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A SIMULTANEOUS PREDICTIVE MODEL OF THE UNITED STATES DOMESTIC SOYBEAN INDUSTRY

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ABSTRACT

A SIMULTANEOUS PREDICTIVE MODEL OF THE
UNITED STATES DOMESTIC SOYBEAN INDUSTRY

By Thomas H. Christensen

This study estimates parameters related to soybean meal and soybean oil demand for the United States in the marketing years 1954-1977. Parameter estimates related to soybean supply in the United States are also estimated for this same period.

A twelve-equation simultaneous model for the United States soybean industry is developed. The quantity of soybeans produced at the beginning of a marketing year is first estimated from pre-determined (known) values. The estimated supply of soybeans is then interacted with domestic (and exogenous foreign) demand conditions to yield an estimate of domestic soybean utilization and soybean price.

The entire system of equations is then solved, using forecasted values for all exogenous variables, in order to provide estimates of the market conditions that will prevail in the United States soybean industry through the market year of 1982.

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CHAPTER I

INTRODUCTION

Soybeans have come from a position of relative obscurity in the post-World War II era, with about 10 million acres harvested, to approximately 65 million harvested acres in 1978. Soybeans are second only to corn in contribution to the cash income of U.S. farmers. In the world today, soybeans are the most dominant of the oilseeds; soybean oil is the most important of the edible oils; soybean meal is the leading high-protein feed for livestock. Rapid expansion in soybean production has been the result of technological improvements and of an attractive economic position in relation to other crops. Improved corn varieties, herbicides and pesticides have increased corn yields, making it possible to satisfy the demand for corn with a smaller proportion of total cropland than in the immediate post-war period. Feed-grain prices have been relatively low in most of the post-war years, and government programs have been aimed at reducing feed grain production. These conditions have opened the door for a new crop in the Corn Belt: soybeans. In a like manner, soybeans have moved on to acreage formerly devoted to cotton in the South. Cotton production in the South has become less attractive as the effects of government programs aimed at reducing cotton acreage and competition from other areas and fibers has been felt. The demand for soybeans has been growing steadily over this same period, both domestically and abroad. Soybean prices have remained bouyant throughout the post-war period. In years where allotments have been imposed on corn and cotton acreage, soybeans have been allowed on the feed grain base in all but 1971. A combination of increased world demand for soybeans and soybean products, acreage controls on competing crops in the U.S., and the variability of foreign supply have all acted together to maintain favorable soybean prices while production has steadily grown in the United States.

The Problem

The wide fluctuations of both soybean and soybean products' prices that has been observed in recent years has stimulated general interest in the ability of the agriculturalist to foresee changes in market conditions and the impact that these changes will have, both in the United States and abroad. The intent of this study is to examine the economic forces which interact in the domestic market for U.S. soybeans and their products in order to establish a framework for analyzing the impact of actual and expected market conditions. "The need for such a framework has long been recognized",[1] and several other studies are devoted to

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[1]David Kenyon and R.S. Evans (1975) "Short-Term Soybean Acreage Projection Model Including Price and Policy Impacts" Virginia Polytechnic Institute and State University Research Bulletin (106):4.

this same end.[2,3]

The Objectives

The main objective of this research is to provide a framework for examining the interaction of the domestic soybean market with the purpose of forecasting the impact of expected market conditions. To accomplish this, an economic model is constructed based upon the theories of the firm and of the consumer as they apply to the production and consumption of soybeans and their products.

The ultimate goal of this effort is to provide a description of a method of analyses of the impact of varying sets of market expectations. It is hoped that the results of this research will provide a practical technique for interacting the analyst's expectations as to the level of exports, income, yields and other relevant market information, in order to provide an estimate of the resulting conditions in the U.S. soybean industry.

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[2] Ibid.

[3] James P. Houck, Mary E. Ryan, Abraham Subotnik (1972) Soybeans and Their Products, University of Minneapolis Press.

CHAPTER II

THE UNITED STATES SOYBEAN INDUSTRY

The United States soybean industry is a complex entity. As the complexity of a subject grows, so does the number of interpretations. It is useful to review the vantage point from which the analyst views the subject in order to better understand how a particular interpretation has evolved. The following is a discussion of the aspects of the soybean industry that are considered important to this particular study. It is by no means an exhaustive history, but rather a sketchy outline.

Growth of the United States Soybean Industry

Soybean production has grown steadily over the past few decades. Immediately after World War II, output had risen from 78 million bushels in 1940 to 200 million bushels annually in 1946 (spurred by a cutoff of foreign edible oil sources). Things did not return to normal after the war; U.S. soybean production continued to climb so that by 1978, 1,792 million bushels of soybeans were harvested. The value of soybeans has grown in relation to other crops. It is now second only to corn as a cash crop, with a farm value of over $11 billion in 1978. Soybeans are the most important source of edible oil and animal high protein feed, both nationally and worldwide. The United States has become the most important producer and exporter of soybeans and soybean products, making the soybean a real American success story.

Soybeans have been raised in the United States for decades (mostly in the Atlantic States), but the first real boost towards their present prominence was given by World War II. The cutoff of foreign oil sources by the Japanese led to the introduction of soybeans to new acreage, notably in the Corn Belt. Since the soybean is ideally suited to the same soil and climatic conditions that favor corn and other feed grains,[4] their introduction to the Corn Belt was opportune. Advances in corn technology brought great increases in corn yields, and with greater yields came government policies designed to reduce corn acreage and maintain corn prices. By allowing the demand for feed grains to be filled by smaller areas of cropland, the advances in corn technology opened acreage to a new crop, soybeans.

The demand for soybeans is derived from the demand of the two joint soybean products: soybean oil and soybean meal. Both of these products have enjoyed a continuing growth in demand over the past three decades. Technological changes in the soybean processing industry have improved extraction efficiency. The reduced costs that have resulted from this new technology have enhanced the competitive position of soybean products and fueled the demand for them.

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[4]James P. Houck, Mary E. Ryan, Abraham Subotnik (1972) Soybeans and Their Products, University of Minneapolis Press.

The growth in demand for soybean products and the attractiveness of soybeans as a crop alternative provides a framework for further study. In analyzing the domestic markets for soybean oil and soybean meal, the sources of the demand that have encouraged the growth of this soybean industry will become clear.

Soybean meal and soybean oil account for most of the utilization of soybeans. The relative contribution made by each of these products to total value of a soybean crop has changed dramatically over time. In the early 1950s, the value of the oil produced from a bushel of soybeans was about equal to the value of the meal produced from the same bushel. By 1978, almost two-thirds of the value of soybean production came from the meal portion of soybeans.

Soybean Meal

Soybean meal is used primarily as a high-protein supplement in livestock and poultry feeds. As disposable income levels have risen in the United States, so has the demand for animal products. Livestock production has become increasingly concentrated as the efficient commercial producer has come into prominence. This new breed of operator has come to rely increasingly upon formula feeds and custom mixes that incorporate high protein supplements as a major constituent. As the use of prepared feeds continues to expand, the demand for high-protein sources will grow proportionally, with soybean meal being the most attractive of the alternative protein supplements.

Soybeans, cottonseed, peanuts, sunflowerseed, rapeseed, linseed, copra and palm kernels are all sources of oilseed meal. Among these substitute sources of high-protein meal, soybean meal is one of the highest in crude protein content by weight. Soybeans have a higher percentage of meal to oil than the other oilseeds. This makes soybeans an attractive source of oilseed meal when the demand for edible oil is not as strong as the demand for oilseed meal. The most important competitive source of oilseed meal is cottonseed meal. Cottonseed meal is a byproduct of the cotton industry and as such, has never contributed more than 8 percent to the total value of United States' cotton production. It is doubtful that cotton production will ever be responsive to changing oilseed market conditions.

There are several other sources of high protein available to the feed industry. Fish meal is one which is very high in protein, but has the disadvantage of imparting a "fishy taste" to the resulting animal product (notably, milk). Synthetic urea is another important source of high-protein feed. It has not gained a large share of the market to date and, with current unfavorable natural gas market conditions, further expansion of this source appears to be questionable.

The status of soybean meal as the most important source of high protein for livestock does not seem threatened at present. The horizontal integration of the prepared feed and soybean processing industries only serves to demonstrate the widespread expectation of the continued importance of soybean meal.

Soybean Oil

Soybean oil is produced at the same time that soybean meal is made, but the markets for these two soybean products are unconnected. Soybean oil competes with animal and vegetable fats and oils, especially those fats and oils used in food production. Edible fats and oils are used in processed foods, cooking oils, salad oils, shortening and margarines. Peanut oil, cottonseed oil, corn oil, and to a lesser extent, palm oil, are some of the substitute oils that compete directly with soybean oil as ingredients in products which incorporate edible fats and oils; butter and lard substitute for finished edible oil products in consumption.

Soybean oil has come to dominate the market for fats and oils in the United States. There has been a 15 percent increase in the per capita consumption of all fats and oils products since 1963. During this same period the per capita consumption of soybean oil has increased by 40 percent. Most of this growth in soybean oil consumption has occurred because of changing consumer preferences. Consumer tastes have moved away from animal products, such as butter, towards vegetable oil products, like margarine.

Products with desirable flavor and improved physical characteristics have been made possible by new technology.

There is now widespread public acceptance of the health and cost advantages of vegetable oil products, and as these vegetable oil products improve, the substitution of vegetable for animal products involves little loss of consumer satisfaction.

There exist many substitutes for soybean oil, yet few appear likely to gain the status that soybean oil enjoys in the fats and oils market. Cottonseed oil is the byproduct of a larger industry, and as such, it contributes only a small proportion of the total value product of the industry. The contribution of the cottonseed oil to the total value of the cotton crop was only 6.5 percent in 1976. Only a cataclysmic change in the fats and oils market would have any significant effect on the cotton industry. The supply of cottonseed oil is exogenous to the fats and oils market. In a like manner, lard and butter supplies are relatively unaffected by fats and oils market conditions. Butter was the source of only 7 percent of the total value of milk production in 1976. Peanuts are another important source of oil, but if current government policy continues, it is doubtful that peanut oil production will expand much more rapidly than it has in the past.

The most important source of competition for soybean oil in the future is likely to be palm oil. Presently palm oil is used primarily in shortening and processed foods, but it is becoming a more common ingredient in margarine and cooking oil. Palm oil is extremely competitive with soybean oil;

"U.S. imports of duty-free palm oil from Malaysia and Indonesia are expanding sharply because of its price advantage over soybean oil and cottonseed oil."[5]

Direct Utilization of Soybeans

Some soybeans are not crushed but are used directly on the farm as feed or held as seed. These usages combined have not exceeded 6 percent of total production in the last decade.

Soybean Production: Alternative Crops and Regionality

Soybeans are a hardy and versatile legume. They require less nitrogen fertilizer than most crops (although they may require more herbicides). Most soybean varieties have a short growing season and do not require any great capital outlay for specialized machinery. These characteristics combine to make soybeans an attractive crop alternative in much of the United States. Much of the crop land formerly devoted to corn or cotton has now become soybean acreage. The switch from corn to soybeans has been precipitated by advances in corn varieties and the potential glut that higher corn yields have brought. The acreage devoted to cotton production is particularly sensitive to government policy

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[5]George W. Kromer (Aug. 4, 1975). "Trends and Patterns in Soybean Oil Use For Food And Industrial Products" U.S. Department of Agriculture Economic Research Bulletin (611),12.

changes.[6] Much of the acreage that was at one time in cotton is currently in soybeans, reflecting both the results of "the cotton program which has restricted acreage" and "the increase in soybeans' competitive position relative to cotton."[7]

In reporting the acreage and production of soybeans in the United States, the U.S. Department of Agriculture has identified six major production regions: the Corn Belt, Lakes states, Delta states, Atlantic states, Plains states, and other states (see Figure 1b.).

The Corn Belt states are the most significant of all regions with about half of the total U.S. soybean cropland and production. Small grains and hay acreage have been reduced greatly in the past half century, so that corn is now the dominant competitive crop in the Corn Belt states. Typically, a third of the total acreage of this region is in soybeans, while most of the rest of the Corn Belt cropland is devoted to corn.

In the Lakes states, the main crop alternatives are corn and soft red wheat. Typically, 10 percent of national soybean production occurs in this area, with the bulk of the soybean cropland being found in areas adjacent to the Corn Belt region. There has been little growth in Lakes states'

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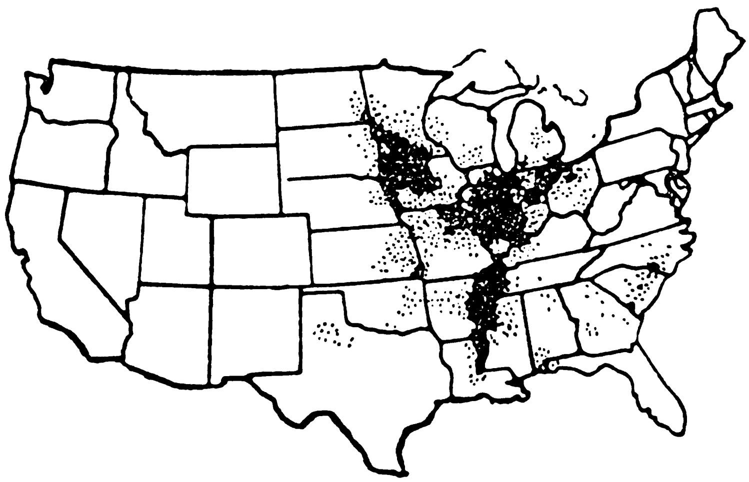
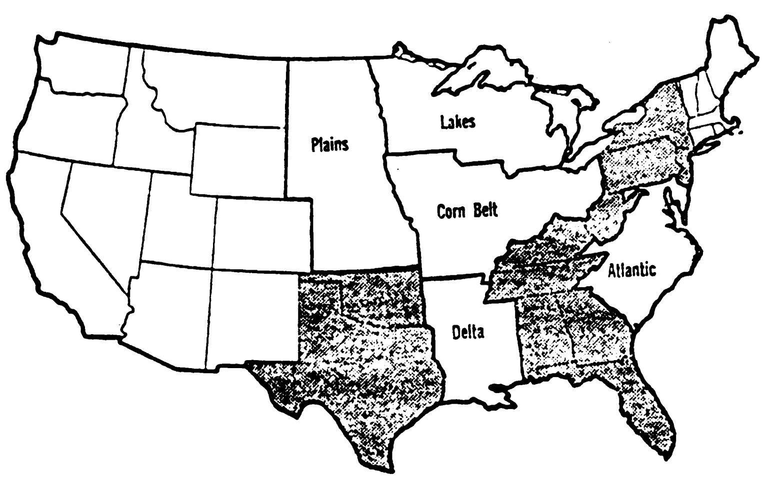
[6] David Kenyon and R.S. Evans (1975). "Short-Term Soybean Acreage Projection Model Including Price and Policy Impacts" Virginia Polytechnic Institute and State University Research Bulletin (106), 6.

[7] W.A. Boutwell, H.A. Harris, D. Kenyon (1966) "Competition Between Soybeans and Other Crops in Major U.S. Regions" USDA, Economics Research Bulletin (588).

Figure 1. · · Soybean Production Areas — United States.



Location of U.S. Soybean Production.
One dot equals 5,000 acres.
Source: Census of Agriculture, 1964



Production Regions for U.S. Soybeans.
The shaded areas include those
states in "other states" (see text).
Source: U.S. Department of Agriculture.

soybean acreage in recent years.

The Plains states contribute about five percent of total U.S. soybean production on average. Most of the soybean acreage in this area is found along the region bordering the Corn Belt and the Lakes states.

The Delta states have experienced a continued expansion in soybean cropland during the last thirty years. Between the years 1968 and 1978, the rate of increase of soybean cropland expansion in the Delta states has reached an average of 14 percent per year. Some of this expansion in soybean acreage has been on newly opened cropland, but much of the land now in soybeans was previously devoted to corn, small grains or cotton. Cotton acreage has been declining in the Delta states as a result of government policy, the movement of cotton production to the West, and the strong competitive position of soybeans. Soybeans are now the major crop of the Delta states, with nearly two-thirds of this region's total cropland now in soybeans.

The Atlantic states have experienced a steady growth in soybean acreage. Here the main options are cotton and corn. Declines in cropland devoted to cotton and corn have accompanied the increase in soybean acreage in the Atlantic states.

The bulk of soybean production that occurs in the other states region is found in the areas bordering the Corn Belt region.

The preceeding analysis of the U.S.D.A.-defined regions identifies the competitive crops and geographic location of soybean production in each respective region. In some regions the important crop alternative is corn and geographically, most of this production is clustered around the Corn Belt. These regions are: the Corn Belt states, the Lakes states, the Plains states. Other states have crop alternatives of more importance than corn; cotton is often found to be in a competitive position. These regions are found in the more temperate areas to the South that were identified as the Delta and Atlantic regions. Similar crop alternatives and geographic locations suggest two major areas of soybean production in the United States. One of these regions would be in the North, with corn as the main competitive crop and production centered around the Corn Belt region. This region will hereafter be referred to as the Northern region and consists of the states in the Corn Belt, Plains states, Lakes states and other states. The other production region, the Southern region, is made up of the Delta and Atlantic states. This area has corn and cotton as competitive crops and located in the more temperate zones of the southern United States.

Soybean Yields

Soybean yields along with the harvested acreage of soybeans will determine production for a given year. Soybean yields in the Northern United States region were 23 bushels per acre during the post-Korean War period and have risen to an average of 29 bushels per acre in recent years. In the Southern United States region, the average yield per acre was about 20 bushels after the Korean War. In recent years this average has risen to 22 bushels per acre. Enhanced soybean yields have resulted from the introduction of new varieties suited to local climatic conditions; improved weed, insect and disease control; and better management practices.

Much variability in crop yields has resulted from changing climatic conditions. Evidence of sunspot cycles being associated with drought cycles, and thereby affecting crop yields has been demonstrated in other studies. "Many analysts have suggested a twenty to twenty-two year cyclical pattern for yields in the Great Plains and Corn Belt."[8] It may be possible to better understand this aspect of soybean yield variability through the study of these sunspot cycles.

Soybean Market Interaction

Soybean Supply

In the beginning of the crop year, soybean production is determined by the acres of soybeans harvested and the yield per acre of soybeans (See Figure 2). A small portion of the crop is held for seed, or residual uses on the farm, but most of the production enters the market. As the new crop becomes

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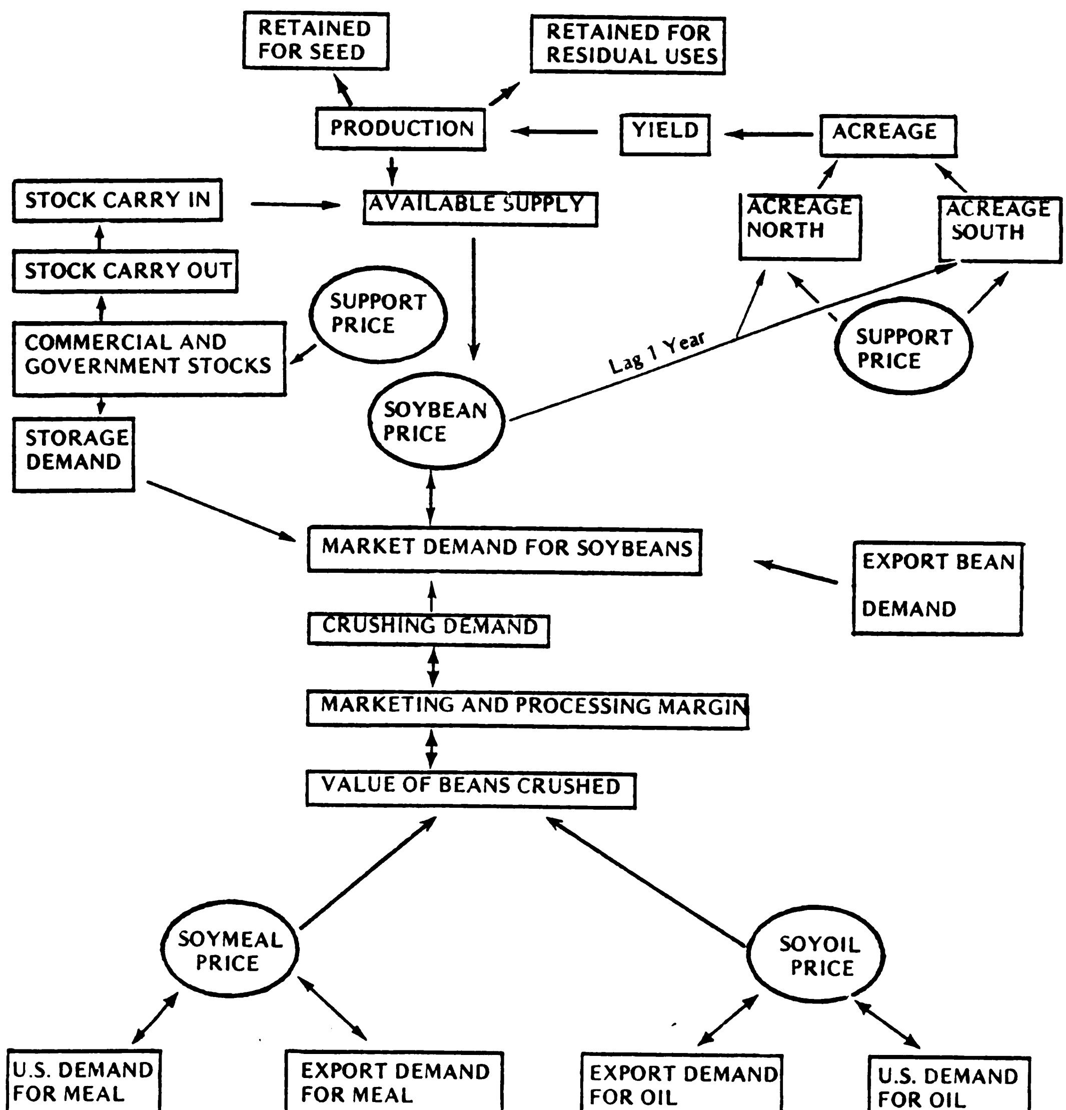
[8] J. Roy Black and Stanley R. Thompson (1978) "Some Evidence on Weather-Crop Yield Interaction" American Journal of Ag. Economics (60).

FIGURE 2.--U.S. Supply and Disposition of Soybeans and Soybean Products.



available, there are stocks of soybeans remaining that are also available in the market at a discount (reflecting a loss of quality over time). The carry-in stocks and production, minus soybeans held for seed and residual uses, determine the soybean supply for that crop year.

Soybean Demand

There are several sources of demand for soybeans. Processors demand soybeans for crushing in order to satisfy their markets for soybean oil and meal. The revenue from the sales of oil and meal combine to create the value of the beans that are crushed, which will influence the total quantity of beans demanded by the processors. Foreign and domestic markets exist for soybeans; over one-third of all U.S. soybean production has gone to foreign markets in recent years. If exports of domestically produced soybean oil and soybean meal are considered, half of the United States' soybeans and soybean products have been exported in the past decade. Speculative demand for soybeans and their products may influence the stock levels that are held domestically. The level of stock demand (if any), domestic crushing demand and foreign demand for soybeans, are the components of the total demand for soybeans each crop year.

The price that each farmer receives for his soybeans is determined by the interaction of the supply of soybeans at harvest time with the total market demand conditions. The price received by farmers for their soybeans will interact with other considerations (i.e. support price levels, previous planting practices, the market price for alternative crops, etc.) to determine soybean acreage planted in the coming season.

The price received by farmers for their soybeans is determined by the interplay of the demand for beans with a predetermined level of supply. The demand for beans, whether foreign or domestic, is derived from the demand for the two soybean products: meal and oil. With about 4 pounds of soybean meal yielded per pound of oil produced, the ratio of oil to meal production is physically determined. However, the demands for the two soybean products are largely unrelated. The quantities of soybean meal and oil demanded must approximate to the crushing ratio for the market to clear. The only way the quantities of meal and oil demanded can be linked to this crushing ratio is through price adjustment. In recent years it is interesting to note that soybean meal prices have been trending upwards while the price of soybean oil has often been weak. The strength of demand for soybean meal has often been strong in relation to that of soybean oil, as attested by the shift in their relative prices.

CHAPTER III

REVIEW OF THE LITERATURE

In 1958, King[9] published a study which focused upon the relationship of all high-protein feeds as a group, to all feed grains. In addition, the relationship of each high-protein feed to all other high-protein feeds was estimated in a series of two-equation relationships. A demand equation for soybean meal was estimated and compared to an equation for other high-protein feeds (it is important to note that during the data period of this study, soybean meal was not as dominant in the high-protein feed market as it is today). In the soybean meal equation the quantity of high-protein feeds as a group was dependent upon the price of high-protein feeds, the price of feed grains, the price of livestock and associated products, and the number of grain consuming animal units. The market share of soybean meal was estimated from soybean meal price and other high protein meal prices in a simultaneous solution with an equation for other high-protein feeds.

The King study demonstrated: (a) that high-protein feeds

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[9] Gordon A. King (1958). "The Demand and Price Structure for Byproduct Feeds" U.S.D.A. Technical Bulletin (1183).

are highly competitive with feed grains, and (b) there exists qualitative differences in the various high-protein feed groups which is reflected in a degree of independence of demand for each group.

In another study conducted by the U.S.D.A.,[10] soybean meal price was estimated in varying specifications which included the following variables: the total supply of soybean meal, the quantity of soybean meal fed to livestock, the total quantity of other high protein meals produced, the quantity of other high protein meals fed, high-protein consuming animal units, the average prices for livestock and livestock prices and the production of formula feeds. The specification that was finally arrived upon had soybean meal price as a function of the total supply of soybean meal, the average price received for livestock, and the production of formula feeds.

Attempting to develop a predictive equation for soybean meal price led Hieronymus to try a large number of alternative specifications for soybean meal demand.[11] The equations that were deemed best included soybean meal supply (either as total production or as production minus exports), high-protein consuming animal units and livestock prices.

The construction of the high-protein consuming animal

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[10]U.S.D.A. (1959) "Factors Influencing Soybean Meal Prices" Feed Situation (July).

[11]T.A. Hieronymus (1961) "Forecasting Soybean Meal Futures Prices" Commodity Yearbook, Commodity Research Bureau Inc.

units series is of particular interest. In contrast to the U.S.D.A. data series, which computes average consumption rates based on the utilization of all high-protein feeds, the rates used in this study were specific to soybean meal. The data series is then adjusted for trends towards greater soybean meal consumption over the period considered.

James P. Houck has been the pioneer in the study of the entire soybean industry with all its complexity. In 1963, Houck developed an eight-equation model to simulate the market demand relationships for soybeans and their products.[12] Houck envisioned the price determination of both soybeans and soybean products as a simultaneous interrelated process.

The process of market interaction was simulated in the Houck study by an eight-equation model representing the various market demands and price links that exist in the soybean industry. Five of the eight equations are viewed as stochastic: (a) soybean meal demand; (b) soybean oil demand; (c) crushing and handling margin; (d) export demand for soybeans; and (e) storage demand for soybeans. The other three equations were definitional for: the price of soybeans received by farmers, the value of the two soybean products -- meal and oil.

The stochastic parameters were estimated via two-stage least squares and ordinary least squares regression procedure in the reduced form. Both methods yielded statistically

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[12]James P. Houck (1963) "Demand and Price Analysis of the U.S. Soybean Market" University of Minnesota Ag. Experimental Sta. Technical Bulletin (244).

significant estimates of a similar magnitude. It was the first successful treatment of the soybean industry in an integrated form.

In the following years Houck updated his model to include estimates of soybean production in the United States and export demand for soybeans and soybean products.[13] The supply of soybeans was treated as the sum of the production of six regions in the U.S. In a like manner, the export demands for soybean meal, soybean oil and soybeans are estimated for each of either five or six regions and then summed to determine total export demand. The market demand model was respecified from the formulation originally put forth,[14] and while the crushing and handling margin was no longer estimated or defined, individual equations for soybean meal and soybean oil exports were estimated. Another stochastic equation was introduced for the stocks of soybean oil. Meal and oil production, soybean prices, market clearing equations for soybeans, soybean meal and soybean oil are all treated as identities.

As an alternative specification, total world exports of soybeans, meal and oil were made in three equations, with highly satisfactory results. All parameters were estimated by three alternative techniques: (a) ordinary least squares; (b) two-stage least squares, and (c) three-stage least squares.

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[13] James P. Houck, Mary E. Ryan, Abraham Subotnik, op. cit.

[14] James P. Houck, op. cit.

"Of particular interest is the similarity between the LS, 2SLS and 3SLS estimates. The parameter estimates were very stable, with little change seen when an alternative estimation procedure was employed."[15]

Houck's treatment of the soybean industry has been fundamental and has served as the foundation for much of the predictive work conducted by the U.S.D.A. in following years.[16] A recent study conducted by Kenyon and Evans incorporates an effective soybean price (which considers both prices received by farmers, the set-aside program and support price levels) in predicting the harvested acreage in the six production areas treated in Houck's most current study.[17]

Other economic investigations of the soybean industry have utilized spatial equilibrium analysis[18] and operations research.[19]

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[15] James P. Houck, Mary E. Ryan, Abraham Subotnik, op. cit.

[16] Fats and Oils Situation, November, 1971, and July 1973.

[17] David E. Kenyon, R.S. Davis, op. cit.

[18] H. Nakamua, T.A. Hieronymus and G.C. Judge (1963). Interregional Analyses of the Soybean Sector, University of Illinois, Dept. of Ag. Econ. AERR-67.

[19] Earl C. Hedlund (1952) Transportation Economics of the Soybean Processing Industry. University of Illinois Press.

CHAPTER IV

THE MODEL

The model of the United States domestic soybean industry presented in this study is a simplified one, both from economic and statistical viewpoints. Economic relationships are formulated by using a generalized version of the market for soybeans and soybean products in the United States (see Figure II,p.16) and a number of simplifying assumptions. These simplifying assumptions are necessary in order to reduce the analytical complexity, inherent in the interrelated markets for soybeans, soybean meal and soybean oil, to a manageable level. Variable selection for each of the economic relations, represented as a stochastic equation, is based upon *a priori* considerations from economic theory and upon the results of previous investigations.

The structure of the model is presented in terms of the economic relationships between the variables. These relationships are then explained, along with the rationale for each respective structural equation. Beginning with a presentation of the variables that are employed, followed with a discussion of model structure, a description of the economic model is developed. A discussion of the underlying assumptions and model rationale complete the discussion of the economic model.

THE MODEL - DESCRIPTION

The following model of the United States soybean industry is treated as a two-part system. The domestic supply of soybeans is recursively determined: it is assumed that all major production decisions are made on the basis of information available before harvest. The domestic demand for soybeans is treated as a simultaneous system, where the derived demands for the joint soybean products -- meal and oil -- determines the level of crushing demand. In this simultaneous system, the current period prices and quantities of soybeans and their products interact with each other and with other market conditions to determine the level at which the market will clear.

The statistical technique employed to determine estimates of the parameters for both the supply and demand components of the model was the ordinary least squares procedure. Simultaneous estimation procedures were not employed in the estimation of the parameters for the demand equations' variables. Houck used several simultaneous estimation techniques in his study of the soybean industry and noted, "The similarity between the LS, 2SLS and 3SLS estimates" with "the magnitude of the coefficients" being "generally similar form method to method."[20] In light of these results, the use of ordinary least squares estimation procedures seems adequate.

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[20]James P. Houck, Mary E. Ryan, Abraham Subotnik, op. cit.

Variables Employed

The model makes use of 19 endogenous, 11 predetermined and 12 exogenous variables. These variables were either reported on a market year basis (year beginning October 1) or converted from a calendar to a market year via adjustment weights. Mnenomic variable names are used for ease in interpretation of the total model structure. The sample period is from 1954 to 1977.

Endogenous Variables

The following are treated as endogenous variables in the model:

AHSBTS= (1a) acres of soybeans harvested in southern U.S. region, thousand acres, southern U.S. includes: Ark., Miss., Ala., N. Car., S. Car., Virg., Mar., Del.

AHSBTN= (1a) acres of soybeans harvested in northern U.S. region, thousand acres, northern U.S. includes all production areas not found in the southern U.S. region.

APSBTS= (1a) acres of soybeans planted in the southern U.S., thousand acres.

APSBTN= (1a) acres of soybeans planted in the northern U.S., thousand acres.

SOYBYTS= (1a) average soybean yield in the southern U.S., bushels per acre.

SOYBYTN= (1a) average yield in the northern U.S, bushels per acre.

SOILPT= (1d.)	average price of domestic crude soybean oil, cents per pound.
SOILSTKT1= (1c.)	ending stocks of soybean oil (year ending September 30), million pounds.
SBSEDT= (1b.)	soybeans used for seed, million bushels.
SBRIST= (1b.)	residual and feed usage of soybeans, million bushels.
OILSPREAD= (1f.)	farm-retail price spread of soybean oil, cents per pound.
CRUSHT= (1b.)	soybeans processed in United States, million bushels.
SOYBQT= (1a.)	Soybean production in the U.S., thousand bushels.
SBSTKT1= (1b.)	ending stocks of soybeans (year ending September 30), million bushels.
SOYBPT= (1a.)	average soybean price received by farmers, dollars per bushel.
SOYMQTD= (1c.)	quantity of soybean meal demanded domestically, excluding exports, thousand tons.
SOYMPT= (1d.)	average price of soybean meal, bulk Decatur, at 44 per cent protein, dollars per hundredweight.
TOTOIL= (1e.)	total U.S. consumption of all oils and fats, million pounds.
OTHEROIL= (1e.)	total U.S. consumption of all oils, excluding soybeanoil, million pounds.

SOILQTD= (1c.) quantity of soybean oil consumed in the U.S., excludes exports and changes in stocks, million pounds.

SOYBEXP= (1c.) quantity of soybeans exported during the market year, million bushels.

SOYMQT= (1c.) soybean meal produced in the U.S., thousand tons.

SMEXT= (1c.) Soybean meal exports from U.S., thousand tons.

SOILEXT= (1c.) soybean oil exports from U.S., million pounds.

SOYBEXPT= (1a.) U.S. export price of soybeans, dollars per bushel.

Predetermined Variables

The predetermined variables in the model consist of all those variables which have either lagged values or values that would be known at the beginning of a marketing year. These are:

DSOYBPLI= (1a.) deflated average soybean price received by farmers, lagged one year, dollars per bushel.

DCORNPLI= (1g.) deflated average corn price received by farmers, lagged one year, dollars per bushel.

DWHTPLI= (1h.) deflated average wheat price received by farmers, lagged one year, dollars per bushel.

DCOTPLI= (1i.) deflated average cotton price received by farmers, lagged one year, cents per pound.

DPVISBT= deflated effective support rate for soybeans, dollars per bushel.

LAPSBTNLI= (1a.) log of acres planted soybeans, northern U.S., lagged one year, thousand acres.

LAPSBTSLI= (1a.) log of acres planted soybeans, southern U.S., lagged one year, thousand acres.

TIME= linear trend, 1954=54...1980=80.

TSQR= curvilinear trend, 1954=2916(54^2)...1980=6400(80^2).

DUMWEATHER=dummy variable with value of one for years with predicted drought cycles, (1952-58, 1974-80).[21]

Exogenous Variables

These variables are also predetermined in the sense that they are not generated internally in the model, yet these are variables which would not be known before a market year began. These are:

CPI= index of prices paid by consumer, U.S. Bureau of Labor statistics.

INTT= (2) short term prime interest rate, bankers acceptances, 90 day notes, 1967=100.

CORNPT= (1g) average price of corn received by farmers, dollars per bushel.

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[21] J. Roy Black and Stanley R. Thompson. (1976), op. cit.

LPBEEF= log of average price received by farmers for various categories of beef cattle, weighted by various feed rates, adjusted to market year, dollars per hundred weight. The log function is used to simulate the decreasing rate of adjustment to price that has occurred over time.[22]

HPCAUT= high-protein consuming animal units, U.S.D.A. weights applied to major livestock production categories, adjusted to market year.

CONSUMRAT= ratio of per capita margarine consumption to
(1j) per capita lard and butter consumption, pounds.

EDIBLEI= index of edible oil price, 1967=100.
(1k)

POPT= resident population of the U.S., July 1,
(3) millions persons.

DPCIT= disposable per capita income, dollars per
(4) person.

RAINS= deviation from average rainfull in Lake Charles, La., inches.

GMSOYMEAL= the gross margin for soybean meal, calculated from annual livestock data, soybean meal price and adjusted for market year, cents per pound.

Notes On Some of the Variables

The sources of the data correspond to a numbered code

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[22] T.A. Hieronymus (1961) op. cit.

which appears directly below each variable name. These are listed in Appendix A. The following will help clarify further questions.

1. The prefix DEF- refers to any price that has been deflated by the consumer price index, CPI. In the case of calendar year data that has been adjusted to market year, the same adjustment has been made to the CPI.

2. The suffix -L1 refers to a lag of one period.

3. The prefix CHG- refers to the change in a quantity.

4. Beef prices and numbers were generated from an allocation program which attempts to distinguish fed-beef from non-fed beef using published data series. A suitable substitute for PBEEF and HPCAUT can be obtained from data series published by the U.S.D.A. in "Livestock Statistics".[23]

5. "The effective support rate is equal to the loan rate discounted by the factor by which set asides impose upon program participation plus deficiency payments discounted by the national program allocation factor."[24]

6. Export quantities of soybeans, soybean meal and soybean oil are not determined within this model. This study has been a collaboration with another study of export markets for U.S. soybeans and soybean products.[25]

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[23]U.S.D.A. (1976) "Livestock Statistics" Statistical Bulletin (531).

[24]Eric Wailes (1979) "The M.S.U. Agriculture Model - Domestic Policy Component", Michigan State University Department of Agricultural Economics, unpublished monograph.

[25]William Tierney (1979), Michigan State University Department of Agricultural Economics, unpublished research.

The structure of the model is presented below, with the causal relationships being identified as estimated equations and the identities as definitional equations. Mnemonic names identical to those previously identified are used. The endogenous variables in each structural equation are presented first followed by a colon and then all predetermined or exogenous variables follow.

Demand Component

A. Estimated Equations

1. Average price received for soybeans, SOYBPT, OIL-SPREAD, SOYMPT, SOILPT.

2. Quantity of Soybean Meal Consumed in U.S., SOYMQTD, SOYMPT: CORNPT, LPBEEF, HPCAUT.

3. Total Oil Consumption in the U.S., TOTOIL: CONSUMRAT, EDIBLEI, POPT.

4. Quantity of Soybean Oil Consumed in U.S., SOILQTD, DEFSOILPT, OTHEROIL: DEFDPCIT.

5. Soybean Seed Demand in U.S., SBSEDT, APSBT: DFSOYBPLI.

6. Residual and Feed Use of Soybeans; U.S., SBRIST: CORNPT, GMSOYMEAL, HPCAUT.

7. Residual Soybean Stocks in U.S., SBSTKT1, SOYBQTD: SOYBEXP, SBSTKT.

8. Speculative Soybean Stocks in the U.S., SBSTKT1, SOYBPT: SOYBEXPT, INTT, SBSTKT.

9. Residual Soybean Oil Stocks in the U.S., SOILSTKT1, SOILQTD, SOYMQTD: SOILEXT, SOILSTKT.

10. Speculative Soybean Oil Stocks in the U.S., SOILSTKT1, SOILPT, SOYMQTD: INTT, SOILSTKT.

B. Definitional Equations

1. Soybeans Processed in the U.S., CRUSHT=.02(SOYMQTD) +.05(SOILQTD).

2. Soybean Meal Produced in the U.S., SOYMQT=SOYMQTD+ SMEXT.

3. Oil Other Than Soybean Oil Consumed in the U.S., OTHEROIL=TOTOIL-SOILQTD.

4. Soybean Oil Produced in the U.S., SOILQT=SOILQTD+ SOILEXT+CHGSOILSTK.

Supply Component

A. Estimated equations

1. Acres of Soybeans Planted in Northern U.S., APSBTN: DSOYBPL1, DCORNPL1, DWHTPL1, LAPSBTNL1.

2. Acres of Soybeans Planted in Southern U.S., APSBTS: DSOYBPL1, DCOTPL1, DCORNPL1, DPV1SBT, LAPSBTSL1.

3. Average Soybean Yield in Northern U.S., SOYBYTN: TIME, TSQR, DUMWEATHER, DEFSOYBPT.

4. Average Yield; Southern U.S., SOYBYTS: TIME, TSQR, RAINS, DEFSOYBPT.

Assumptions

The structural equations presented above make a certain number of simplifying assumptions. The soybean industry is treated as a competitive industry which implies that certain conditions hold true.

1. Soybeans and soybean products are treated as homogeneous commodities. In reality soybeans vary in grade, and the price received for different grades reflects its relative quality. Soybean meal varies in quality, with some grades having a smaller proportion of fiber to protein than do other grades. Soybean oil is fairly uniform, with only minimum quality requirements. The fact that the prices used for soybeans and soybean meal are average prices helps to adjust for varying qualities, but the quantities reported of both soybeans and soybean oil do not reflect grade differences. The inaccuracy introduced by product heterogeneity could conceivably become the source of unexplained variation.

2. In order to have a competitive market for soybeans and soybean products the number of buyers and sellers must be large enough so that no one individual has the market power to influence price. The large processors which increasingly characterize the soybean industry fail to meet this criterion. Any collusive activity on the part of processors could violate the assumptions underlying the model and introduce more "noise" to the system.

3. It is assumed that the processing of soybeans yields meal and oil in a fixed proportion. This assumption seems reasonable since there has been less than one percent variation of this yield ratio (about 4 to 1) in the past twenty years.

4. The trading of soybeans and their products is assumed

to occur uniformly throughout the marketing year. This is not what actually occurs, so that there may be some inaccuracy in the adjustment of calendar year data to an October 1 marketing year basis when this adjustment is made by weighting each month equally.

5. Soybean meal stocks barely exist, but soybeans store fairly well for up to a year and soybean oil will retain quality for long periods of time. This creates an opportunity for speculative holdings, especially of soybean oil. To test whether or not there is empirical evidence to support the hypothesis that there is significant speculative storage of soybeans and soybean oil, the structural equations for stocks of each commodity have two alternative specifications. One specification is definitional in that it treats soybean oil and soybean stocks as the residual of the difference between supply and demand. The alternative specification has these stocks as a function of prices, both foreign and domestic. The F-statistics will then be tested for significance, and compared to one another to determine whether a specification which treats stocks as speculative is preferable to a residual treatment of stocks.

Model Rationale

Production of soybeans in the United States involves both decisions on the part of the farm manager and influences beyond his control, such as weather and improved technology. In order to reflect this, the production of soybeans is estimated in a two-step manner with the acres planted by farmers as a function of economic criteria and the yield realized on this acreage as a function of weather and trend (trend variables represent various technological improvements). The real price of soybeans at harvest is the economic criteria that is used by the farm manager to decide how much of his acreage is worthy of harvest. This decision will in turn influence the average yield realized. On this basis, the deflated price of soybeans is included in the soybean yield equations. Acres harvested of soybeans is treated as a constant function of acres of soybeans planted. An alternative specification would be to estimate acres harvested of soybeans as a function of deflated soybean price and acres planted.

The production of soybeans is regionalized into the Northern and Southern regions on the basis of similar crop alternatives and weather within each region. The deflated prices of the major crop alternatives and the soybean policy variable are included in the acres planted equations for each of the two regions. A weather variable is included in the yield equation for the Northern U.S., whereas observed average rainfall is used in the Southern U.S. for the lack of an appropriate weather variable to account for climatic influences. Once acres planted are estimated for each region, acres harvested are defined. Acres harvested are then multiplied by the yield estimates to provide an estimate of soybean production for each region.

The demand component of the model estimates the domestic demand for soybean oil and soybean meal and then defines the quantity of soybeans demanded for processing from the quantities of each of these two joint products that is demanded. The price received by farmers for soybeans is treated as a function of the price of soybean meal, soybean oil and of the farm-retail price spread for soybean oil (intended as a measure of the average marketing margin realized by processors). The quantity of total demand for soybeans can be defined from the internal estimates of production, soybeans processed, seed, feed and residual utilization, stocks and estimates of soybean exports obtained from an export market study.[26] In a like manner total quantities of soybean oil and meal demanded can be defined from export, stocks and production data.

At the heart of this demand component are the demand equations for soybean meal and soybean oil. Soybean oil accounted for 43 percent of total fats and oils consumption in 1977. Other fats and oils are very competitive with soybean oil and are good substitutes in most cases. The market share of the total demand for fats and oils that soybean oil will realize in any given year is expressed as a function of the market share of competing oils, deflated income and deflated soybean oil price. Total oil demand is also estimated; based upon trends in consumption (CONSUMRAT), an index of price levels for all edible oils (EDIBLEI) and population (POPT). When the system of demand equations is simultaneously

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[26] Such as: William Tierney (1979) op. cit.

solved the relative market shares of soybean oil and competing oils are estimated, with the competing oils' market share being defined as the difference between total and soybean oil quantities demanded.

The position of soybean meal in the domestic market is much more dominant than that of soybean oil in the fats and oils market. Soybean meal accounts for about 90 percent of current oilseed meal consumption in the U.S. Most of the supplies of competitive high protein feeds are constrained, as was discussed above. It seems appropriate to estimate soybean meal consumption directly since it is, in essence, the total oilseed meal market. The major feed substitute for soybean meal is corn, the dominant feedgrain. Typical adjustments in feeding rations involve a substitution of corn for soybean meal or visa-versa, at least within their range of substitutibility. The price of corn is included along with the price of soybean meal to reflect this product substitutibility. The quantity of soybean meal fed will also vary directly with the population of animals on feed. Since this population is heterogeneous, each group is adjusted with constants reflecting different rates of soybean meal utilization for each livestock category. The adjusted populations for each category are then summed to yield a measure of the total population of high-protein consuming animal units.

A change in the price received for the finished livestock product will influence the amount of soybean meal that will be fed. Yet how this adjustment is made is an important consideration. In short-cycle production processes (e.g. pork, poultry) the number of animals will be changed in response to the change in product price. An adjustment of this sort would be reflected as a change in the high-protein consuming animal units number. In longer production cycles, liquidation is not as feasible of an alternative, so changes in feeding rations will occur. For this reason, the price of beef was included as an explanatory variable in the soybean meal demand equation. The price of beef was entered into the soybean meal demand equation as a natural log function in order to reflect a growing inflexibility in feeding rate adjustments to price. This price inelasticity has been observed to be growing over the estimation period, possibly because of the increased use of pre-mixed and custom-mixed feeds in beef production.[27]

The stocks of soybeans and soybean oil are specified in two alternative forms in order to test the hypothesis that demand for stocks may be speculative rather than residual in nature. If the results indicate that the demand for either soybeans or soybean oil is not speculative, that quantity will be treated as a residual in the final model.

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[27]T.A. Hieronymus (1961) op. cit.

CHAPTER V

RESULTS OF ESTIMATION

The estimated equations are presented below, with the parameter estimates preceeding each mnenomic variable name. The t-statistic estimates are not reported here, but may be calculated from the standard error estimates which appear below each variable name in parenthesis. The corrected coefficient of determination ($\bar{R}^2$) appears below each equation. Also the Durbin-Watson statistic (d) associated with each equation appears as a test for serial correlation. The Durbin-Watson statistic (d) is not reported in those equations where a geometrically-lagged dependent variable is specified. Instead, Durbin's h statistic is used to test for autocorrelation. This statistic (h) is distributed in a standard normal distribution.

<u>Supply Equations</u>

1. <u>Acres Planted: Soybeans, northern U.S</u>.

```
APSBTN= -206437. + 7690.25 DSOYBPLI -12229.4
        (22390.5) (1044.73)          (3672.6)
        DCORNPLI - 1470.90 DWHTPL1 + 22750.2
                   (1640.3)          (2329.7)
        LAPSBTNL1
```

$\bar{R}^2$=.96 Durbin's h statistic = -.00006

2. Acres Planted: Soybeans, southern U.S.

APSBTS= -72838.5 + 1378.40 DSOYBPL1 -33.87

(12651.3) (600.36) (39.34)

DCOTPL1 - 1119.11 DCORNPL1 + 1092.81

(1285.76) (856.39)

DPVISBT + 8666.23 LAPSBTSL1

(1217.31)

$\bar{R}^2$=.94 Durbin's h statistic =.000005

3. Soybean Yield, southern U.S.

SOYBYTS= -57.79 + 2.33 TIME - .016TSQR

(35.72) (1.09) (.008)

+.144 RAINS - 1.42 DEFSOYBPT

(.05) (.69)

$\bar{R}^2$=.61 d=1.33

4. Soybean Yield, northern U.S.

SOYBYTN= 136.63 - 3.67 TIME + .032 TSQR

(58.43) (1.77) (.014)

-2.11 DUMWEATHER - 2.31 DEFSOYBPT

(1.15) (.59)

$\bar{R}^2$=.83 d=2.22

Demand Equations:

1. Soybean Meal, Quantity Demanded

SOYMQTD= -27108.30 - 344.52 SOYMPT

(2525.89) (117.80)

+474.22CORNPT + 4664.00 LPBEEF + .355HPCAUT

(331.05) (1363.94) (.045)

$\bar{R}^2$=.94 d=1.82

2. Total Oil, Quantity Demanded

TOTOIL=2515.37 + 1864.01 CONSUMRAT - 11.03 EDIBLEI

(8666.43) (1416.47) (4.92)

+86.08 POPT

(49.63)

$\bar{R}^2$=.87 d=1.63

3. Soybean Oil, Quantity Demanded

SOILQTD = -151.91 + 4.04 DEFDPCIT

(1657.66) (.298)

-45.77 DEFSOILPT - .53 OTHEROIL

(19.78) (.12)

$\bar{R}^2$=.96 d=1.70

4. Soybean Price, Received by Farmers

SOYBPT= -.92 + .05 OILSPREAD + .13 SOYMPT

(.38 (.014) (.06)

+.14 SOILPT

(.016)

$\bar{R}^2$=.96 d=2.84

5. Soybeans Used for Seed

SBSEDT=7.62 + .0011 APSBT-2.66 DSOYBPT

(2.82) (.00007) (2.36)

$\bar{R}^2$=.92 d=2.44

6. Soybeans Fed and Residual Usage

SBRIST=52.49 + 6.99 CORNPT -.28

(23.12) (4.88) (.37)

GMSOYMEAL + .0007 HPCAUT

(.0003)

$\bar{R}^2=.38$ d=1.79

7. A) Soybean Ending Stocks, Speculative Demand

SBSTKT1=13.66 - 245.77 SOYBPT + 214.67 SOYBEXPT

(71.89) (213.71) (189.97)

+214.67 INTT + .25 SBSTKT

(146.03) (.27)

$\bar{R}^2=.40$ F(4,10)=2.00 Durbin's h statistic=.03

7. B) Soybeans Ending Stocks, Residual Formulation

SBSTKT1= -.261.54 + .0008 SOYBQTD

(33.27) (.00007)

--1.54 SOYBEXP + .78 SBSTKT

(.15) (.08)

$\bar{R}^2=.93$ F(3,11)=59.91 Durbin's h statistic =.61

8. A) Soybean Oil Ending Stocks, Speculative Demand

SOILSTKT1= -.364.58 - 2.20 SOILPT - 11.67 INTT

(337.58) (9.57) (38.91)

+.087 SOYMQTD + .045 SOILSTKT

(.028) (.24)

$\bar{R}^2=.40$ F(4,10)=3.36 Durbin's h statistic =0.44

8. B) Soybean Oil Ending Stocks, Residual Formulation

SOILSTKT1 = -914.40 - .34 SOILQTD -.45 SOILEXT

(315.31) (.14) (.16)

+.32 SOYMQTD + .46 SOILSTKT

(.09) (.21)

$\bar{R}^2=.67$ F(4,10)=8.19 Durbin's h statistic =1.7

THE RESULTS IN GENERAL

The results are generally satisfactory with the expected coefficient signs and acceptable levels of significance for most parameter estimates. Most of the estimated equations explain an acceptable level of the variation in the observed dependent variable.

The Results: Supply Component

Acres Planted: Soybeans, northern U.S.

In light of the results of estimation, the parameter estimates for this equation seem reasonable. The own-price elasticity estimate for soybeans is in line with the results of other studies (see Table 1).[28,29] Cross-price elasticity estimates for corn and wheat are also reasonable and correspond to those cited in Table 1 . There is a high level of variation associated with the parameter estimate for the price of wheat. Wheat (especially soft-red wheat) is of some importance as a crop alternative in the Corn Belt states, but it is even more important in the Lakes States, where 10 percent of national soybean production typically occurs. While the effect of wheat price is not a powerful one, it is reasonable in magnitude. It's inclusion in this equation is desirable, despite the low level of significance associated with wheat price's parameter estimate.

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[28] James P. Houck, Mary E. Ryan, Abraham Subotnik (1972) op. cit.

[29] David E. Kenyon, R.S. Evans (1975) op. cit.

Durbin's h statistic[30] is not significant at the 95 percent confidence level; the test for serial correlation is insignificant.

Acres Planted: Soybeans, southern U.S.

All of the parameter estimates vary with the dependent variable in a manner which corresponds to the expectations one would develop from economic theory. The variation of the parameter estimates associated with corn and cotton price are both rather high. When compared to the cross-price elasticity estimates generated in other studies (see Table 1 p.47, the cross-price elasticity estimate for cotton price derived in this estimation is low. Durbin's h statistic is again insignificant at the 95 percent confidence level; the test for serial correlation is insignificant. The fitted and actual values for soybean acres planted are presented in Figure 3a.

Soybean Yield Equations

At first glance these estimated equations may seem disappointing. The soybean yield equation for the northern U.S. may overestimate yields in the future, as the positive influence of the square of time overshadows the negative effect of time variable. The estimated yields for the southern region should exhibit more stability as the signs on time and

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[30] Samuel B. Richmond (1964) Statistical Analysis, Ronald Press Company, New York.

Table 1. - - A Comparison of Estimated Supply Elasticities.

Region/Study	Effective Price Short-Run				Effective Price Long-Run			
	Own-Price	Cross-Price			Own-Price	Cross-Price		
	Soybeans	Corn	Cotton	Wheat	Soybeans	Corn	Cotton	Wheat
NORTH								
Christensen (1979)	.70	-.47	—	-.08	6.26	-4.68	—	-5.02
Houck, Ryan, Subotnik (1972)	.68	-.57	—	—	—	—	—	—
Kenyon, Evans (1975)	.71	-.51	—	—	5.47	-3.63	—	—
SOUTH								
Christensen (1979)	.39	-.13	-.09	—	2.63	-2.01	-1.71	—
Houck, Ryan, Subotnik (1972)	.96	—	—	—	—	—	—	—
Kenyon, Evans (1975)	.30	—	-.38	—	4.00	—	-5.05	—

FIGURE 3a.--Acres of Soybeans Planted - Southern U.S. 1965 - 1977

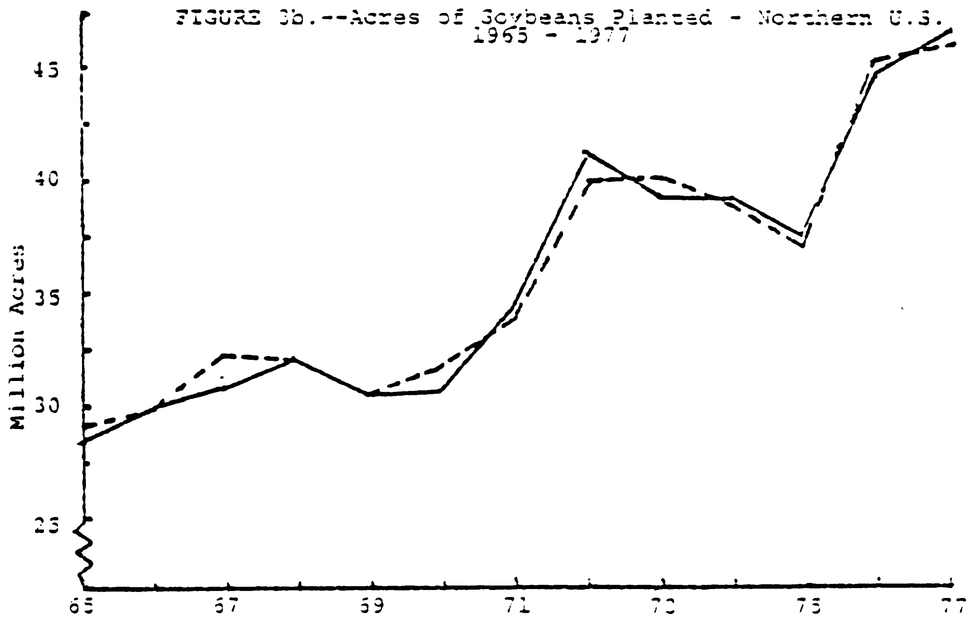

FIGURE 3b.--Acres of Soybeans Planted - Northern U.S. 1965 - 1977

time-squared variables are reversed. The weather variable (DUMWEATHER) performs well. The tracking record in the southern U.S. region is very poor, even in light of the great variability of soybean yields in this region. In contrast, the estimate of average soybean yield for the northern U.S. tracks well, correctly following eleven out of nineteen turns. In the last five years the estimates of soybean yields in the northern U.S. were estimated within 10 percent of their actual value, with every turn being caught correctly.

The Results: Demand Component

Soybean Meal: Quantity Demanded

The results of estimation are satisfactory for this equation. While the coefficient associated with the price of corn is not significant at the 95 percent confidence level, all of the estimates behave in accordance with economic theory. The Durbin-Watson test for serial-correlation is insignificant at the 95 percent confidence level. The equation tracks well, missing only two out of fourteen turns (see Figure 4a.). The residual terms are stable, except in the marketing years of 1971 and 1975, when the residual term is larger than one standard error .

Total Oil: Quantity Demanded

While all of the estimated coefficients have the signs indicated by economic theory, the parameter estimate for the consumer taste variable (CONSUMRAT) is not significant

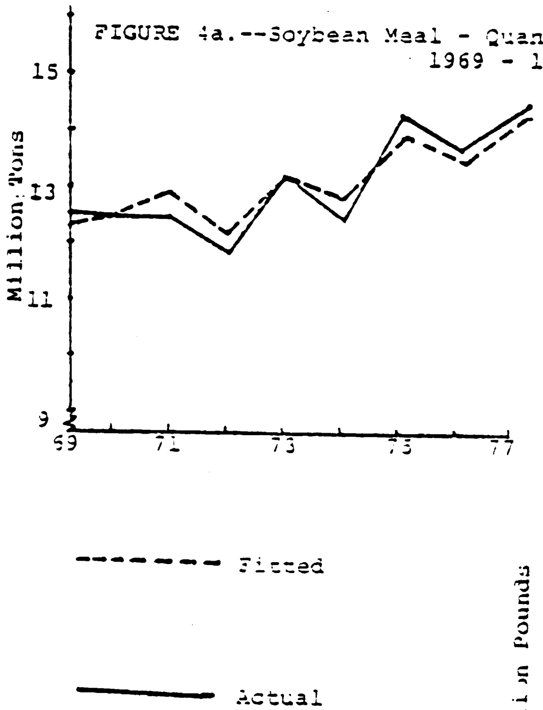

FIGURE 4a.--Soybean Meal - Quantity Demanded 1969 - 1977

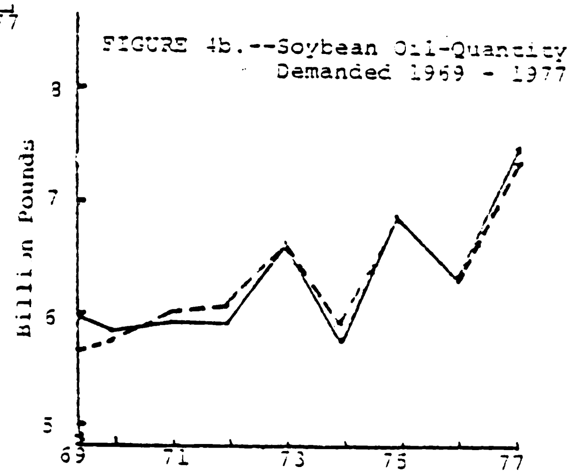

FIGURE 4b.--Soybean Oil-Quantity Demanded 1969 - 1977

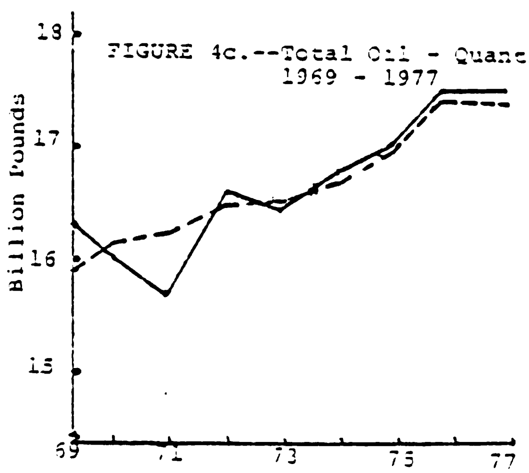

FIGURE 4c.--Total Oil - Quantity Demanded 1969 - 1977

at the 95 percent confidence level. The Durbin-Watson test for autocorrelation is inconclusive at this same confidence level. The estimate of the dependent variable tracks poorly in the first third of the observation period, missing the first five turns. Thereafter, all ten of the next turns are correctly caught. The residual terms become successively smaller over the final two-thirds of the sample period (see Figure 4c.).

Soybean Oil: Quantity Demanded

This equation is satisfactory. It has the expected signs, a high level of confidence associated with each parameter estimate, and a good fit with the dependent variable's observations (see Figure 4b). Only two out of fifteen turns are missed, both early in the sample period. The residual terms are stable over the entire sample period beyond the forth observation. The Durbin-Watson test for autocorrelation is inconclusive.

Soybean Price Recieved By Farmers

This equation is nearly definitional, which explains many of it's desirable characteristics. The Durbin-Watson test for autocorrelation was significant at the 95 percent confidence level.

Soybeans: Ending Stocks

Two alternative specifications were considered: one based upon the assumption of speculative demand and one which treats soybean stocks as a residual. The F-statistic for the speculative stocks specification was not significant at the 95 percent confidence level; the residual specification was. Stocks are treated as a residual in the final specification. Durbin's h statistic is significant at the 95 percent confidence level; the test for serial correlation is significant in the soybean ending stock residual formulation.

Soybean Oil: Ending Stocks

Two formulations were tested for significance here, one for a speculative demand assumption and one for a residual stocks assumption. The F-statistic associated with the speculative demand specification was insignificant, while the residual stock specification's F-statistic was significant at the 95 percent confidence level. Soybean oil stocks are treated as a residual in the final specification. It is interesting to note that the quantity of soybean meal demanded is statistically significant in both specifications. This reinforces the assumption that high levels of soybean meal demand, relative to soybean oil demand, may result in a buildup of soybean oil stocks. Durbin's h-statistic is significant in both specifications; the test for serial-correlation is significant.

Soybeans Used for Seed

Parameter estimates for both total acres of soybeans planted in the U.S. and for the deflated price of soybeans are in accordance with the expectations of economic theory. A large part of the variation of the dependent variable is accounted for.

Table 2. - - A Comparison of Short-Run Demand Elasticities for Soybean Oil and Soybean Meal.

Price/Equation-Study	Soybean Meal Price	Corn Price	Beef Price	Deflated Soybean Oil Price	Deflated Disposable Per Capita Income
Soybean Meal Demand					
Christensen (1979)	- 0.18	0.06	0.46	-	-
Hieronymus (1961)	- 0.74	-	-	-	-
Houck, Ryan, Subotnik (1972)	- 0.18	-	-	-	-
Paulino (1966)	- 0.76	-	-	-	-
Soybean Oil Demand					
Christensen (1979)	-	-	-	- 0.11	2.14
Hieronymus (1961)	-	-	-	-	-
Houck, Ryan, Subotnik (1972)	-	-	-	- 0.28	-
Paulino (1966)	-	-	-	- 1.30	-

Soybeans: Residual Usage

This specification is notably weak, with only a third of the variation of the dependent variable around it's mean being explained. Luckily, residual usage of soybeans has never accounted for more than 2 percent of soybean production historically.

Analysis Of Forcasting Ability

As a prelude to the actual forecast, an examination of statistics which measure the ability of an equation to track observed data is made. A final test of the forecasting ability of the entire system of equations will be made with data from 1978, a year beyond the estimation sample period. Evaluation of the accuracy of the fitted values, in both the sample period and in 1978, will provide additional criteria for evaluation.

Theil Coefficients

Theil coefficients are a means of residual analysis which tests the ability of an equation or system of equations to fit the actual data. There are four Theil coefficients which measure predictive ability (see Table 3).

The first Theil coefficient, U1, compares the actual and fitted values. It is standardized to fall with the range of 0 and 1, where 0 corresponds to a perfect forecast.

The second Theil coefficient compares the estimated value to the value observed in the previous period. This serves to

TABLE 3.--Analysis of the Forecasting Ability of the Model.

Equation	Theil Coefficients				Mean-Square Error Decomposition					
	U1	U2	U3	U4	U1M	U1R	U1D	U3M	U3R	U3D
Soybean Meal Demand	.026	.463	.369	.636	.00008	.00007	.9998	.003	.003	.994
Soybean Oil Demand	.021	.283	.200	.381	.00000	.00000	1.000	.004	.002	.994
Total Oil Demand	.010	.544	.439	.716	.00000	.00000	1.000	.010	.010	.986
Acres Planted Soybeans-North	.018	.363	.291	.577	.00000	.00000	1.000	.001	.086	.913
Acres Planted Soybeans-South	.027	.629	.478	.912	.00000	.00000	1.000	.001	.276	.723
Soybean Yield-North	.022	.476	.459	.725	.00000	.00000	.999	.001	.026	.973
Soybean Yield-South	.032	.640	.436	.753	.00000	.00000	1.000	.010	.011	.978

give a point of reference, where the model under scrutiny is compared to a naive model: one which assumes that this year's value is identical to last year's value. When the average of the residual terms of the tested and naive model are identical, the value of U2 will be 1. If the tested model performs well, then the value of U2 will be less than one, whereas if the tested model performs very poorly, (i.e. worse than the naive model), then value of U2 will be greater than one.

The third Theil coefficient, U3, compares the observed change to the fitted change of a value. U3 is standardized to fall within 0 and 1, where a perfect forecast would have a value of 0.

The fourth Theil coefficient compares the fitted changes to the change observed in the previous period. The value of U4 that indicates an equality between the tested and naive models varies between samples.

Decomposition of Mean-Square Error

Mean-square error (MSE) is decomposed in one of two ways: bias, variance and covariance components or bias, regression and disturbance components. The bias component of MSE, hereafter denoted Um, measures the deviation between the actual and fitted average changes in value. If Um is large[31], the fitted values do little to explain this deviation. On the basis of past evaluation, there is little information to be

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[31](Um+US+Uc = Um+Ur+Ud= 1).

gained from the examination of the variance and covariance proportions of the mean-square error term (denoted Us and Uc respectively).[32] In the same analysis, it was demonstrated that the regression proportion (Ur) is consistent: in a perfect forecast both Um and Ur will tend towards zero.

Results of Estimation: Forecast Ability

The results of estimation in terms of Theil coefficients and mean-square error decomposition are presented in Table 3. In general, the Theil coefficients indicate there has been a substantial improvement over the naive model in all three demand equations, with a good fit to actual values. Changes in the actual data are not explained as well, as both U3 and U4 are higher than U1 and U2 in all the demand equations. The Theil coefficients of the supply equations show less difference from a naive model than do the demand equations. With a lagged dependent variable in the acreage planted equations, and trend in the yield equations, this is no great surprise.

The changes in actual data are not explained well in either of the yield or acreage planted, Southern U.S., equations. This may be the result of the use of trend and geometrically lagged endogenous variables to estimate relationships over a long period of growth in observed values.

The decomposition of mean square proportions attributes very little of the error to bias of the regression in any of

[32]C.W.J. Granger and P. Newbod (1973) "Some Comments on the Evaluation of Economic Forecasts" Applied Economics (p.35-47).

the demand equations. Such is not the case in the supply equations, where the proportions of the mean-square error attributed to bias or regression error are substantial.

The most important indication of the analysis of Theil coefficients and the decompostion of mean-square error proportions is an inflexibility and significant degree of error associated with the four supply functions. While the demand equations explain a good deal of the change in the quantities of soybean meal and oil demanded, the soybean acreage planted for the southern U.S. seems to be more rigid. Since this supply equation was estimated ovdr a long sample period, and since this was a period of acreage expansion and average yield increase, one might expect this rigidity to be in a downward direction.

Results Of Simultaneous Solution

The entire soybean model was solved via the Gauss-Seidel simultaneous solution technique. The Gauss-Seidel simultaneous solution technique solves a system by first calculating a value for each endogenous variable from actual values for the right-hand side endogenous variables and the exogenous variables. In each of the following iterations a value is calculated for each right-hand side endogenous variable which equals seventy-five percent of the value that was calculated for each right-hand side endogenous variable in the previous iteration plus twenty-five percent of the value calculated for each right-hand side endogenous variable during the current iteration. This process is continued until the change in the estimate for each endogenous variable is less than one percent in the final iteration.

Where Y1n= b0+b1X1+b2Y2n

X1= exogenous variable 1

Y1n= endogenous variable 1, nth iteration

Y2n= endogenous variable 2, nth iteration

Y1,1= b0+b1X1+b2Y2

Y1,2= b0+b1X1+b2((.75*Y2,1)+(.25*Y2,2))

$$\vdots \qquad\qquad\qquad \vdots$$

Y1n= b0+b1X1+b2((.75*Y2,n-1)+(.25*Y2,n))

This solution provides information which will be used to analyze the capability of the entire model to predict future market conditions. The most important criteria in this assessment is the accuracy of the model estimates when the model is in simulation mode (i.e. internal estimates are used to generate the final set of estimated values). The stability of the model can be tested by comparing the results of simulation mode solution to the actual data. A further test of the model is made when forecasts of known values are made, but these values were not included in the sample period over which each equation was estimated. This occurs in the year 1978.

Underlying Assumptions of the Forecast

To understand the forecast made in this solution, the assumptions about the exogenous variables must be known. These assumptions are:

1. The level of soybean oil exports will rise at same rate as the 1974-1978 average of 4 percent annually.

2. The trends of consumer preference, reflected in the ratio of margarine to butter and lard consumption variable: CONSUMRAT, will continue to increase at the 1974 to 1978 average annual rate of 4 percent annually.

3. Soybean oil stocks are set at the 1974-1978 average rate of 4 percent increase.

4. The consumer price index is assumed to increase to 194.8 in 1978, 208.3 in 1979, 220.9 in 1980, 232.4 in 1981, and 245.9 in 1982.[33]

5. Disposable Personal Income is set at 1452.9 in 1978, 1598.5 in 1979, 1740.0 in 1980, 1884.2 in 1981, and 2048.8 in 1982.[34]

6. Soybean exports are assumed to expand at the 1974-78 average rate of 7 percent annually.

7. Rainfall in the southern United States will be the same as during 1977 and 1978 (four inches above average).

8. The level of resident U.S. population will be 219 millions in 1978, 220 millions in 1979, 222 millions in 1980,

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[33]Michael K. Evans (1978) Long-Term Macroeconomic Forecasts, Chase Econometric Associates, Inc.

[34]Ibid.

224 millions in 1981 and 226 millions in 1982.[35]

Exogenous Forecasts from the National Model

All other exogenous data is provided by the M.S.U. Agricultural Model solved in a simulation mode. These estimates are summarized below:

High Protein	1978	1979	1980	1981	1982
Consuming Animal Units (HPCAUT)	98,765	100,330	104,156	106,240	106,175
Beef Price - dollars per cwt. (LPBEEF)	40.0	43.5	38.5	37.6	41.5
Policy Variable for Soybeans - dollars per bushel (PVISBT)	2.50	2.25	2.25	2.25	2.25
Cotton Price - cents per pound (COTPT)	60.1	51.1	58.8	50.0	57.5
Corn Price - dollars per bushel (CORNPT)	3.21	2.73	2.80	2.88	3.21

The Forecast

The results of the simultaneous solution of the entire

[35]Bureau of the Census (1976) Statistical Abstract of the United States, Washington D.C.: Government Printing Office.

system of equations are presented graphically in the Figures 5 through 12, inclusive. It is important to note that while no actual values are reported for the years from 1978 to 1982, the actual value for 1978 is plotted on the graph in each figure and reported above each table in each of the figures.

Conditional Forecasts

Additional forecasts are presented in Appendices B, C, D, E, pages 78 through 109 inclusive.

In Appendix B, all of the original underlying assumptions are maintained while the national average soybean yield is reduced by 12 percent for the entire period (1972 to 1982).

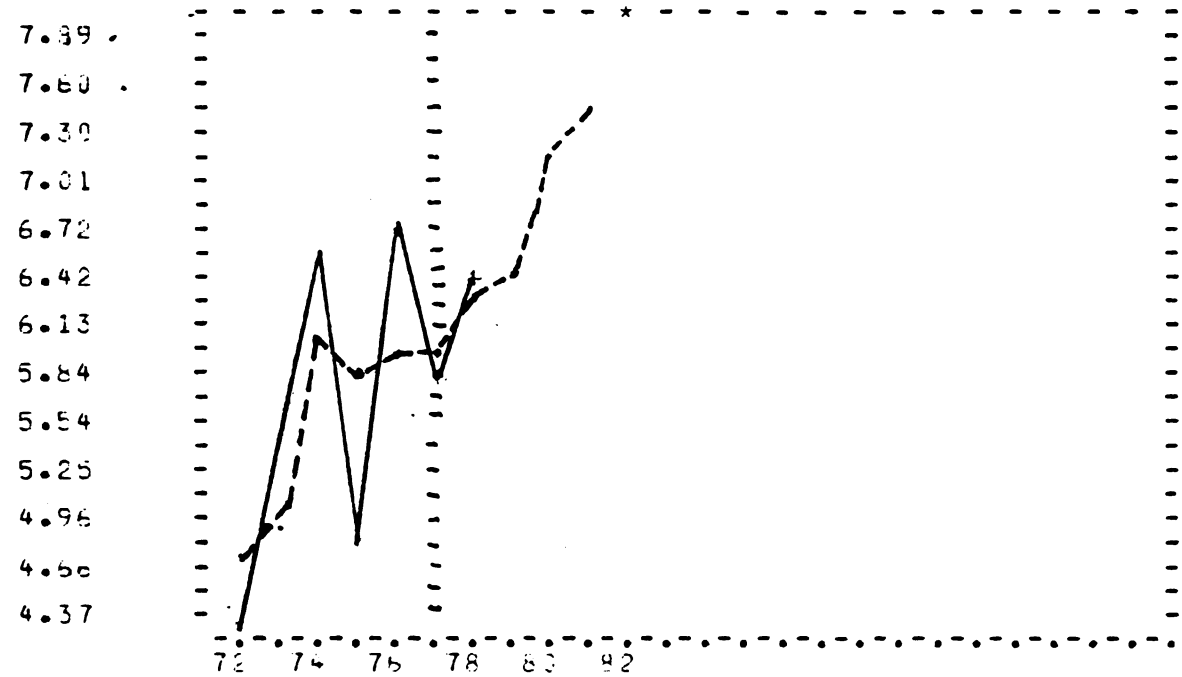
In Appendix C, the national average soybean yield is increased by 12 percent, while all other exogenous factors are held at the levels assumed in the original forecast.

In Appendix D, soybean meal exports and soybean exports are increased by 10 percent annually, while soybean oil exports are increased by 5 percent annually. All other exogenous factors are held at the levels assumed in the original forecast.

In Appendix E, soybean meal exports and soybean exports are reduced by 10 percent annually, while soybean oil exports are reduced by 5 percent annually. All other exogenous factors are held at the original forecast levels.

FIGURE 5.--Soybean Price, Dollars Per Bushel, 1978
Actual = 6.50

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

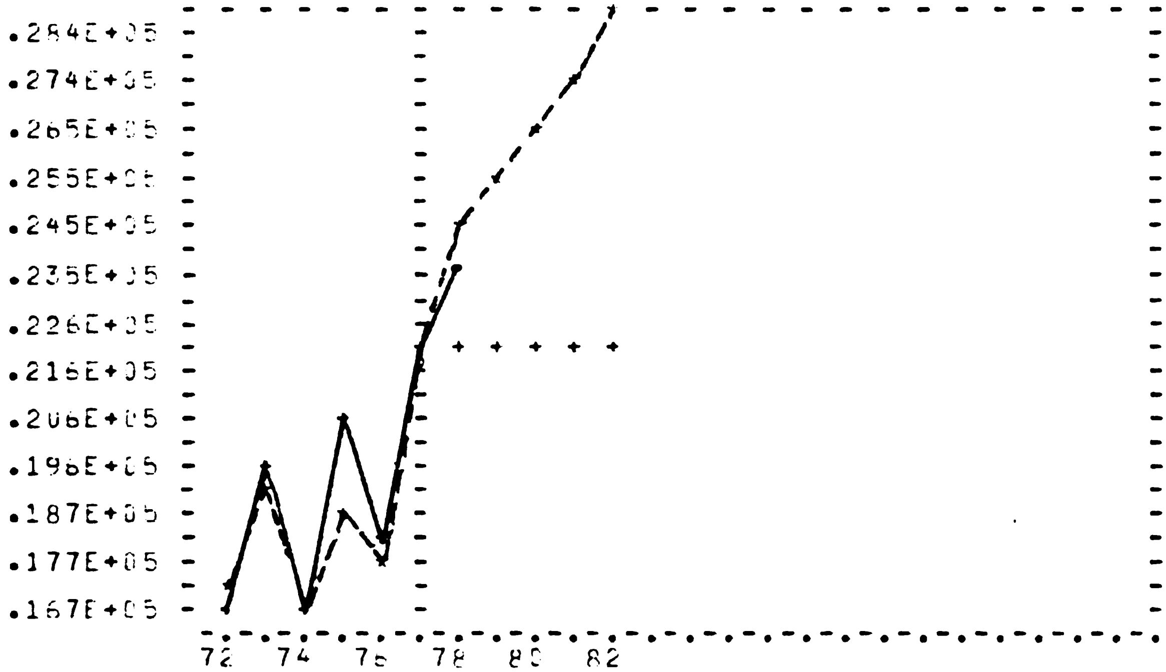


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 1-SOYBPT

YEAR	LEVELS (+)	(*)
1972	4.370	4.720
1973	5.680	5.000
1974	6.640	6.123
1975	4.920	5.956
1976	6.610	6.066
1977	5.880	6.014
FORECAST		
1978	5.880	6.279
1979	5.880	6.491
1980	5.880	7.219
1981	5.880	7.529
1982	5.880	8.036

FIGURE 6.--Soybean Meal Production, 1000 Tons, 1978 Actual = 23,754.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.

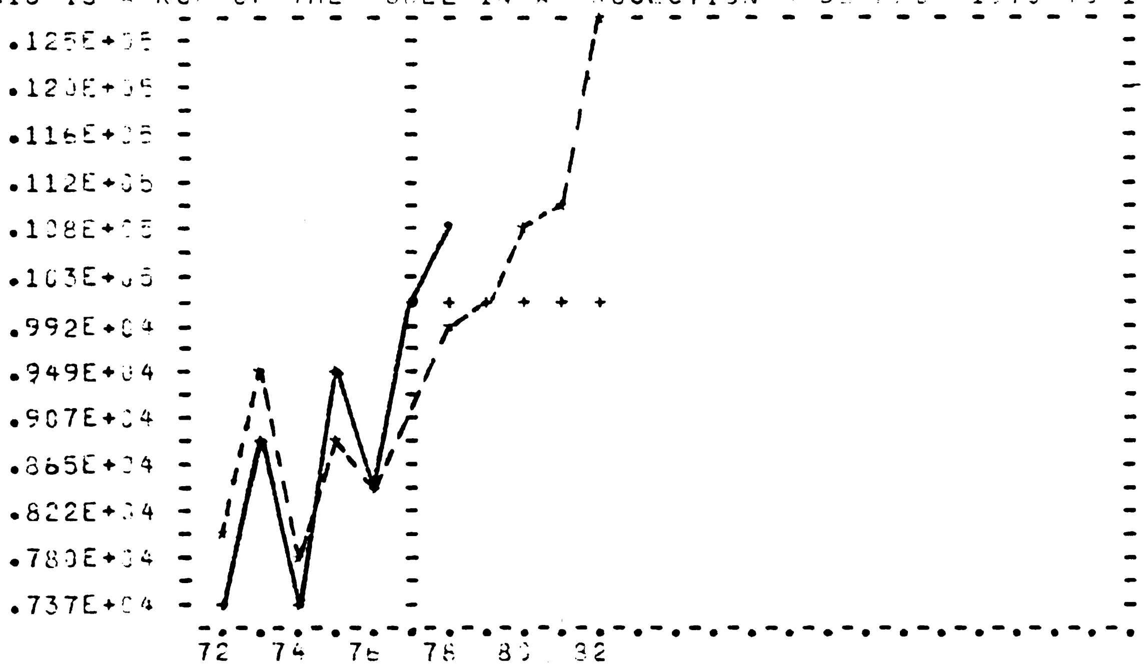


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 2-SOYMGT

YEAR	LEVELS (+)	(*)
1972	16708.000	17261.076
1973	19674.000	19333.109
1974	16702.000	16954.440
1975	20754.000	16844.843
1976	18488.000	18001.812
1977	22371.000	22228.849
FORECAST		
1978	22371.000	24802.637
1979	22371.000	25545.203
1980	22371.000	26656.863
1981	22371.000	27871.502
1982	22371.000	28903.818

FIGURE 7.--Soybean Oil Production, Million Pounds,
1978 Actual = 10,800.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.

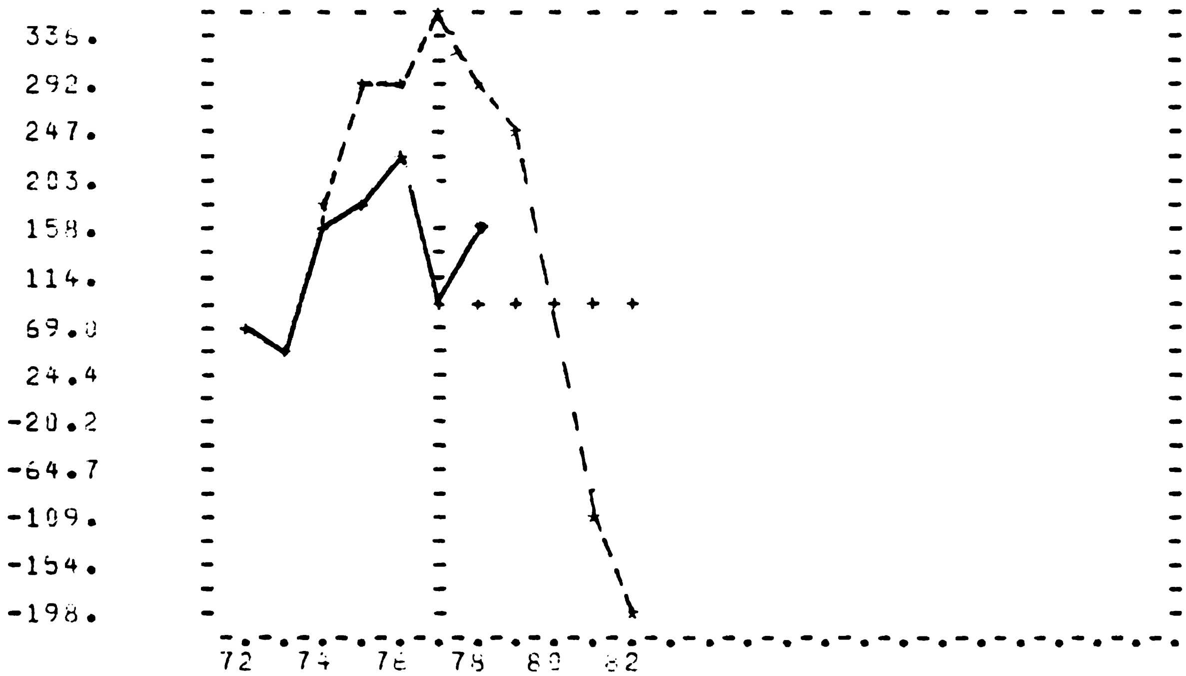


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 4-SOILGT

YEAR	LEVELS (+)	(*)
1972	7501.000	8068.015
1973	8995.000	9603.463
1974	7375.000	7969.280
1975	9630.000	9056.816
1976	8578.000	8585.768
1977	10288.000	10276.016
FORECAST		
1978	10288.000	10076.233
1979	10288.000	10275.589
1980	10288.000	10819.983
1981	10288.000	11152.784
1982	10288.000	12672.073

FIGURE 8.--Beginning Soybean Stocks, Million Bushels, 1978 Actual = 161, 1979 Actual = 150.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

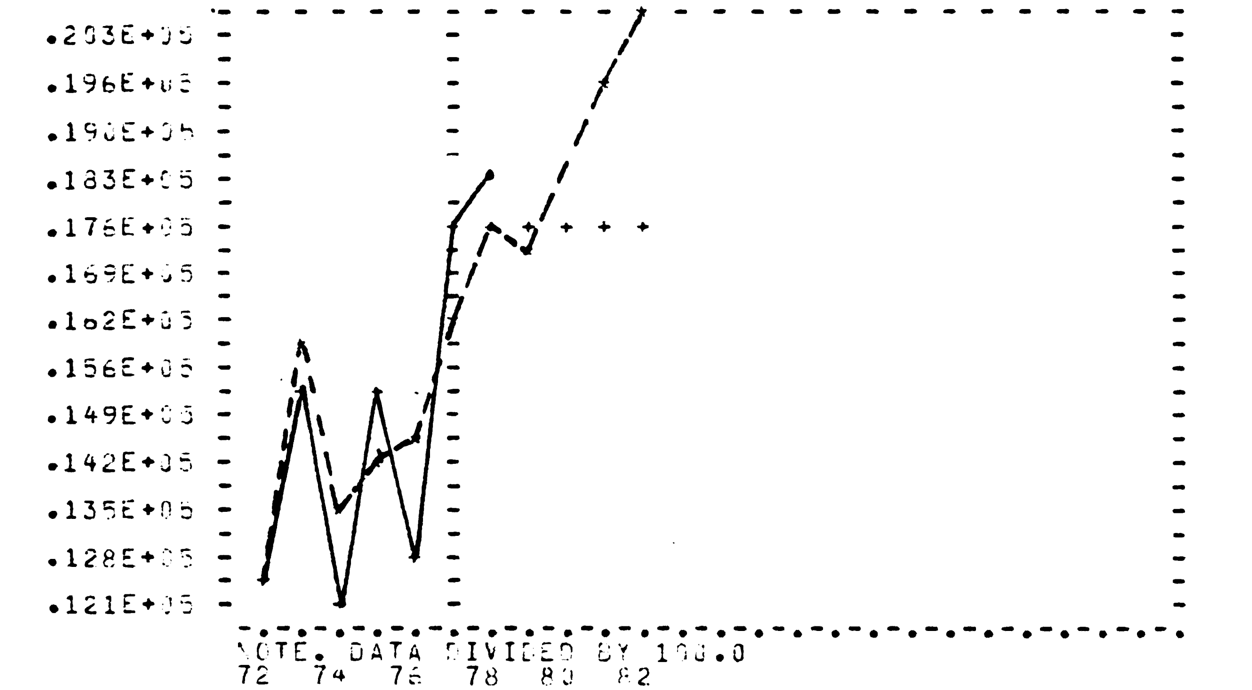


ACTUAL (+) AND ESTIMATED (*) VALUES FOR E-SBSTKT

YEAR	LEVELS (+)	(*)
1972	71.960	71.874
1973	59.640	58.276
1974	170.880	184.094
1975	185.340	313.031
1976	244.600	295.593
1977	103.000	358.703
FORECAST		
1978	103.000	300.578
1979	103.000	261.818
1980	103.000	99.929
1981	103.000	-99.798
1982	103.000	-198.441

FIGURE 9.--Soybean Production, 1000 Bushels, 1978 Actual = 1,842,647

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

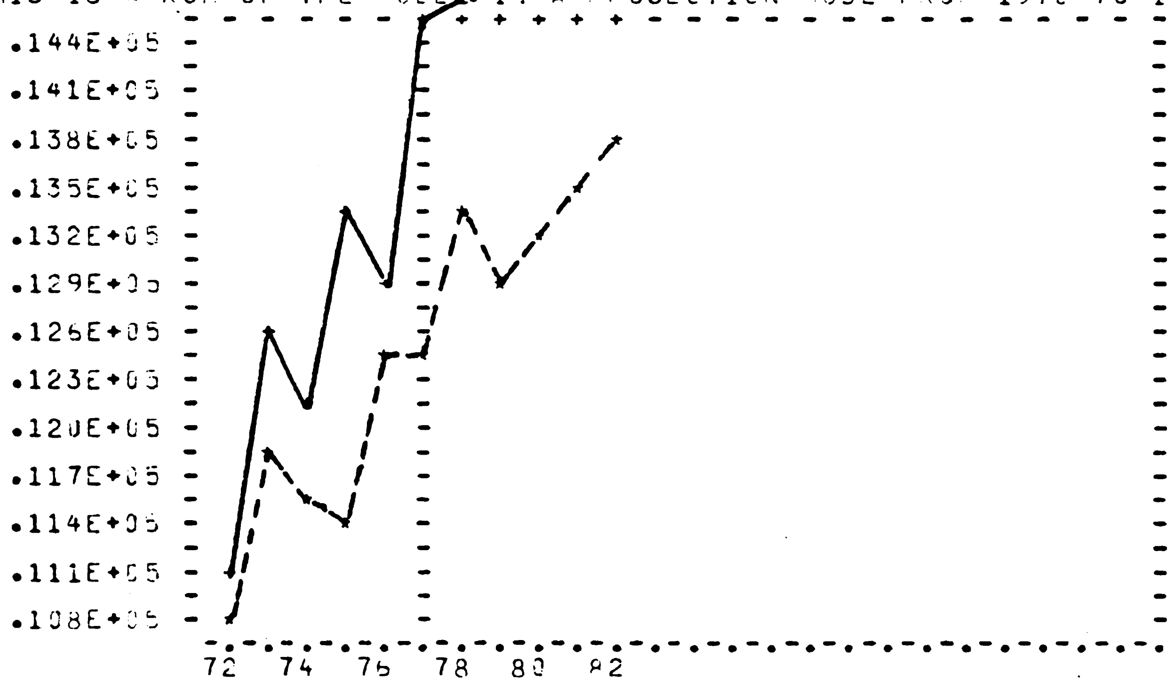


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 7-SOYPGT

YEAR	LEVELS (+)	(*)
1972	12706.300	12828.731
1973	15471.650	15914.472
1974	12148.020	13590.536
1975	15461.200	14254.637
1976	12875.600	14847.276
1977	17617.550	16514.403
FORECAST		
1978	17617.550	17689.253
1979	17617.550	17261.816
1980	17617.550	17930.923
1981	17617.550	19968.718
1982	17617.550	20557.674

FIGURE 10.-Acres of Soybeans Harvested - Southern U.S., 1000 Acres,1978 Actual = 15,560.

THIS IS A RUN OF THE MODEL. IN A PROJECTION MODE-FROM 1970 TO 1982.

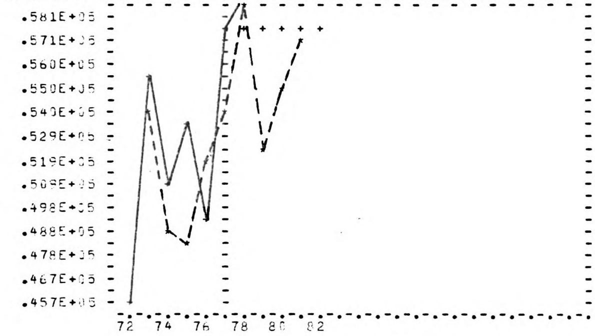


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 11-AHSBTS

YEAR	LEVELS (+)	(*)
1972	11190.000	10792.731
1973	12736.000	11935.616
1974	12198.000	11606.715
1975	13483.000	11534.381
1976	12982.000	12483.553
1977	14593.000	12592.884
FORECAST		
1978	14593.000	13507.952
1979	14593.000	12947.841
1980	14593.000	13339.993
1981	14593.000	13613.525
1982	14593.000	13948.120

FIGURE 11.--Acres of Soybeans Harvested - U.S., 1000 Acres, 1978 Actual = 63,033.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

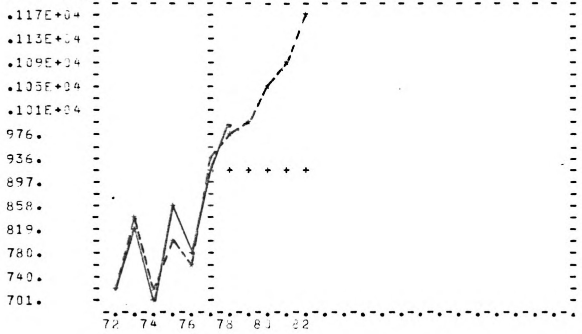


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 12-AHSBT

YEAR	LEVELS (+)	(*)
1972	45683.000	46057.682
1973	55667.000	54242.719
1974	51341.000	48928.583
1975	53579.000	48524.075
1976	49358.000	52152.319
1977	57612.000	54138.465
FORECAST		
1978	57612.000	58627.089
1979	57612.000	52540.480
1980	57612.000	55295.647
1981	57612.000	57417.552
1982	57612.000	57975.195

FIGURE 12.--Soybeans Processed, Million Bushels, 1978 Actual = 1000.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.



ACTUAL (+) AND ESTIMATED (*) VALUES FOR 18-CRUSHT

YEAR	LEVELS (+)	(*)
1972	721.800	735.413
1973	821.300	847.669
1974	701.300	724.879
1975	865.100	811.828
1976	790.000	773.953
1977	927.000	939.520
FORECAST		
1978	927.000	985.656
1979	927.000	1010.578
1980	927.000	1058.985
1981	927.000	1099.955
1982	927.000	1190.978

CHAPTER VI

CONCLUSION

The estimated model performs well over the sample period. The fitted values of the dependent variables track the actual values well, especially in current years, a period of greater variation (see Figures III and IV). The estimated economic parameters seem reasonable, as they compare favorable with the findings of other studies (see Tables 1 and 2) .

Major Findings

1. Comparison of the elasticity estimate for soybean meal price from the soybean meal demand equation in this model, to estimates from other models, (with older sample periods) indicates that soybean meal demand is becoming more inelastic over time.

2. Stocks of soybeans and soybean oil are the result of quantities demanded being in less than quantities supplied, not the result of speculation.

3. Feed grains (i.e. corn) are in direct competition with soybean meal in the livestock industry. This is evidenced by a positive cross-price elasticity estimate for corn in the soybean meal demand equation. Corn is a substitute

for soybean meal in the production of livestock and livestock products.

4. The logrithmic specification of beef price in the soybean meal demand equation works well. This would support the hypothesis that there may be a declining cross-price elasticity between beef price and soybean meal price as feeding practices become more fixed.

5. The soybean acreage planted equations, taken together, performed well. The average absolute error of 2,200,000 acres annually for the 1966-1974 period represents a 4.7 percent error. In comparison, another, more disaggregated, model appears to perform better over the same observation period (3.6 percent improvement). Kenyon and Evans'study had an average absolute error of only 510,000 annually for this same sample period.[36]

6. The weather variable, based upon sunspot activity, is statistically significant at the 95% confidence level. This variable has promise for future efforts to forecast crop yields in the midwestern United States.

7. The own price elasticity for soybean oil was estimated to be 2.14, a value which would indicate that soybean oil is a superior good in consumption, or at least a constituent of such goods.

The only obvious improvement that can be made on the basis of the results would be the disaggregation of the supply of soybeans into the six regions suggested by the

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[36] D. Kenyon and R. Evans, 1974 op.cit.

U.S.D.A. The gains that would be realized by disaggregating are tangible, but not enormous. There is a tradeoff between simplicity and incremental accuracy gains when disaggregation is considered.

Results of the Forecast

The estimated quantities of soybeans produced and processed domestically both correspond closely to the observed values throughout the entire sample period. In the year 1978, the production estimate is 4 percent too low for the quantity of soybeans produced (compared to an average absolute error of 7.5% over the estimation period). The estimated quantity of soybeans processed in 1978 is 27 percent too low, which compares favorably with a 3 percent average absolute error for the estimation period .

A closer examination of the source of the error in the production estimate for 1978 reveals that the estimate for total acreage harvested for soybeans in the U.S. is 5% too low. This pattern repeats itself throughout the sample period, with a negative 3 percent average error for the entire U.S. and a negative 8 percent average error for the southern U.S. region. With an average of 25 percent of all production occurring in the southern U.S. during the 1972-1978 period, a substantial portion of the total error in the soybean production estimate could stem from a consistent underestimation of soybean acreage harvested in the southern U.S. region. The estimated yields are apparently too high in many years, which would be the only plausible explanation for a positive error for estimated soybean production in years where the error for soybean acreage harvested is negative. The results of simultaneous solution re-affirm the results of statistical analysis: the soybean acreage planted in the southern U.S. performs poorly and the yield equations have an upward bias. The improvement of these equations will be the focus of future efforts.

The source of error in the estimate of soybeans processed in the U.S. is easily decomposed. While the average absolute error for the soybean meal quantity produced in the U.S. has an absolute error of about 3 percent associated with it, the average error is about 1 percent too low. The bias is in the opposite direction in the soybean oil produced equation; with an average absolute error of almost 5 percent and an average error of 2.5 percent. The average error associated with the quantity of soybeans processed in the U.S. estimate is less than 1 percent. There seems to be no systematic under or over-estimation of this quantity. In light of favorable performance in all respects, the demand component of the model: soybean meal demand, soybean oil demand and quantity of soybeans processed, is considered satisfactory.

Beginning soybean stocks are overestimated consistently from 1975 on, but this is due, in a large part, to the large positive error associated with soybean production in 1974. Since each year's estimate of beginning stocks will depend, in part, on the previous year's estimate, the error begun in 1975 will be repeated in each of the following years.

Soybean price does not respond well to year-to-year changes in total supply and total demand. A plausible method of adjustment would be to respecify soybean price as being, in part, a function of soybean stocks (as a measure of total market conditions). This alternative will be explored.

Closing Remarks

While the model put forth in this study has some shortcomings, it does provide a workable framework for the examination of the entire U.S. soybean industry. In this sense the initial objective of this research has been satisfactorily fulfilled. Applications of this study are illustrated in Appendices B, C, D, E, where various assumption alternatives are incorporated into conditional forecasts.

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APPENDIX A.

SOURCES FOR DATA

1. Agricultural Statistics, 1978.S.R.S., U.S.D.A.

   a. Table 178, page 129.

   b. Table 180, page 130.

   c. Table 182, page 131.

   d. Table 185, page 133.

   e. Table 194, page 138.

   f. Table 188, page 143.

   g. Table 39, page 30.

   h. Table 82, page 61.

   i. Table 48, page 38.

   j. Table 201, page 144.

   k. Table 203, page 146.

2. Survey of Current Business, various issues.

3. Statistical Abstract, 1978. Table 2, page 6.

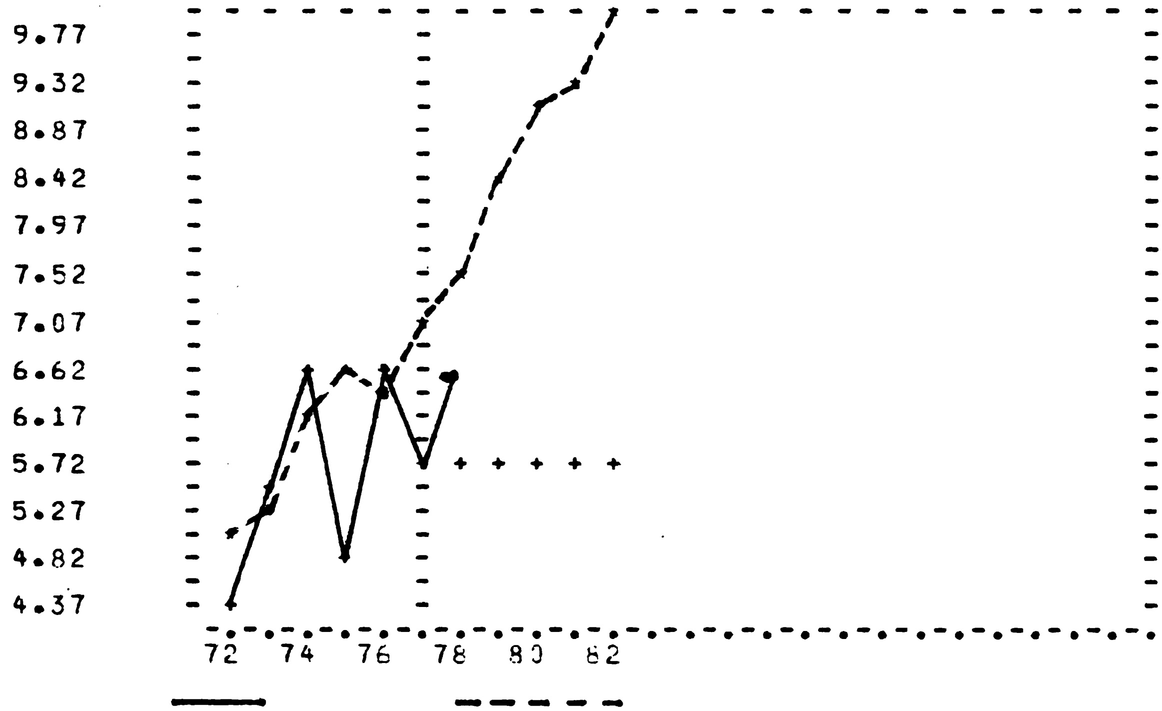
4. Business Statistics, 1978.

APPENDIX B

REDUCED YIELD SCENARIO

FIGURE 13.--Soybean Price, Dollars Per Bushel, 1978
Actual = 6.50, Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

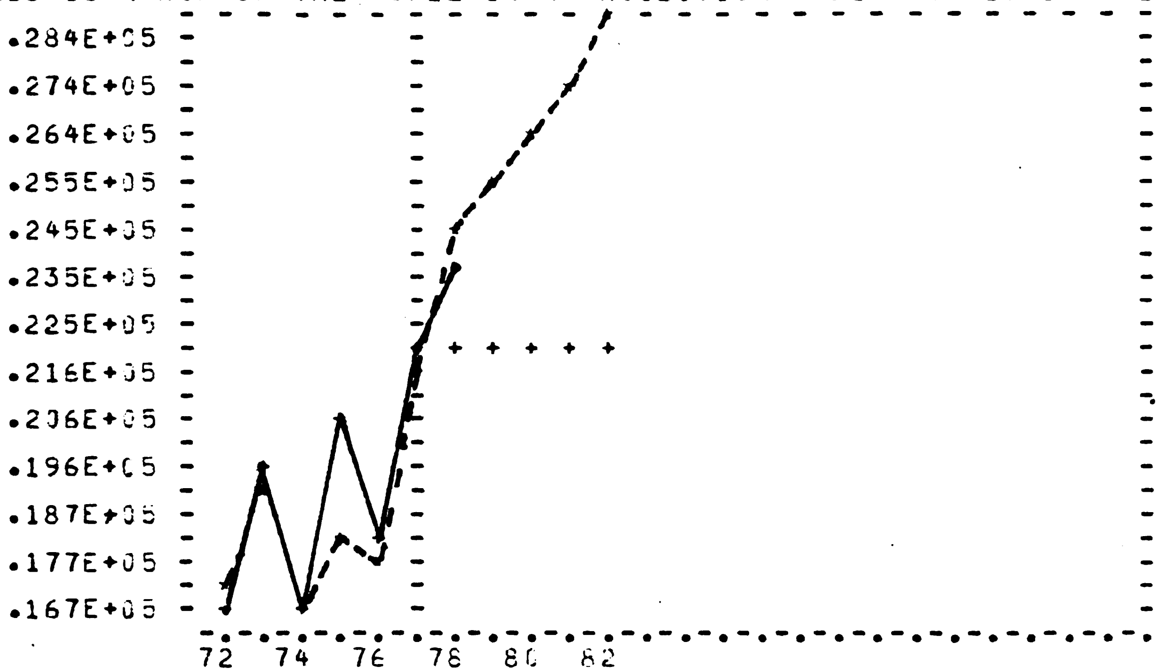


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 1-SOYBPT

YEAR	LEVELS (+)	(*)
1972	4.370	5.269
1973	5.680	5.332
1974	6.640	6.255
1975	4.920	6.825
1976	6.810	6.522
1977	5.880	7.122
FORECAST		
1978	5.880	7.702
1979	5.880	8.517
1980	5.880	9.259
1981	5.880	9.507
1982	5.880	9.998

FIGURE 14.--Soybean Meal Production, 1000 Tons, 1978 Actual = 23,754, Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

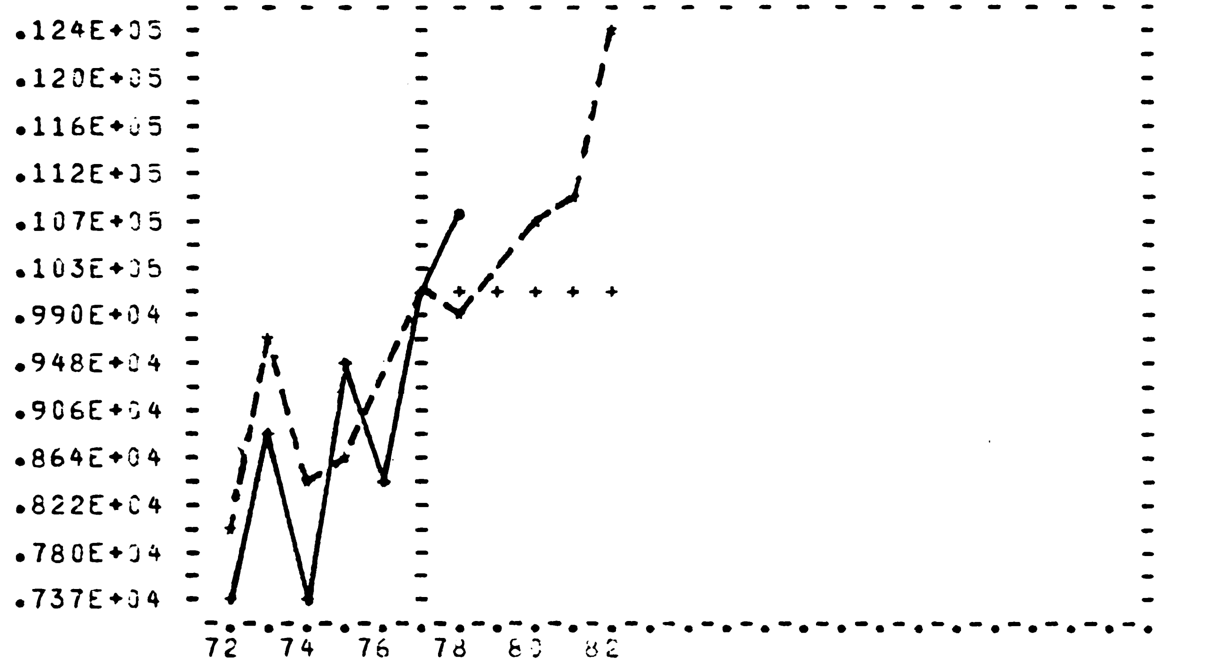


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 2-SOYMGT

YEAR	LEVELS (+)	(*)
1972	16708.000	17271.137
1973	19674.000	19211.519
1974	16702.000	16845.044
1975	20754.000	18411.726
1976	18488.000	17998.794
1977	22371.000	22026.166
FORECAST		
1978	22371.000	24938.526
1979	22371.000	25508.809
1980	22371.000	26584.078
1981	22371.000	27808.477
1982	22371.000	28879.927

FIGURE 15.--Soybean Oil Production, Million Pounds,1978 Actual = 10,800, Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

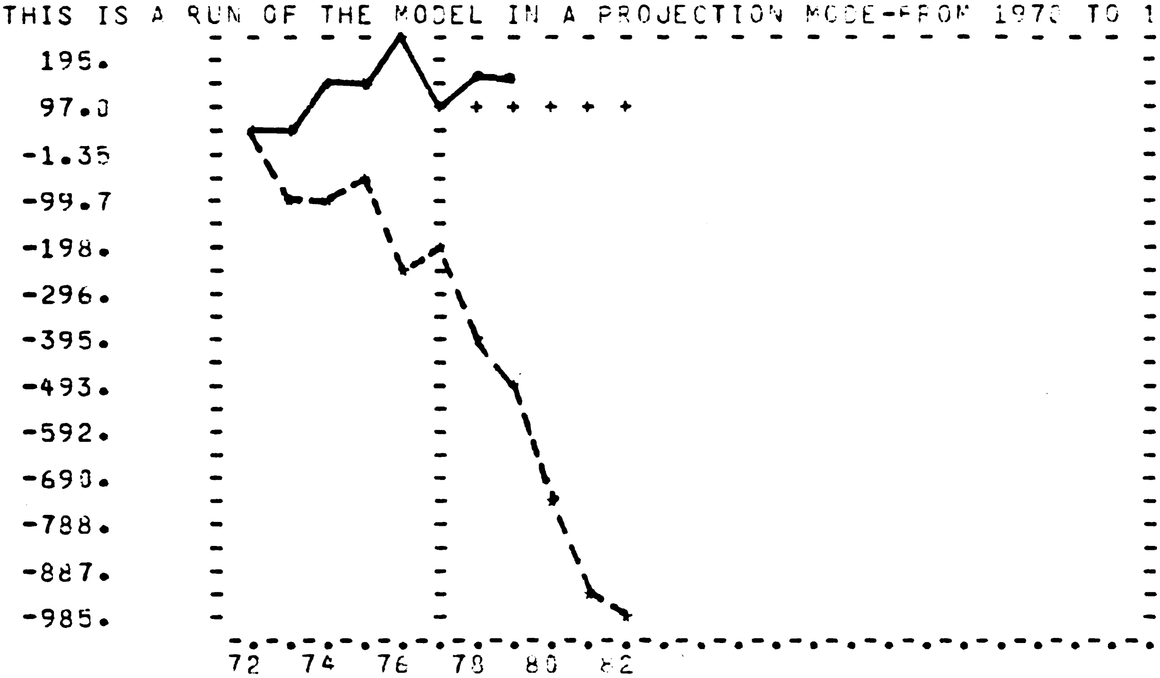


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 4-SOILGT

YEAR	LEVELS (+)	(*)
1972	7501.000	8161.790
1973	8995.000	9740.237
1974	7375.000	8462.367
1975	9630.000	8778.905
1976	8578.000	8622.358
1977	10288.000	10276.236
FORECAST		
1978	10288.000	10001.859
1979	10288.000	10301.816
1980	10288.000	10804.010
1981	10288.000	11138.520
1982	10288.000	12626.137

FIGURE 16.--Beginning Soybean Stocks, Million Bushels, 1978 Actual = 161, 1979 Actual = 150,Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

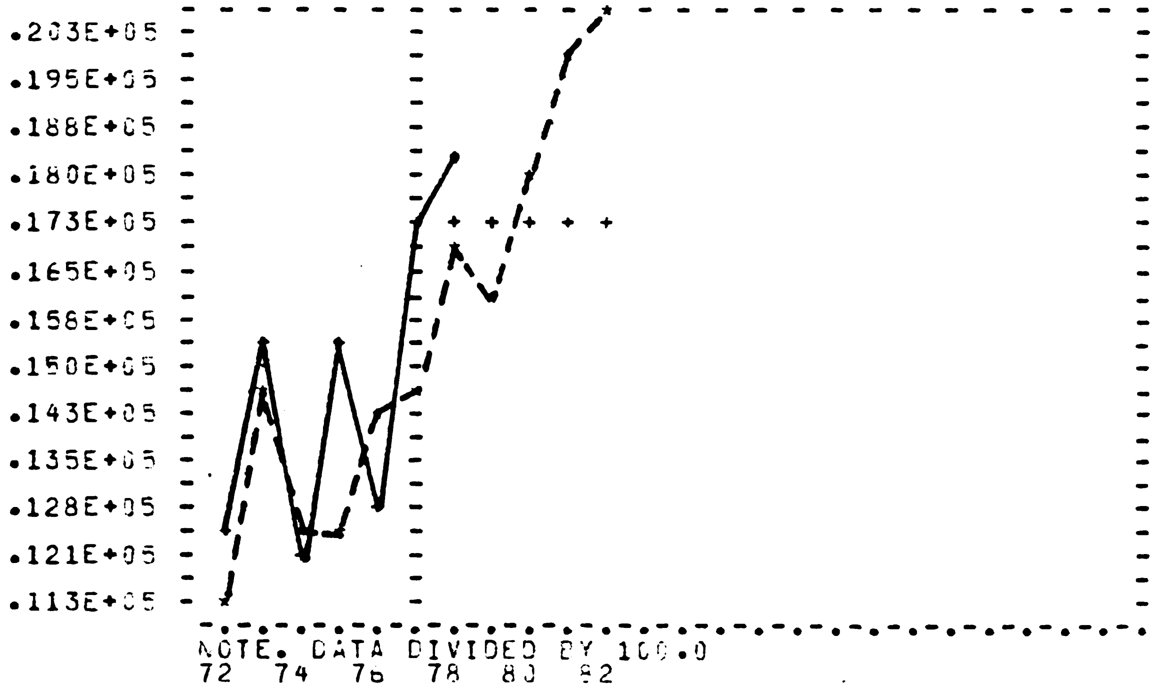


ACTUAL (+) AND ESTIMATED (*) VALUES FOR F-SBSTKT

YEAR	LEVELS (+)	(*)
1972	71.960	71.869
1973	59.640	-96.462
1974	170.880	-59.620
1975	185.040	-49.501
1976	244.600	-216.131
1977	103.000	-164.469
FORECAST		
1978	103.000	-368.008
1979	103.000	-456.205
1980	103.000	-715.422
1981	103.000	-898.500
1982	103.000	-985.172

FIGURE 17.--Soybean Production, 1000 Bushels, 1978 Actual = 1,842,647, Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.

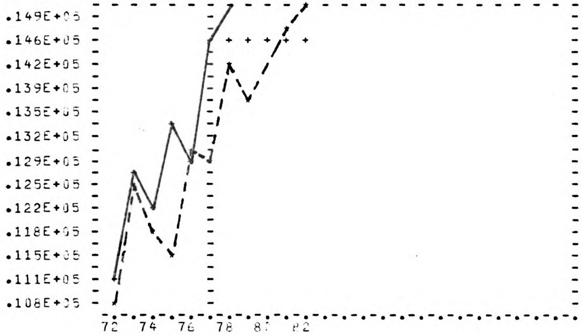


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 7-SOYBOT

YEAR	LEVELS (+)	(*)
1972	12706.300	11302.099
1973	15471.650	15[illegible]32.426
1974	12148.020	12502.260
1975	15461.200	12432.764
1976	12875.600	14653.794
1977	17617.550	15021.756
FORECAST		
1978	17617.550	17245.384
1979	17617.550	16237.381
1980	17617.550	18041.731
1981	17617.550	20062.784
1982	17617.550	20524.037

FIGURE 18.--Acres of Soybeans Harvested - Southern U.S., 1000 Acres, 1978 Actual = 15,560, Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE FROM 1970 TO 1982.

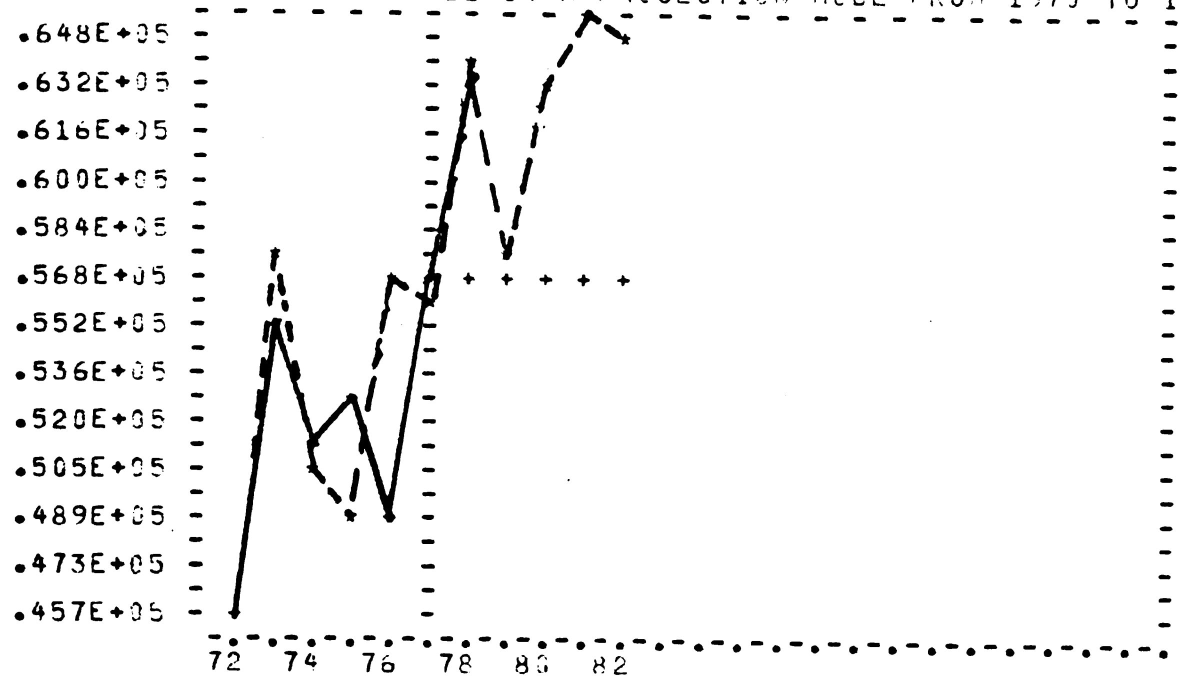


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 11-AHSHTS

YEAR	LEVELS (+)	(*)
1972	11190.000	10770.360
1973	12736.000	12530.023
1974	12198.000	11819.823
1975	13483.000	11544.603
1976	12982.000	13161.327
1977	14593.000	12897.574
FORECAST		
1978	14593.000	14413.717
1979	14593.000	13858.996
1980	14593.000	14630.791
1981	14593.000	14869.843
1982	14593.000	15108.312

FIGURE 19.--Acres of Soybeans Harvested - U.S., 1000 Acres, 1978 Actual = 63,033, Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

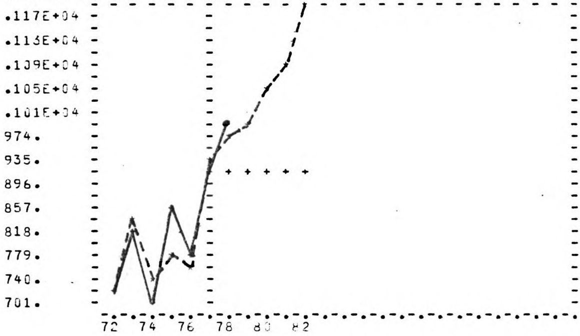


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 12-AHSET

YEAR	LEVELS (+)	(*)
1972	45683.000	46078.781
1973	55667.000	58217.724
1974	51341.000	50622.371
1975	53579.000	49025.549
1976	49358.000	57139.709
1977	57612.000	56399.490
FORECAST		
1978	57612.000	64372.911
1979	57612.000	58101.537
1980	57612.000	63571.753
1981	57612.000	65577.049
1982	57612.000	65529.313

FIGURE 20.--Soybeans Processed, Million Bushels, 1978 Actual = 1000, Reduced Yield Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.



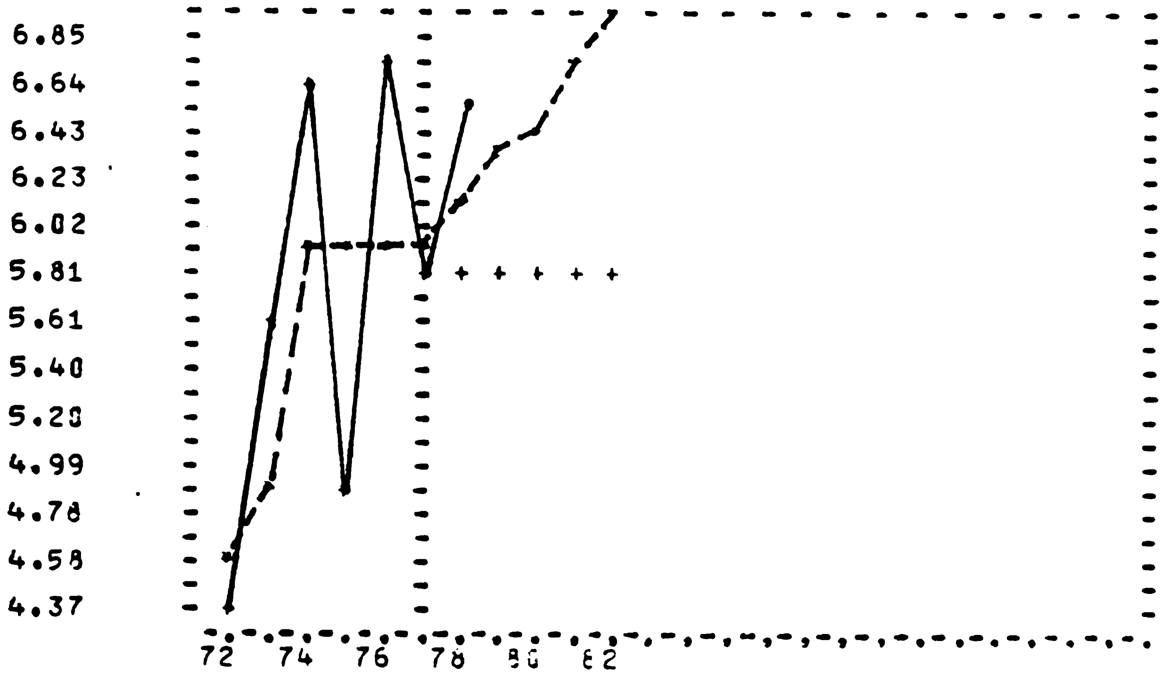
ACTUAL (+) AND ESTIMATED (*) VALUES FOR 18-CRUSHT

YEAR	LEVELS (+)	(*)
1972	721.800	738.538
1973	821.300	851.474
1974	701.300	743.066
1975	865.100	790.746
1976	790.000	774.968
1977	927.000	935.691
FORECAST		
1978	927.000	985.235
1979	927.000	1011.005
1980	927.000	1056.710
1981	927.000	1097.966
1982	927.000	1188.382

APPENDIX C

INCREASED YIELDS SCENARIO

FIGURE 21.--Soybean Price, Dollars Per Bushel, 1978 Actual = 6.50, Increased Yields Scenario.

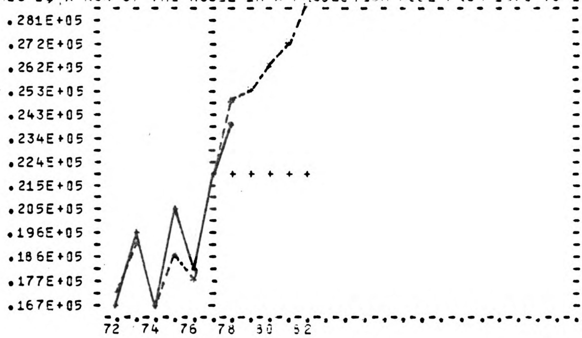


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 1-SOYBPT

YEAR	LEVELS (+)	(*)
1972	4.370	4.675
1973	5.660	4.959
1974	6.640	5.867
1975	4.920	5.987
1976	6.710	5.944
1977	5.880	5.974
FORECAST		
1978	5.880	6.217
1979	5.880	6.416
1980	5.880	6.532
1981	5.880	6.774
1982	5.880	6.949

FIGURE 22.--Soybean Meal Production, 1000 Tons, 1978 Actual = 23,754, Increased Yields Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.

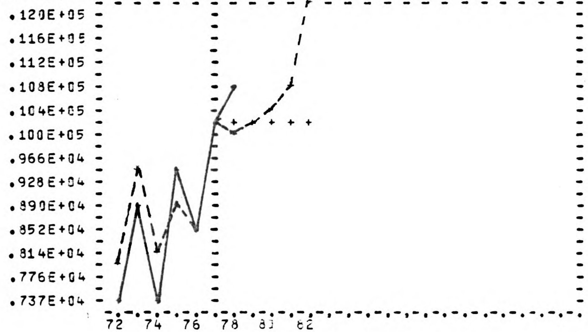


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 2-SOYMQT

YEAR	LEVELS (+)	(*)
1972	16708.000	17324.107
1973	19674.000	19433.961
1974	16702.000	17032.926
1975	20754.000	18835.081
1976	18488.000	18129.039
1977	22371.000	22329.283
FORECAST		
1978	22371.000	24353.080
1979	22371.000	25726.279
1980	22371.000	26422.635
1981	22371.000	27324.29[illegible]
1982	22371.000	28609.977

FIGURE 23.--Soybean Oil Production, Million Pounds, 1978 Actual = 10,800, Increased Yields Scenario.

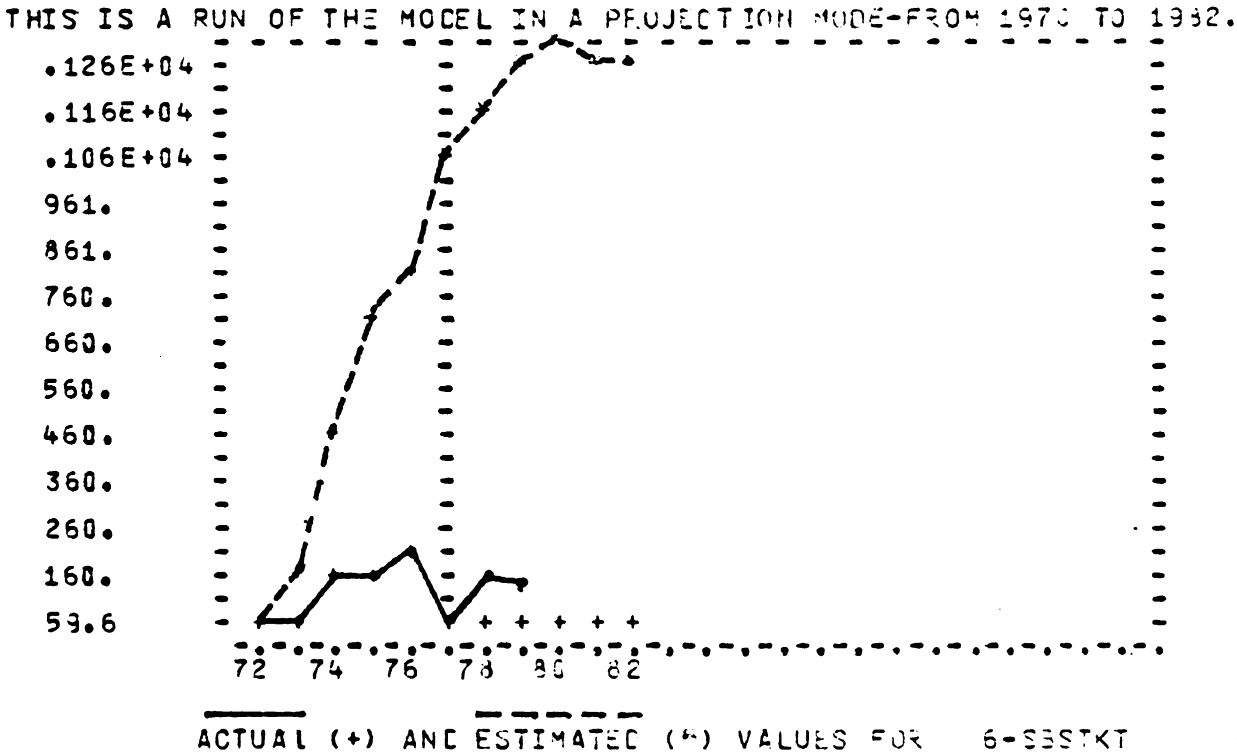
THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1972 TO 1982.



ACTUAL (+) AND ESTIMATED (*) VALUES FOR 4-SOILQT

YEAR	LEVELS (+)	(*)
1972	7501.000	8068.159
1973	8995.000	9603.823
1974	7375.000	8236.194
1975	9630.000	8975.344
1976	8578.000	8610.021
1977	10288.000	10276.286
FORECAST		
1978	10288.000	10077.209
1979	10288.000	10277.192
1980	10288.000	10557.662
1981	10288.000	10864.547
1982	10288.000	12142.303

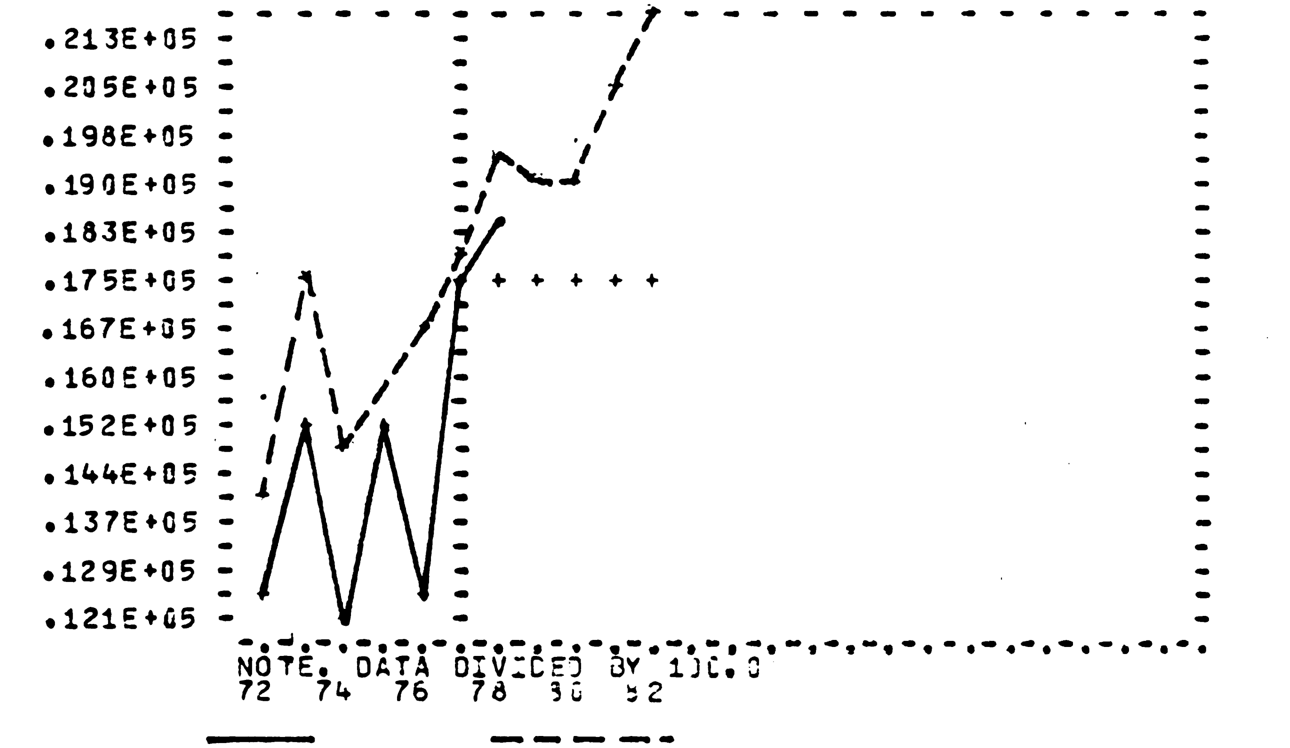
FIGURE 24.--Beginning Soybean Stocks, Million Bushels, 1978 Actual = 161, 1979 Actual = 150, Increased Yields Scenario.



YEAR	LEVELS (+)	(*)
1972	71.960	71.874
1973	59.640	195.245
1974	170.860	484.890
1975	185.[illegible]	741.[illegible]3
1976	244.600	835.274
1977	103.000	1033.331
FORECAST		
1978	103.000	1170.048
1979	103.000	1236.932
1980	103.[illegible]	[illegible].078
1981	103.000	127[illegible].424
1982	103.000	1261.369

FIGURE 25.--Soybean Production, 1000 Bushels, 1978 Actual = 1,842,647, Increased Yields Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.

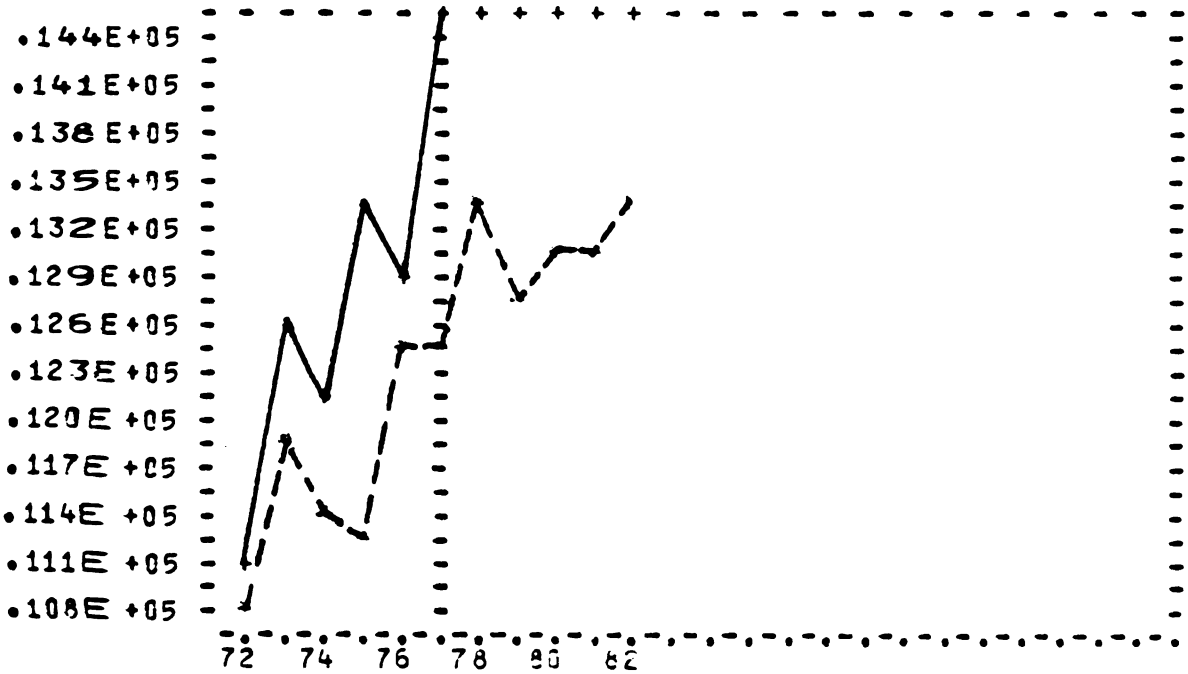


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 7-SOYEQT

YEAR	LEVELS (+)	(*)
1972	12706.300	14256.672
1973	15471.650	17534.232
1974	12148.020	15095.411
1975	15461.200	15466.601
1976	12875.600	16366.969
1977	17617.551	18217.735
FORECAST		
1978	17617.550	19633.898
1979	17617.550	19193.144
1980	17617.550	19253.021
1981	17617.550	20695.521
1982	17617.550	21683.856

FIGURE 26.--Acres of Soybeans Harvested - Southern U.S., 1000 Acres, 1978 Actual = 15,560, Increased Yields Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

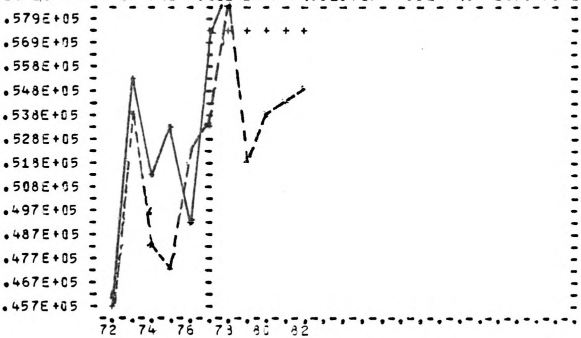


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 11-AHSETS

YEAR	LEVELS (+)	(*)
1972	11190.000	10792.731
1973	12736.000	11909.44[illegible]
1974	12198.000	11469.685
1975	13483.000	11343.658
1976	12982.000	12471.19[illegible]
1977	14593.000	12498.512
FORECAST		
1978	14593.000	13469.358
1979	14593.000	12905.446
1980	14593.000	13132.922
1981	14593.000	13178.376
1982	14593.000	13449.307

FIGURE 27.--Acres of Soybeans Harvested - U.S., 1000 Acres, 1978 Actual = 63,033, Increased Yields Scenario.

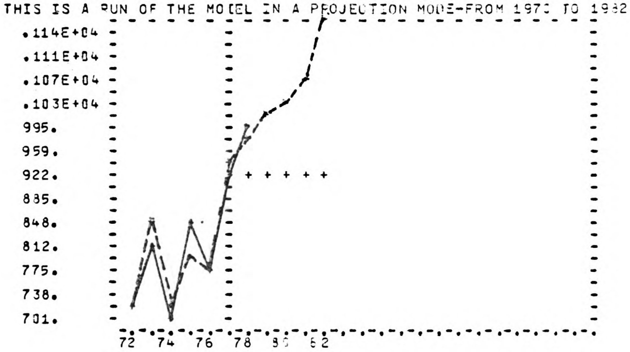
THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.



ACTUAL (+) AND ESTIMATED (*) VALUES FOR 12-AHSHT

YEAR	LEVELS (+)	(*)
1972	45683.000	46057.682
1973	55667.000	54072.597
1974	51341.000	48274.177
1975	53579.000	47484.353
1976	49358.000	52530.908
1977	57612.000	53525.028
FORECAST		
1978	57612.000	58376.219
1979	57612.000	52264.902
1980	57612.000	53364.205
1981	57612.000	54490.613
1982	57612.000	54989.717

FIGURE 28.--Soybeans Processed, Million Bushels, 1978 Actual = 1000, Increased Yields Scenario.



ACTUAL (+) AND ESTIMATED (*) VALUES FOR 18-CRUSHT

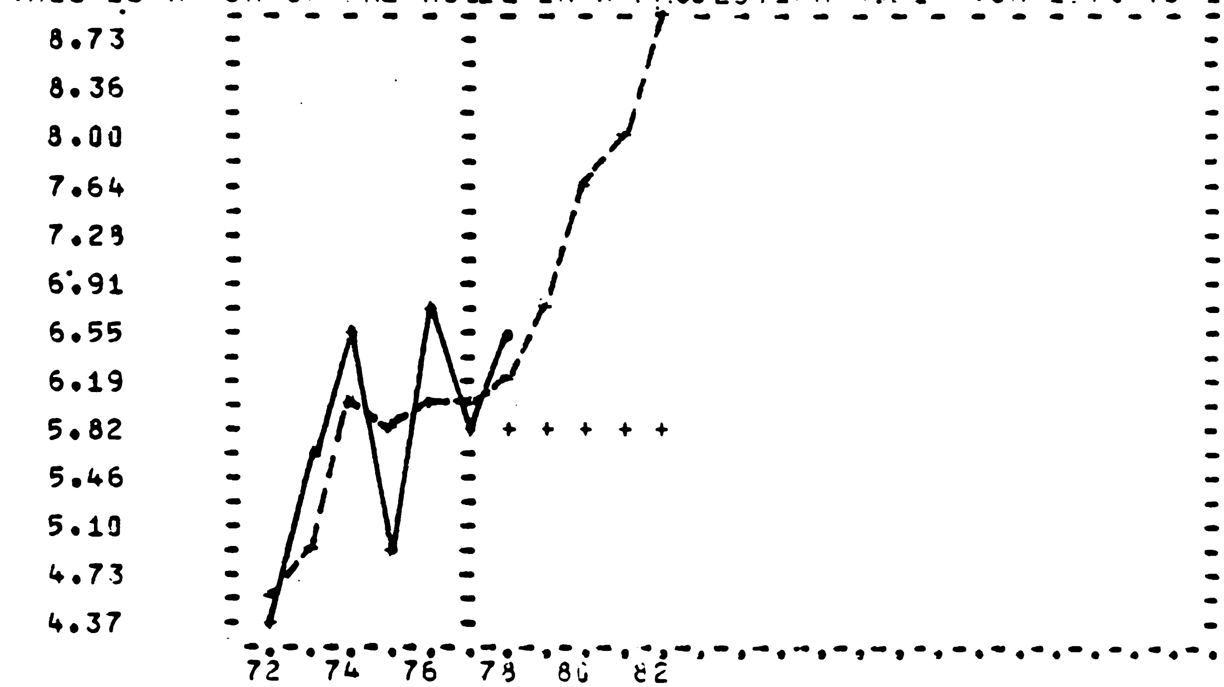
YEAR	LEVELS (+)	(*)
1972	721.800	736.760
1973	821.300	849.831
1974	701.300	737.228
1975	665.100	808.267
1976	790.000	777.332
1977	927.000	941.669
FORECAST		
1978	927.000	988.901
1979	927.000	1014.503
1980	927.000	1042.075
1981	927.000	1084.011
1982	927.000	1160.546

APPENDIX D

INCREASED EXPORT SCENARIO

FIGURE 29.--Soybean Price, Dollars Per Bushel, 1978
Actual = 6.50, Increased Export Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.

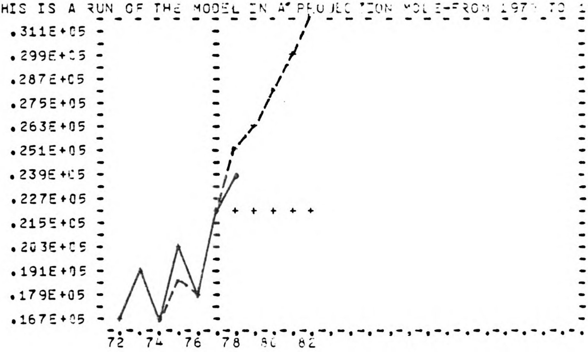


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 1-SOYSPT

YEAR	LEVELS (+)	(*)
1972	4.370	4.700
1973	5.660	5.000
1974	6.640	6.123
1975	4.920	5.956
1976	6.810	6.066
1977	5.880	6.014
FORECAST		
1978	5.880	6.251
1979	5.880	6.972
1980	5.880	7.716
1981	5.880	8.153
1982	5.880	8.939

FIGURE 30.--Soybean Meal Production, 1000 Tons, 1978 Actual = 23,754, Increased Export Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 197[illegible] TO 19[illegible].

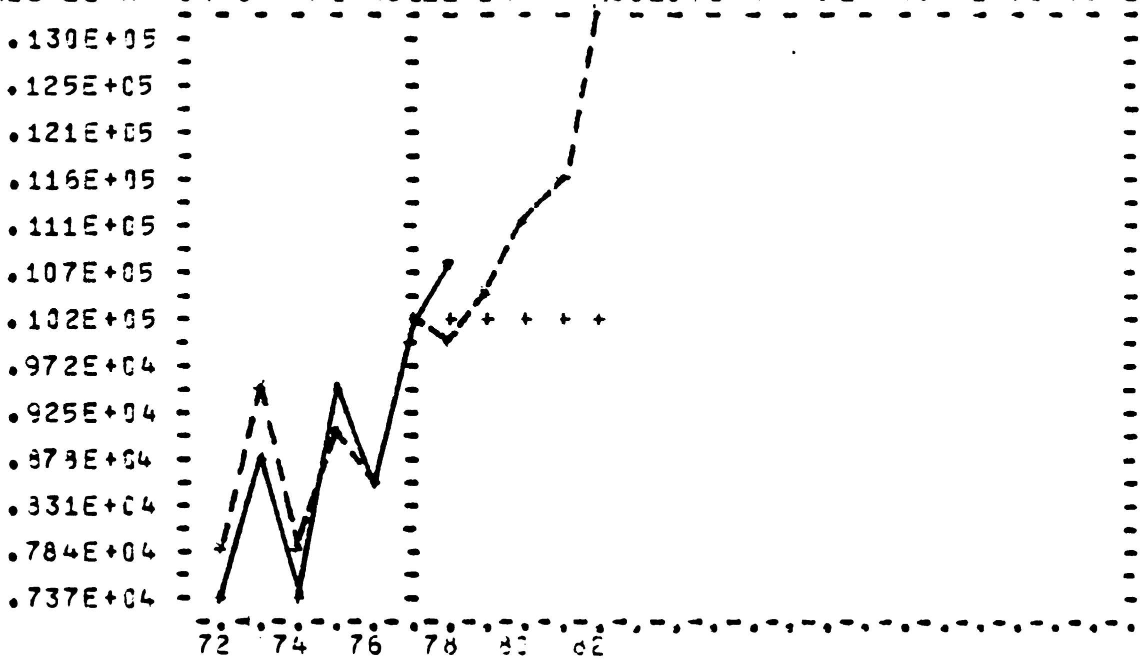


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 2-SOYMOT

YEAR	LEVELS (+)	(*)
1972	16708.000	17261.976
1973	19674.000	19333.109
1974	16702.000	16954.44[illegible]
1975	20754.000	18344.643
1976	18488.000	18002.812
1977	22371.000	22226.849
FORECAST		
1978	22371.000	25131.4[illegible]6
1979	22371.000	26391.485
1980	22371.000	28122.529
1981	22371.000	29919.811
1982	22371.000	317[illegible].[illegible]7

FIGURE 31.--Soybean Oil Production, Million Pounds, 1978 Actual = 10,800, Increased Export Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1973 TO 1982.

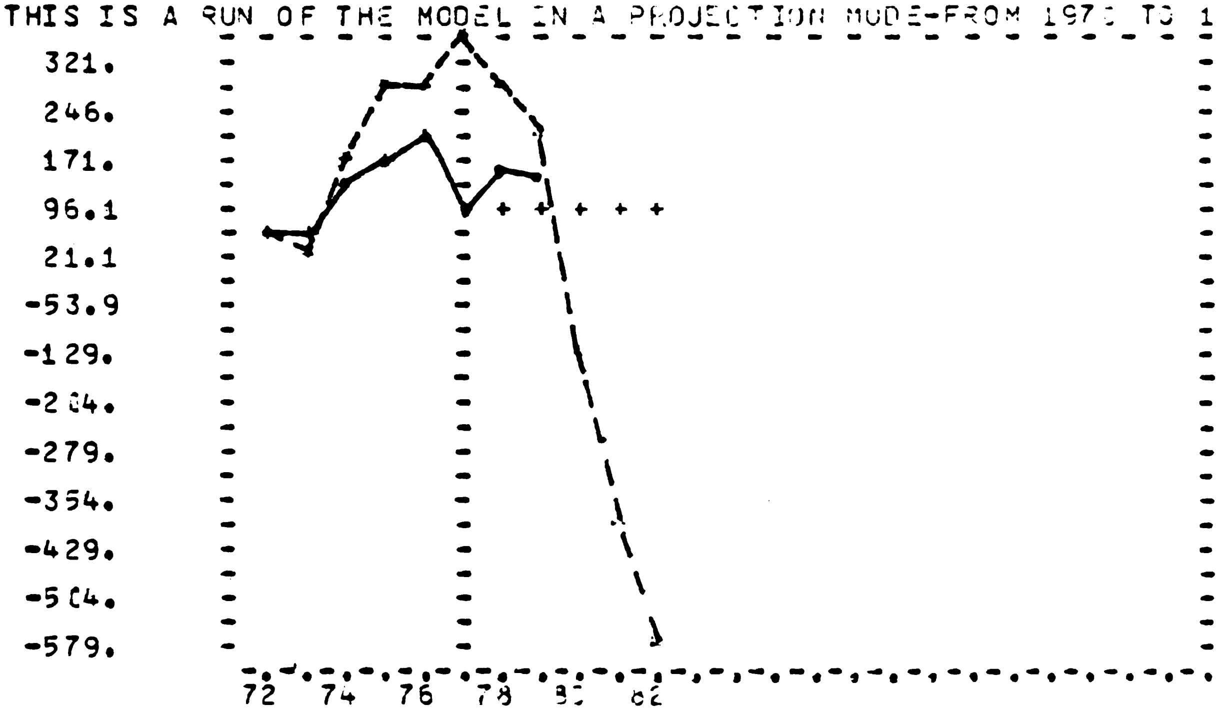


ACTUAL (+) AND ESTIMATED (*) VALUES FOR +-SOILQT

YEAR	LEVELS (+)	(*)
1972	7501.000	8063.015
1973	8995.000	9513.463
1974	7375.000	7969.280
1975	9630.000	9056.816
1976	8578.000	8535.768
1977	10288.000	10276.016
FORECAST		
1978	10288.000	10144.561
1979	10288.000	10528.326
1980	10288.000	11166.690
1981	10288.000	11594.259
1982	10288.000	13234.643

FIGURE 32.--Beginning Soybean Stocks, Million Bushels, 1978 Actual = 161, 1979 Actual = 150, Increased Export Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1972 TO 1982.

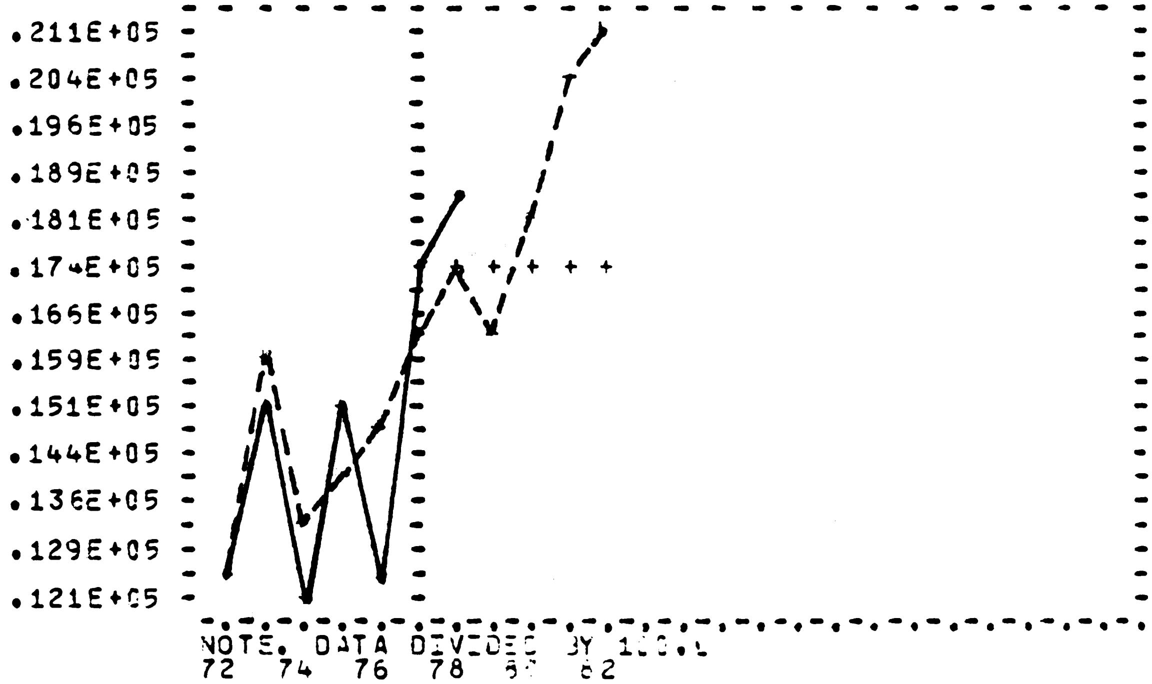


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 6-SBSTKT

YEAR	LEVELS (+)	(*)
1972	71.960	71.874
1973	59.640	58.276
1974	170.880	134.394
1975	185.[illegible]	313.031
1976	244.600	235.593
1977	103.000	353.703
FORECAST		
1978	103.000	300.578
1979	103.000	225.316
1980	103.000	-[illegible]
1981	103.000	-373.609
1982	103.000	-579.022

FIGURE 33.--Soybean Production, 1000 Bushels, 1978 Actual = 1,842,647, Increased Export Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1978 TO 1982.

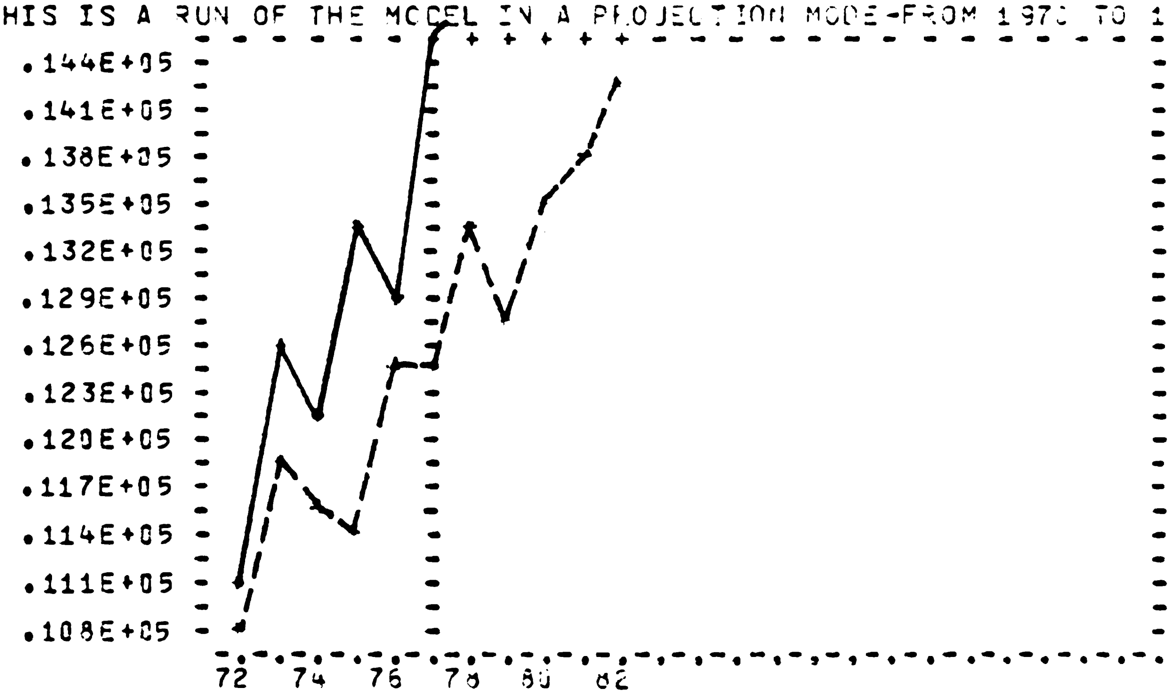


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 7-SOYBQT

YEAR	LEVELS (+)	(*)
1972	12706.300	12628.701
1973	15471.650	15914.472
1974	12148.020	13530.536
1975	15461.200	14254.637
1976	12875.600	14347.276
1977	17617.550	16514.413
FORECAST		
1978	17617.550	17691.526
1979	17617.550	16271.012
1980	17617.550	18483.627
1981	17617.550	20532.783
1982	17617.550	21433.513

FIGURE 34.--Acres of Soybeans Harvested - Southern U.S., 1000 Acres, 1978 Actual = 15,560, Increased Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1972 TO 1982.

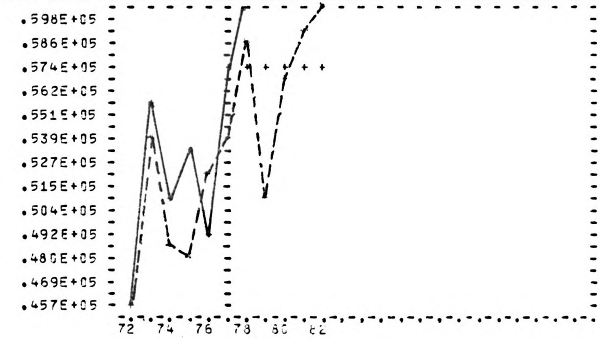


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 11-AHSBTS

YEAR	LEVELS (+)	(*)
1972	11190.000	10792.731
1973	12736.000	11335.616
1974	12198.000	11606.715
1975	13463.000	11534.331
1976	12982.000	12483.553
1977	14593.000	12332.384
FORECAST		
1978	14593.000	13507.952
1979	14593.000	12842.738
1980	14593.000	13617.312
1981	14593.000	13916.796
1982	14593.000	14312.231

FIGURE 35.--Acres of Soybeans Harvested - U.S., 1000 Acres, 1978 Actual = 63,033, Increased Export Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1972 TO 1982.

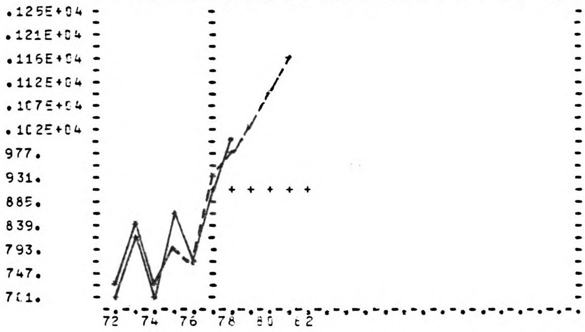


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 12-AHSBT

YEAR	LEVELS (+)	(*)
1972	45683.000	46057.632
1973	55667.000	54242.719
1974	51341.000	48928.533
1975	53579.000	48524.375
1976	49358.000	52152.319
1977	57612.000	54233.465
FORECAST		
1978	57612.000	58627.039
1979	57612.000	51481.927
1980	57612.000	57032.618
1981	57612.000	59385.236
1982	57612.000	60347.731

FIGURE 36.--Soybeans Processed, Million Bushels, 1978 Actual = 1000, Increased Export Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1972 TO 1982.



ACTUAL (+) AND ESTIMATED (*) VALUES FOR 18-CRUSHT

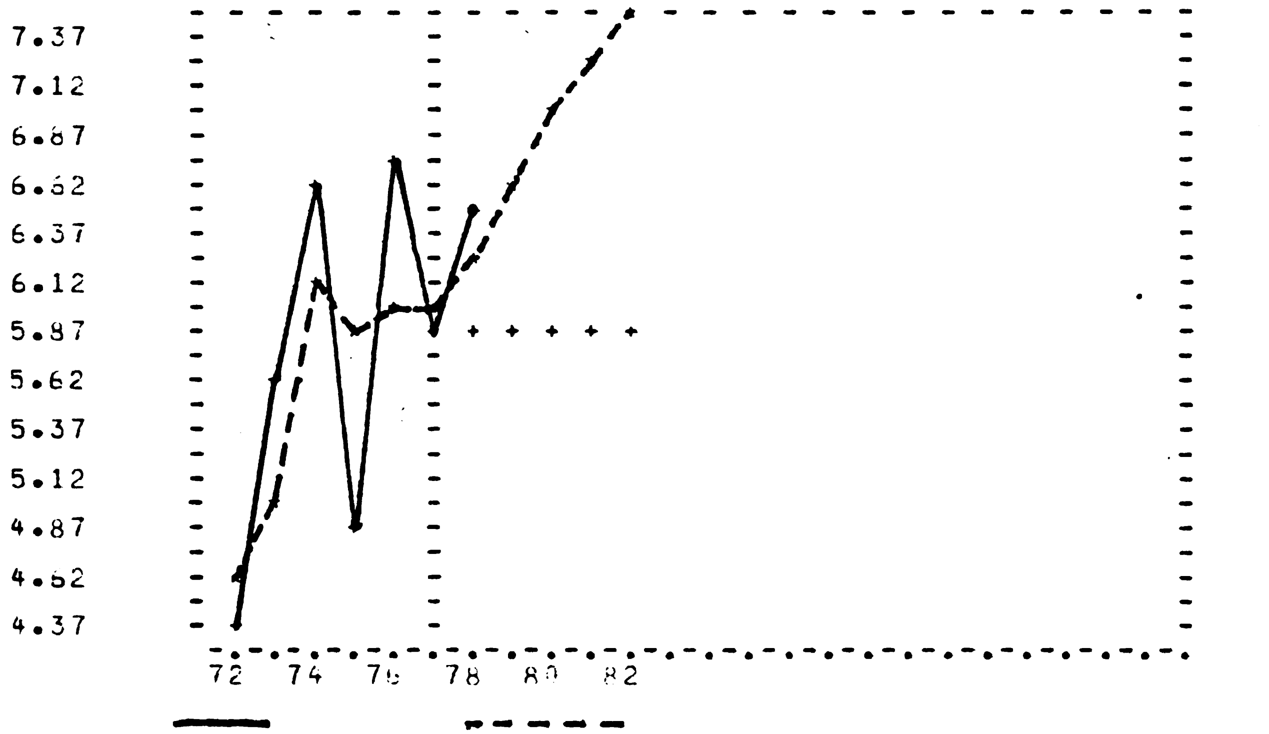
YEAR	LEVELS (+)	(*)
1972	721.800	735.413
1973	621.300	847.669
1974	701.300	724.879
1975	865.[illegible]	611.826
1976	790.000	773.953
1977	927.000	939.520
FORECAST		
1978	927.000	995.757
1979	927.000	1040.080
1980	927.000	1105.937
1981	927.000	1163.633
1982	927.000	1276.256

APPENDIX E

REDUCED EXPORTS SCENARIO

FIGURE 37.--Soybean Price, Dollars Per Bushel, 1978 Actual = 6.50, Reduced Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

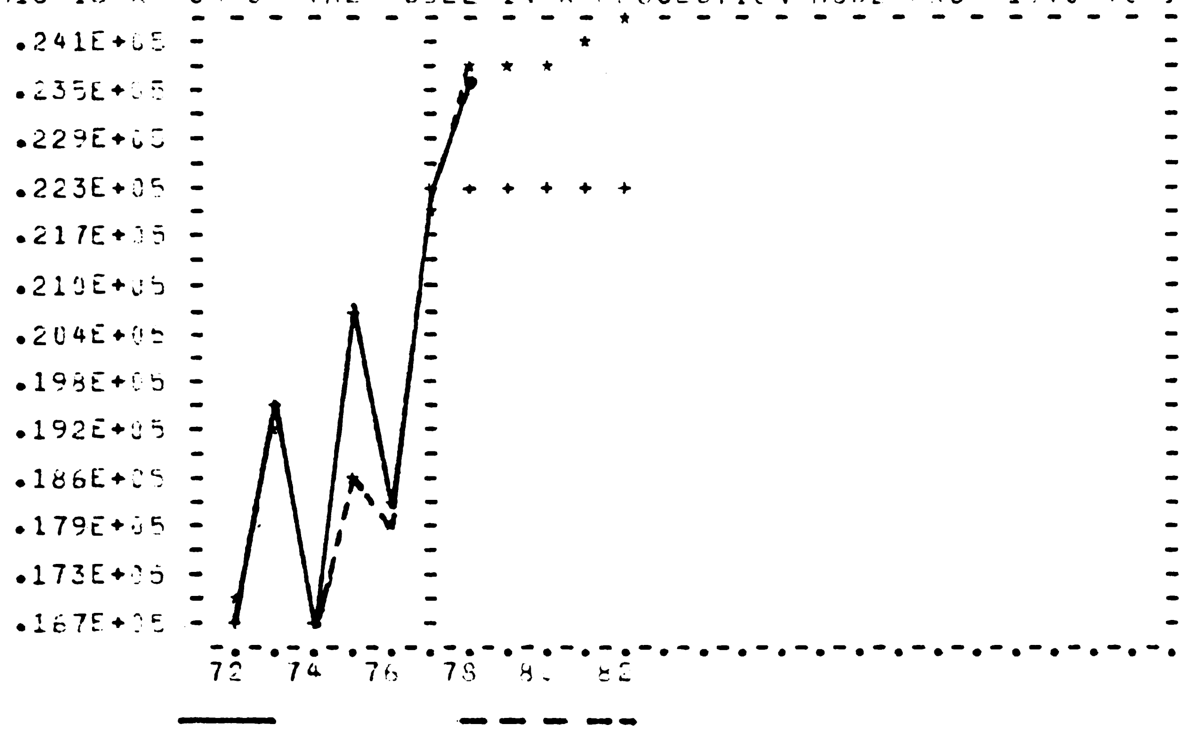


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 1-SOYBPT

YEAR	LEVELS (+)	(*)
1972	4.370	4.700
1973	5.680	5.000
1974	6.640	6.123
1975	4.920	5.956
1976	6.810	6.066
1977	5.880	6.014
FORECAST		
1978	5.880	6.318
1979	5.880	6.652
1980	5.880	7.014
1981	5.880	7.286
1982	5.880	7.491

FIGURE 38.--Soybean Meal Production, 1000 Tons, 1978 Actual = 23,754, Reduced Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

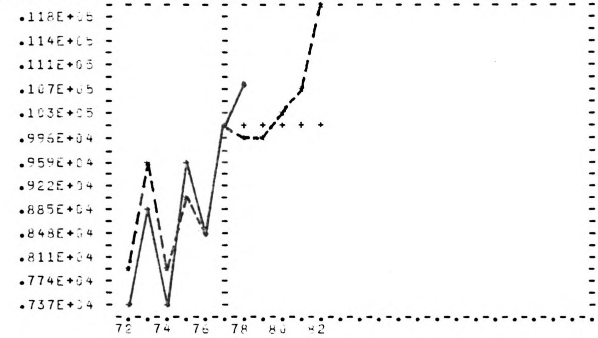


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 2-SOYMQT

YEAR	LEVELS (+)	(*)
1972	16708.000	17261.076
1973	19674.000	19333.109
1974	16702.000	16954.440
1975	20754.000	18844.843
1976	18498.000	18201.812
1977	22371.000	22228.849
FORECAST		
1978	22371.000	24035.527
1979	22371.000	23867.337
1980	22371.000	23978.440
1981	22371.000	24214.944
1982	22371.000	24446.184

FIGURE 39.--Soybean Oil Production, Million Pounds, 1978
Actual = 10,800, Reduced Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

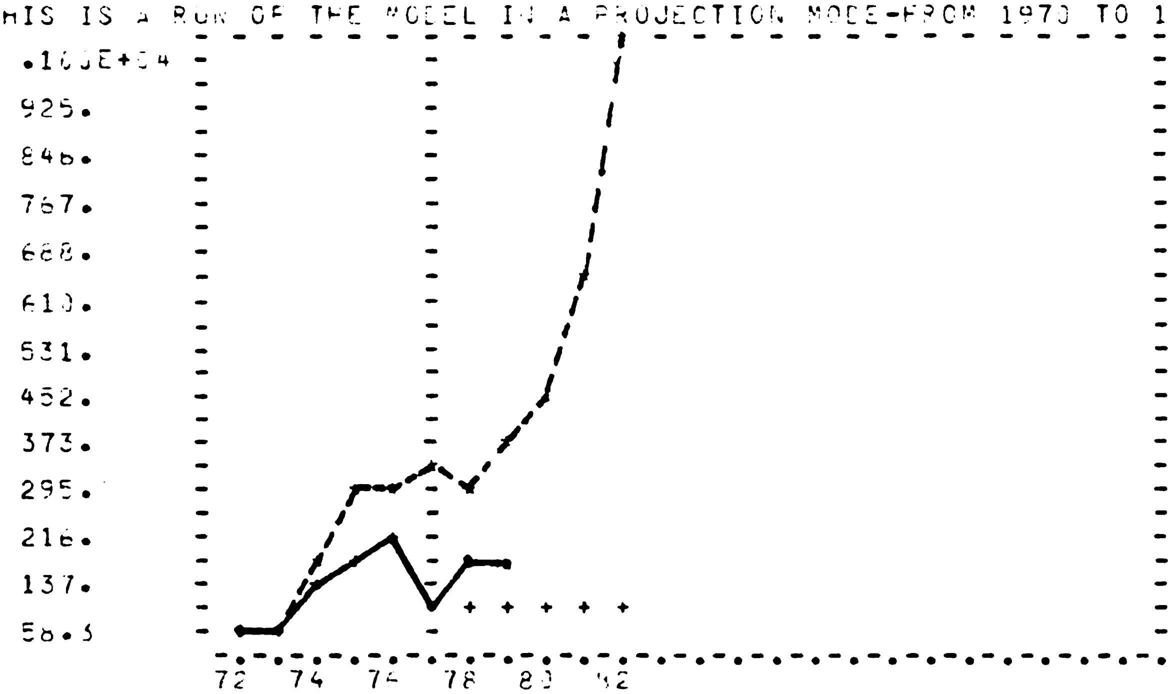


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 4-SOILQT

YEAR	LEVELS (+)	(*)
1972	7501.000	8068.015
1973	8995.000	9603.463
1974	7375.000	7969.280
1975	9630.000	9056.816
1976	8578.000	8585.768
1977	10288.000	10276.016
FORECAST		
1978	10288.000	10006.800
1979	10288.000	10112.589
1980	10288.000	10457.735
1981	10288.000	10723.592
1982	10288.000	11991.033

FIGURE 40.--Beginning Soybean Stocks, Million Bushels, 1978 Actual = 161, 1979 Actual = 150, Reduced Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

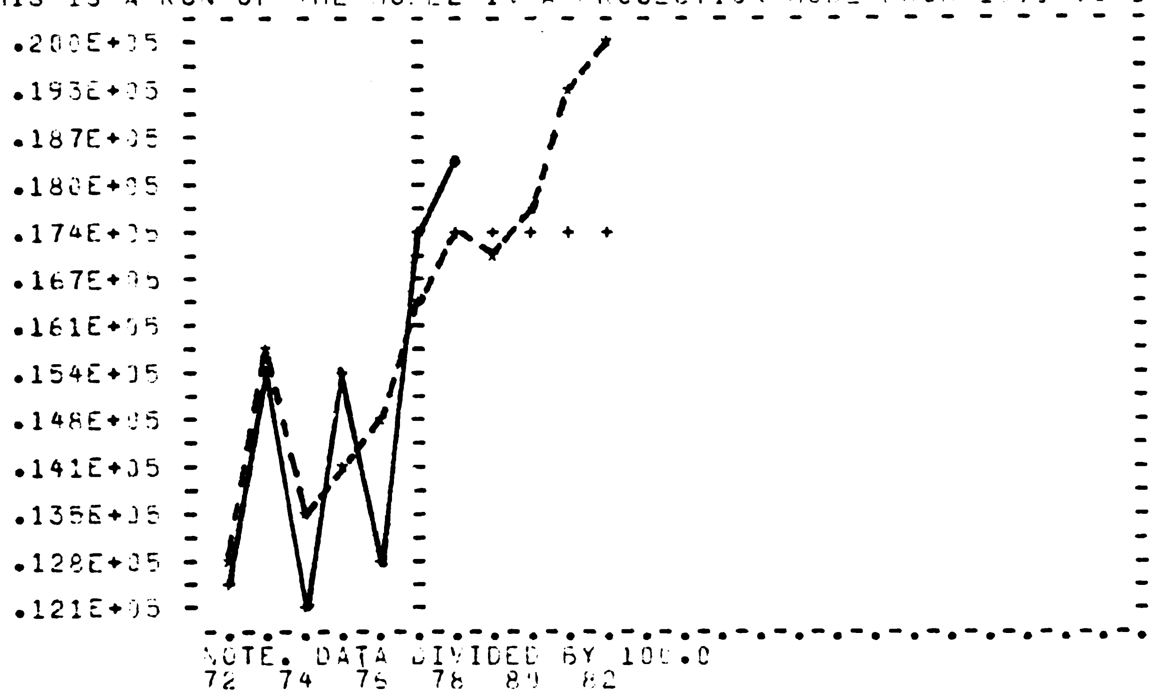


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 6-SBSTKT

YEAR	LEVELS (+)	(*)
1972	71.960	71.874
1973	59.640	58.276
1974	170.880	184.094
1975	185.040	313.031
1976	244.500	295.593
1977	103.000	358.703
FORECAST		
1978	103.000	300.578
1979	103.000	384.645
1980	103.000	471.351
1981	103.000	655.149
1982	103.000	1042.996

FIGURE 41.--Soybean Production, 1000 Bushels, 1978 Actual = 1,842,647, Reduced-Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

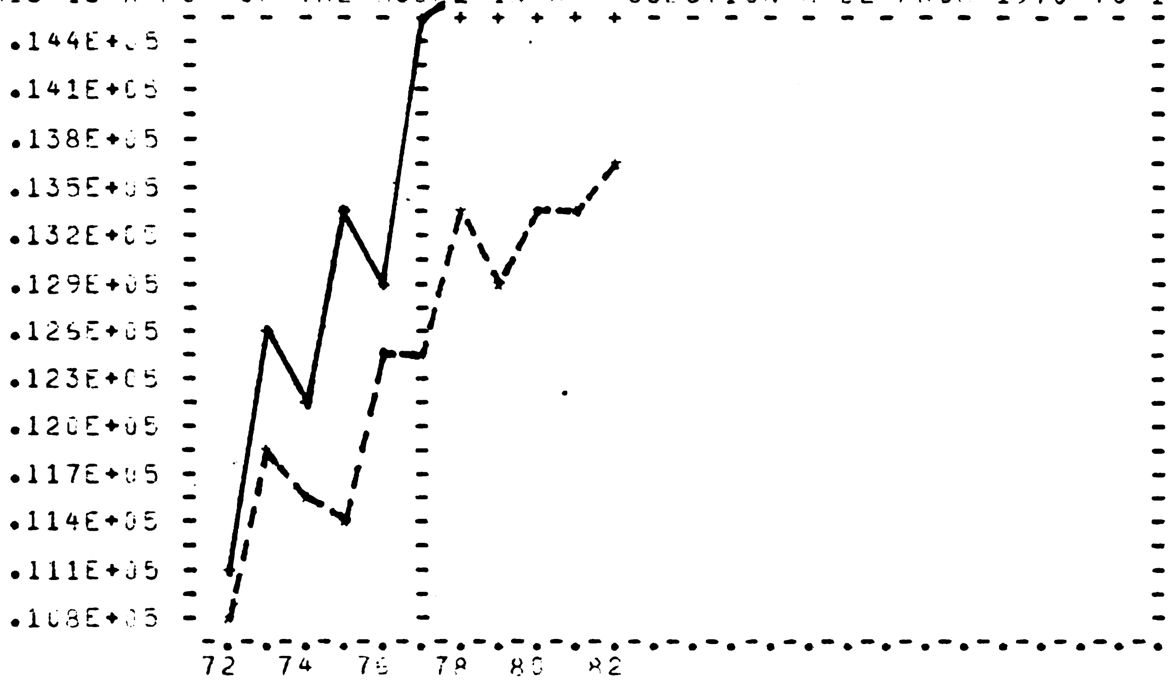


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 7-SOYEGT

YEAR	LEVELS (+)	(*)
1972	12706.300	12828.701
1973	15471.650	15914.472
1974	12148.320	13593.536
1975	15461.200	14254.637
1976	12875.600	14847.276
1977	17617.550	16514.403
FORECAST		
1978	17617.550	17685.980
1979	17617.550	17135.347
1980	17617.550	17735.491
1981	17617.550	19519.109
1982	17617.550	20297.350

FIGURE 42.--Acres of Soybeans Harvested - Southern U.S., 1000 Acres, 1978 Actual = 15,560, Reduced Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

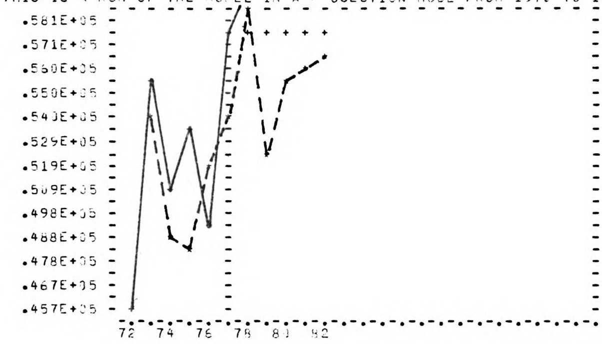


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 11-AHSBTS

YEAR	LEVELS (+)	(*)
1972	11190.000	10792.731
1973	12736.000	11935.616
1974	12198.000	11606.715
1975	13483.000	11534.381
1976	12982.000	12483.553
1977	14593.000	12592.884
FORECAST		
1978	14593.000	13507.952
1979	14593.000	12951.168
1980	14593.000	13384.627
1981	14593.000	13482.307
1982	14593.000	13790.135

FIGURE 43.--Acres of Soybeans Harvested - U.S., 1000 Acres, 1978 Actual = 63,033, Reduced Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.

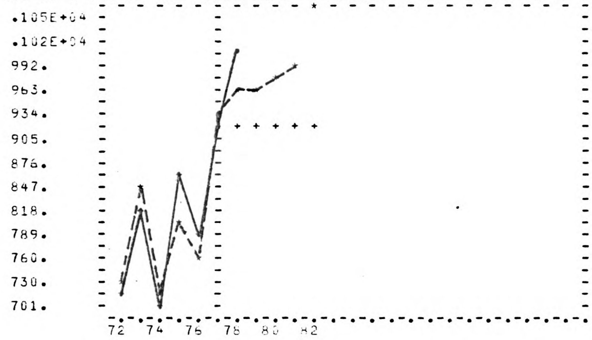


ACTUAL (+) AND ESTIMATED (*) VALUES FOR 12-AHSBT

YEAR	LEVELS (+)	(*)
1972	45683.000	46057.682
1973	55667.000	54242.719
1974	51341.000	48928.583
1975	53579.000	48524.075
1976	49358.000	52152.319
1977	57612.000	54138.465
FORECAST		
1978	57612.000	58627.089
1979	57612.000	52467.920
1980	57612.000	55548.933
1981	57612.000	56540.328
1982	57612.000	57022.521

FIGURE 44.--Soybeans Processed, Million Bushels, 1978
Actual = 1000, Reduced Exports Scenario.

THIS IS A RUN OF THE MODEL IN A PROJECTION MODE-FROM 1970 TO 1982.



ACTUAL (+) AND ESTIMATED (*) VALUES FOR 18-CRUSHT

YEAR	LEVELS (+)	(*)
1972	721.800	735.413
1973	821.300	847.659
1974	701.300	724.879
1975	865.100	811.828
1976	790.000	773.953
1977	927.000	939.520
FORECAST		
1978	927.000	966.178
1979	927.000	967.472
1980	927.000	985.530
1981	927.000	1002.646
1982	927.000	1065.179