybean Meal, Actual and Computed from 3SLSRF and LSNR Estimates, 1955-1972.

APPENDIX F

APPENDIX F

3SLS STRUCTURAL ESTIMATES, 1955-73

The statistical relations fit to the sample period 1955-73 using 3SLS (three-stage least squares) procedure and are presented for comparison in this section. The standard error of each estimated structural parameter appears beneath in parentheses.

In general, the statistical results are similar to those reported in the text. No dramatic change in signs has been observed. However, note that change in the absolute value of some structural coefficients has been large. The estimated coefficients are generally greater than their estimated standard errors. In some equations, the relative magnitude of the regression coefficient over its estimated standard error has become smaller as compared to that previously reported in Chapter IV of this study. The estimated 3SLS structural relations are:

$$\text{3SLS} \quad P^*_{sb} = 11.1 + \underset{(.041)}{.7069P^*_{sm}} + \underset{(.0258)}{.1507P_{so}} - \underset{(.000243)}{.0002725Q_{sms1}}$$

$$\text{3SLS} \quad Q^*_{smc} = -\ 3856 - \underset{(14.55)}{77.91P^*_{sm}} + \underset{(19.32)}{97.74P^*_{om}} + \underset{(.0105)}{.0495Hog}$$

$$+ \underset{(.156)}{3.139Broil}$$

3SLS $Q^*_{omc} = 6410 + 46.42P^*_{sm} - 50.36P^*_{om} - .0389Q^*_{smc}$

(9.02) (12.32) (.0301)

$- 47.65P_c$

(8.38)

3SLS $Q^*_{smf} = - 34460 - 108.5P^*_{sb} + 115.5P^*_{omf} + 37.16H_{paf}$

(27.3) (23.1) (2.12)

3SLS $Q^*_{omf} = - 17050 + 70.47P^*_{smf} - 139.7P^*_{omf} + 33.04H_{paf}$

(27.44) (42.67) (2.43)

3SLS $Q^*_{smx} = - 25700 - 131.6P^*_{sb} + 87.16P^*_{smf} + 29.57H_{paf}$

(47.09) (37.4) (3.06)

3SLS $Q^*_{omi} = 1466 + 20.32P^*_{smf} - 26.6P^*_{omf} + .0374Q^*_{sms}$

(4.57) (4.73) (.0173)

$- .8467H_{paf}$

(.606)

3SLS $Q^*_{sms} = - 3439 + 36.17P^*_{sm} - .9689Q^*_{smx} + 1.592Q_{sms1}$

(5.16) (.1242) (.104)

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AN ECONOMETRIC STUDY ON THE MARKET STRUCTURES
OF THE WORLD DEMAND FOR HIGH PROTEIN
MEALS, WITH SPECIAL EMPHASIS UPON THE
UNITED STATES SOYBEAN ECONOMY

by

Chung-liang Huang

(ABSTRACT)

This study obtains parameter estimates relating to the United States and foreign demand for high protein meals during the period 1955-1972.

The world economy of high protein meals was formulated in a theoretical framework which provided a basis for the statistical estimation. The core of the analysis is a simultaneous equation model composed of eight linear stochastic behavioral relations and four linear identities. The three-stage least squares procedure was employed to estimate the unknown structural parameters of the statistical model.

The statistical analyses of this study contribute to the quantification of demand interrelationships between soybean meal and other high protein meals, and to the demand relationships between the United States and foreign markets. Elasticity measures were computed from the estimated structural coefficients. The results of the present study suggest that domestic, as well as foreign demand, for soybean meal during the 1955-72 period were price inelastic. In

addition, this study suggests that demand for soybean meal has become more elastic in the recent years. A technical complementary relationship was found between corn and other high protein meals in the United States. Soybean and other high protein meals appeared to be very close substitutes as livestock feeds both in the United States and foreign markets. Furthermore, the study indicates that both export and import demands for protein meals were price inelastic. Particularly, the United States demand for imports of other high protein meals which was estimated to be highly price leastic.

Derived reduced forms were computed from three-stage least squares structural parameters. The unrestricted least squares reduced forms were estimated using ordinary least squares procedure. Effects of a specific change in the predetermined variables on all the jointly determined variables were examined using the three-stage least squares reduced form. The price of corn and animal units was found to have a great impact on the consumption of high protein meals.

Economic forecasting was evaluated and performed on the basis of the reduced form equations, using both derived reduced for equations and ordinary least squares estimated reduced form equations. When compared with actual values, within the sample period, ordinary least squares estimated reduced form equations tend to be superior than reduced form equations computed from three-stage least squares structural coefficients. Nevertheless, comparison of the two methods in forecasting test using observations for 1973 and parameters estimated from observations for the period 1955-72 was inconclusive. Finally, this study suggests that a structural change might have occurred in recent years.