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Soybeans

Research Division Bulletin 106
September 1975

Virginia Polytechnic Institute, Research Division

SHORT-TERM SOYBEAN ACREAGE PROJECTION MODEL INCLUDING PRICE AND POLICY IMPACTS

Kenyon and Evans

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SHORT-TERM SOYBEAN ACREAGE PROJECTION
MODEL INCLUDING PRICE AND POLICY IMPACTS

David E. Kenyon and R. S. Evans

Virginia Polytechnic Institute and State University
Blacksburg, Virginia

Research Division Bulletin 106

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SUMMARY

The basic objective of this research was to formulate an acreage response model for soybeans to provide farmers, agribusiness firms, and policymakers with timely, accurate acreage forecasts and a tool to analyze the effects on soybean acreage of changes in farm policies. In order to apply statistical analysis to the problem, a procedure to normalize the changing policy environment within which producers operate had to be developed. Without such a procedure, data generated under one set of policies was not comparable to that generated under a different policy set. A theoretical framework for the construction of price variables adjusted for policy (termed effective prices) was developed based on the theory of choice with respect to farm product substitution. Policy variables were constructed on the basis of applicable support rates, allotments, acreage diversion, acreage set-aside, and target price programs.

The R^2 's for the six regional functions ranged from a low of 0.927 for the Plains region to a high of 0.989 for the Delta region. Projections of harvested acreage were made six months in advance for the years 1966-74. These projections were made by using estimated equations based on data through October of the previous crop year. For 1966-74, the average projection error was 1,989,000 acres for an average error of approximately 4.3 percent of U.S. harvested soybean acreage. The effective price of corn had a significant impact on soybean acreage in the Corn Belt, Lakes and Plains regions. In the Atlantic and Others regions, the effective price of oats entered the model as the crop affecting the acreage of soybeans harvested. In the Delta region changes in the effective cotton price significantly affected harvested soybean acreage. In all regions except the Delta the effective price of soybeans was statistically significant at the 1 percent level. The most significant variable in terms of affecting harvested soybean acreage was harvested soybean acreage lagged one year. The one year lag was included in each equation in recognition of rigidities in the system that normally restrict rapid adjustment.

The national soybean acreage equation had as significant variables the effective prices of soybeans, corn, oats, and cotton and soybean acreage lagged one year. The national equation explained 98.9 percent of the variation in harvested soybean acreage over the years 1948-74. Projections were made six months in advance with an average absolute projection error of 1,989,000 acres or an average error of 4.3 percent. Projections made ten months in advance had an average error of 2.2 million acres or 4.7 percent. Projections were made 12 and 14 months in advance using futures prices with average projection errors of 2.47 million acres (4.9 percent) and 2.66 million acres (5.8 percent), respectively.

Equations for total harvested feed grain acreage and harvested cotton acreage were developed using effective prices determined by the same economic principles developed for the soybean models. The

feed grain equation had as significant variables the effective prices of feed grains, soybeans, and cotton and the diversion payment variable, and feed grain acreage lagged one year. Projections of harvested feed grain acreage made six months in advance for the years 1966-74 had an average error of 7.1 million acres or 7.1 percent. The harvested cotton acreage equation had as significant variables the effective price of cotton and soybeans and cotton acreage lagged one year. The equation explained 93 percent of the variation in cotton acreage over the years 1948-74 and projected harvested cotton acreage six months in advance for the years 1966-74 with an average projection error of 2.9 million acres or 26.8 percent.

CHAPTER I

INTRODUCTION

Soybean acreage has expanded steadily from about 10 million harvested acres in 1948 to approximately 56 million harvested acres in 1973. Today, soybeans are the leading oilseed in world trade; soybean oil is the most important of the edible oils available in the world; soybean meal ranks first in importance in world markets for high-protein livestock feeds; and as a cash crop in the United States soybeans are now rivaled only by corn.¹ The extraordinary expansion of soybean production has resulted from a combination of economic and scientific forces. Improvements in corn production technology have more than doubled corn yields since World War II. As a result, the demand for corn has been met at least until 1974 with fewer and fewer acres. Relatively low feed grain market prices, coupled with government programs designed to reduce feed grain output, have stimulated soybean production throughout the Corn Belt. In the South and Southeast, soybeans have moved onto acres released from cotton and have further expanded at the expense of declining oats acreage. Accompanying the persistent increase in soybean acreage has been an increase in the worldwide demand for soybeans. Supplies (production plus stocks) with few exceptions have increased annually since the mid-1950's. Soybean market prices have not been depressed relative to feed grain market prices, as Figure 1 indicates. Recently, the large increases in soybean prices since 1971 have occurred with record increases in soybean supplies. The main forces permitting increased production at "reasonable" prices include increased worldwide demand for soybeans and soybean products, acreage controls on other feed grains, and more recently, crop failures in different parts of the world, and the devaluation of the United States dollar.

An important consequence of the simultaneous expansion of soybean supply and demand is that acreage controls on soybeans have not been necessary to support prices. In fact, soybean market prices have fallen below the loan rate in only five of the past twenty-five years. The absence of acreage controls on soybeans during the years in which controls were imposed on competing crops such as corn and cotton account for much of the expansion in soybean acreage. An overview of the influences on soybean acreage of feed grain and cotton policy decisions is presented in Table 1. The evidence presented in Table 1 leaves no doubt as to the importance of government policy as a variable to be considered in analyzing and predicting changes in soybean acreage.

¹Houck, James P., Mary E. Ryan, and Abraham Subotnik, Soybeans and Their Products: Markets, Models, and Policy, University of Minnesota Press, Minneapolis, Minnesota, 1972, p. 3.

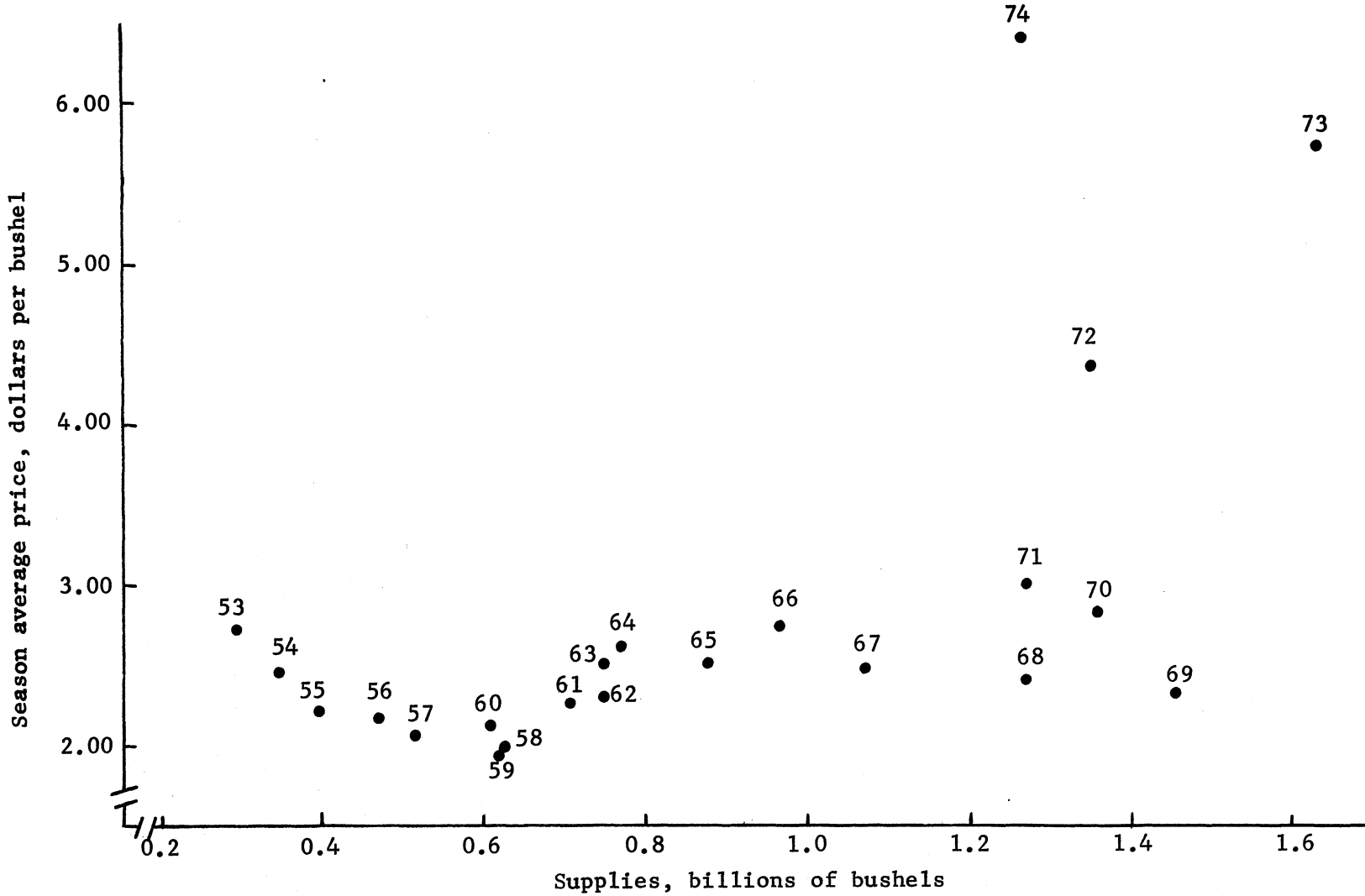


Figure 1. Soybean supplies (September 1) and farm price, United States, 1953-74.

Table 1. Chronology of policy events affecting harvested soybean acreage, 1950-1973

Year(s)	Policy event(s)	Change in harvested soybean acreage from previous year
1950	Allotments imposed on corn and cotton acreage	32 percent increase (3.4 million acres)
1951	Corn and cotton allotments eliminated	1.5 percent decrease (0.2 million acres)
1954	Allotments imposed on corn and cotton acreage	15 percent increase (2.2 million acres)
1959	Corn allotment removed	6 percent decrease (1.3 million acres)
1961-70	Feed grain acreage diversion program in effect	87 percent increase over life of the program (18.6 million acres)
1971	Acreage set-aside program introduced-soybeans not permitted on feed grain base	1 percent increase (0.5 million acres)
1972	Acreage set-aside requirements increased-soybeans permitted on feed grain base	7 percent increase (2.9 million acres)
1973	Feed grain set-aside requirements reduced by approximately 25 million acres-soybeans permitted on feed grain base	23 percent increase (10.7 million acres)

The Problem

The recent increases in the prices of soybeans and other agricultural commodities and the wide variations in agricultural prices within and between crop years have magnified the need for a basic analytical framework for predicting short-run aggregate acreage response to changing prices and government programs. The need for such a framework has long been recognized. T. W. Schultz stated in 1939 that farm management research was failing to provide results useful to policymakers for evaluating alternative proposals for national agricultural policies.² Heady and Shaw in 1954 stated, "While his tools are sharp and plentiful, the economist often lacks the empirical counterpart of his logic to help guide economic adjustments and policies."³ In 1966 Scofield stated that because of preoccupation with mathematical models, research contributions to policy formulation and guidance, in service to farm organizations and to the various sectors of our agricultural complex have fallen short.⁴ While long recognized as top-priority research, efforts to obtain an analytical framework for analyzing short-run effects of price and policy changes on crop acreages were minimal until the formation of the Aggregate Production Analysis Team (APAT) within the Farm Production Economics Division of the Economic Research Service of the U.S. Department of Agriculture in 1964. APAT's purpose was to help answer specific policy questions posed by the Administration and the Congress. The specific objective was to develop a systematic framework to provide short-run estimates of production, resource use, and farm income under alternative government farm programs.⁵ APAT constructed a model consisting of approximately 90 linear programming submodels by a combination of formal and informal methods. To make the submodels predictive rather than normative, "flexibility" restraints based on policy alternatives and other knowledge were imposed on the linear programming solutions. The APAT work will be reviewed in more detail later since it represents a basic approach to the problem under consideration.

Another basic approach to analyzing and predicting short-run aggregate acreage response is through analysis of time-series data using statistical analysis. Work in this area has been complicated by the fact that data generated under one government program may not be directly comparable to data generated under other programs. The information presented

²Schultz, T. W., "Theory of the Firm and Farm Management Research," Journal of Farm Economics, 21:58-70, August 1939.

³Heady, Earl O. and Russell Shaw, "Resource Returns and Productivity Coefficients in Selected Farming Areas," Journal of Farm Economics, 36:243-57, May 1954.

⁴Scofield, William H., "Analyzing the Structure of Agribusiness Relations," Journal of Farm Economics, 48:137-90, December 1966.

⁵Sharpless, Jerry A. and W. Neill Schaller, "Predicting Short-Run Aggregate Adjustment to Policy Alternatives," American Journal of Agricultural Economics, 50(5):1523-66, December 1968.

in Table 1 reflects this problem rather well. The first efforts to develop a systematic method for constructing policy variables applicable to different farm programs were those of Houck and Subotnik in their soybean acreage response study covering the time period 1946-66.⁶ In this study they introduced the concept of a "weighted" support rate. The weighted support rate was designed as a means of combining both announced support rates and acreage restrictions into a single term capable of empirical measurement and estimation. This work will be reviewed later as will subsequent research based on Houck and Subotnik's concept.

Although several useful and interesting studies in the area of acreage response to policy changes have entered the body of literature in recent years, in our judgment there does not exist today a procedure for calculating policy variables which is applicable (for use in a single specific model) to the entire range of government programs witnessed to date. This is especially true with respect to the calculation of policy variables for analyzing the effects of changes in the acreage set-aside programs of 1971-73 and for determining the effects of the feed grain acreage diversion programs of 1961-70 on soybean acreage response.

The Objectives

The main objective of this research was to provide a widely applicable framework for predicting short-run aggregate soybean acreage response under various agricultural programs. To achieve this, an integral part of this study was the construction of analytical models based on the theory of the firm as it relates to farm product substitution to analyze producers' response to alternative farm programs for both soybeans and competing crops.

Production response is, of course, composed of acreages and yields, both of which vary from year to year. Although most production policies are ultimately concerned with product supply, they have been oriented toward acreage rather than quantity. That is, product supply control is effected primarily by restrictions on the land input, and policy questions are formed in terms of acreage response rather than quantity response. Additionally, emphasis upon acreage response reduces the amount of variability that must be considered in evaluating alternative policies. To evaluate producer response to a specific policy, one normally assumes a "normal" yield adjusted for trend, since a major yield variability inducing factor--weather--is beyond the control of man. Thus, acreage response is the crucial variable in policy formulation. For these reasons, this research was devoted to acreage response rather than product supply response.

⁶Houck, James P. and Abraham Subotnik, "The U.S. Supply of Soybeans: Regional Acreage Functions," Agricultural Economics Research, 21(4):99-108, October 1969.

The specific objective of this research was to formulate an acreage response model for soybeans utilizing price variables adjusted on the basis of applicable support rates, allotments, acreage diversion, acreage set-aside, and target prices. To this end both regional and national models were developed and tested against standard economic and statistical criteria. Emphasis was placed on the ability of the models to project soybean acreage six months to fourteen months in advance. The evidence presented in Table 1 clearly demonstrates the need for the construction of policy variables based on sound economic principles for the acreage response model to be capable of withstanding the vital test of projecting acreage.

The highest goal for the analysis and results presented in this report is to provide a timely and practical method for evaluating alternative policies for the purpose of projecting crop acreages. At the minimum it is hoped that this study provides inspiration for additional research into this vital area.

CHAPTER II

APPROACHES TO THE PROBLEM

There are two basic approaches to the problem of predicting short-run acreage response. These are, as noted earlier, linear programming and statistical analysis of time-series data. In this chapter some of the most relevant research based on the two methods will be reviewed for the purpose of identifying the formative elements of the model constructed in the course of this study. In the course of the review, the strengths and weaknesses of each method will be noted with respect to incorporating policy into the model as a variable.

The Programming Approach

An important application of linear programming to the problem of analyzing and predicting aggregative acreage response is contained in the work of J. M. Henderson.¹ Henderson's work is founded upon the hypothesis that in any year only a limited change from the previous year's acreage can be expected due to a multitude of forces. Uncertainties regarding prices and yields, habitual production patterns and restrictions on the supply of production inputs are among the more important. The constraints imposed on the linear programming solution by the economic and behavioral forces limiting adjustments are called "flexibility restraints" by Richard H. Day.² The purpose of the flexibility restraints is to make the model predictive as opposed to normative. To illustrate the actual workings of the flexibility constraints, suppose that the acreage response function of a crop is:

$$(2.1) \quad A_t = a_1 + a_2 P_{t-1} + e$$

where A_t is the current year's acreage, P_{t-1} is market price lagged one year, a_1 and a_2 are constants, and e is a disturbance term.

For a given resource situation the upper and lower limits on the solution acreage may be expressed respectively as:

$$(2.2) \quad A_t \leq (1 + B_u) A_{t-1}$$

¹Henderson, James M., "The Utilization of Agricultural Land," Review of Economics and Statistics, Vol. 41, 1959, pp. 242-59.

²Day, Richard H., "An Approach to Production Response," Agricultural Economics Research, 14(4), October 1962, pp. 134-48.

and

$$(2.3) \quad A_t \geq (1 - B_1) A_{t-1}$$

where B_u and B_1 are the maximum percentage increases and decreases, respectively, from the previous year's acreage, A_{t-1} . The flexibility coefficients (B_u and B_1) may be determined by a variety of methods usually combining time-series data with information concerning, for example, changes in government policies or the introduction of new technology. This synthesis of time-series analysis and linear programming has been labeled "recursive programming."^{3,4} In essence the recursive programming model assumes that producers act to maximize profit within restrictive limits imposed by the conglomerate of economic and behavioral factors noted earlier.

The APAT Research

The model developed by APAT is an elaboration of the cobweb model that uses recursive linear programming to estimate aggregate production and resource adjustments under alternative policies, prices, costs, and technologies.⁵ The 95 programming submodels developed by APAT yielded a total of 3,270 acreage estimates in the five-year test (1960-64). Two-thirds of the estimates were restrained by the crop's upper and lower flexibility restraint.⁶ This emphasizes the importance of estimating flexibility restraints on the basis of theoretically sound economic and statistical reasoning. The argument has been advanced that if the bounds are effective consistently (that is, if the estimated acreages consistently equal an upper or lower bound), they may be taken as estimates of response.⁷ Regardless of the merits of that argument, such dependence on the flexibility restraints with respect to predicted acreages reflects an inherent weakness in the structure of the model (at least, the APAT model). Additionally, in the APAT model the cropland restraint was the only major physical restraint due to the "impossibility" of defining labor, capital, and livestock restraints for a group of farms.

³Day, Richard H., "Recursive Programming and Supply Prediction," A.E.A. Readings in the Economics of Agriculture, Richard D. Irwin, Inc., Homewood, Illinois, 1969, p. 109.

⁴Strictly speaking, flexibility constraints are not a requirement for recursive linear programming.

⁵This section is based on Schaller, W. Neill, "A National Model of Agriculture Production Response," Agricultural Economics Research, 20(2): April 1968, pp. 33-46.

⁶Ibid., p. 40.

⁷Ibid., p. 40.

If the model had been more fully specified with respect to the other restraints, it is likely that the dependence on the flexibility restraints would have been decreased. In addition to data problems, the APAT discovered that the number of flexibility restraints in the model precluded obtaining answers to policy questions in less than a few weeks time since the flexibility restraints had to be reestimated each time any parameter in the model was changed.

Comparison of Linear Programming and Statistical Model

The review of the APAT's work points to some problems of the linear programming approach and leads to its comparison with the statistical approach in predicting acreage response.

Schaller gave the following reason for selecting the programming model as the most appropriate (as opposed to statistical models) to achieve the APAT's objectives: "As statistical models analyze data on actual economic behavior, the resulting estimates are considered more predictive than the solutions to an optimizing model. However, policy questions typically require analyses of effects of production environments that differ substantially from the 'structure' observed in the past."⁸ This reasoning assumes that the flexibility restraints may be adjusted so as to capture the effects of policy changes, whereas no comparable device exists to serve that purpose in statistical analysis. When APAT was formed, there were no published studies concerned with the construction of a basic framework for incorporating policy into the time-series analysis. Linear programming models are generally superior to regression analysis in accounting for technological changes, provided a basis exists for establishing realistic flexibility restraints and new technical coefficients. Given the objectives of this research, regression analysis is considered to be more suitable for a number of reasons. First, regression analysis is less time consuming both in development and operation. For purposes of alternative policy evaluation, one objective is that the model be as current as the data permit and that answers be forthcoming in a short time period. Second, statistical acreage response functions being derived from actual economic behavior are more predictive than linear programming models, provided they account for relevant institutional changes (in this case, policy changes). Third, the dependence of the more predictive linear programming models on the flexibility restraints which means the ability of these models to predict depends upon how accurately these restraints are estimated. If the extent of this aforementioned dependence is extreme, as in the case of the APAT's model, the argument that the bounds themselves be taken as estimates of response has some merit. Furthermore, the bounds by their very nature normally require definition by some sort of time-series analysis.

⁸Ibid., p. 34.

Statistical Model

In view of the above considerations and the ability of statistical analysis to predict observed economic behavior, statistical analysis was deemed the most appropriate method for fulfilling the objectives of this study. The application of regression analysis to the problem is not without difficulties. The most complex problem is to devise a means of normalizing the changing policy environment so that data generated under one set of policies will be comparable to that generated all other sets of policies. This difficulty can be illustrated by the aid of a simple acreage response model of the form:

$$(2.4) \quad A = a_0 + a_1 P_b + a_2 P_c + e$$

where A is harvested acreage of crop B, P_b is the relevant supply inducing price of crop B, P_c is the supply inducing price of a competing crop, C, and e is a disturbance term. Economic theory suggests a positive sign on a_1 and a negative sign on a_2 . Now, suppose that data are obtained over a period of years in which three distinct sets of policies were applied to the competing crop. Suppose these policies were:

Policy X: No acreage restrictions.

Policy Y: Allotment imposed on the competing crop permitting acreage planted to 75 percent of base acreage.

Policy Z: Same as policy Y except that the competing crop is restricted to 50 percent of base acreage.

Assume that acreages A_1 , A_2 , and A_3 have been observed at price P_0 for crop B (Figure 2) and further assume that the price of the competing crop, P_c , has been constant over the three observations. The acreage response function, as presently specified, would have no practical value in either analysis or prediction if the observations were generally of the nature of those presented in Figure 2. The explanation for the variability in acreage of crop B at a constant price for both crop B and C is found outside the model, that is, in the differing policy environments. Our knowledge of the three policies suggests that observation (P_0, A_1) is observed along line X in Figure 2 and that observations (P_0, A_2) and (P_0, A_3) are observed from functions Y and Z, respectively, where line Y corresponds to Policy Y and line Z to Policy Z. In essence, there is a separate acreage response function for each set of circumstances, with the problem being to derive a single function applicable to all observations. The fact that policy has been varied with respect to the competing crop offers a clue to deriving a universally applicable function.

With no price or policy changes for crop B having been observed, the increase in the acreage of B over Policies X to Y to Z may be explained by the decline in the weighted price of crop C where the weights vary directly with magnitude of the acreage allotment. For Policy X, the weight is 1.0; for Y, 0.75; and for Z, 0.50; and the

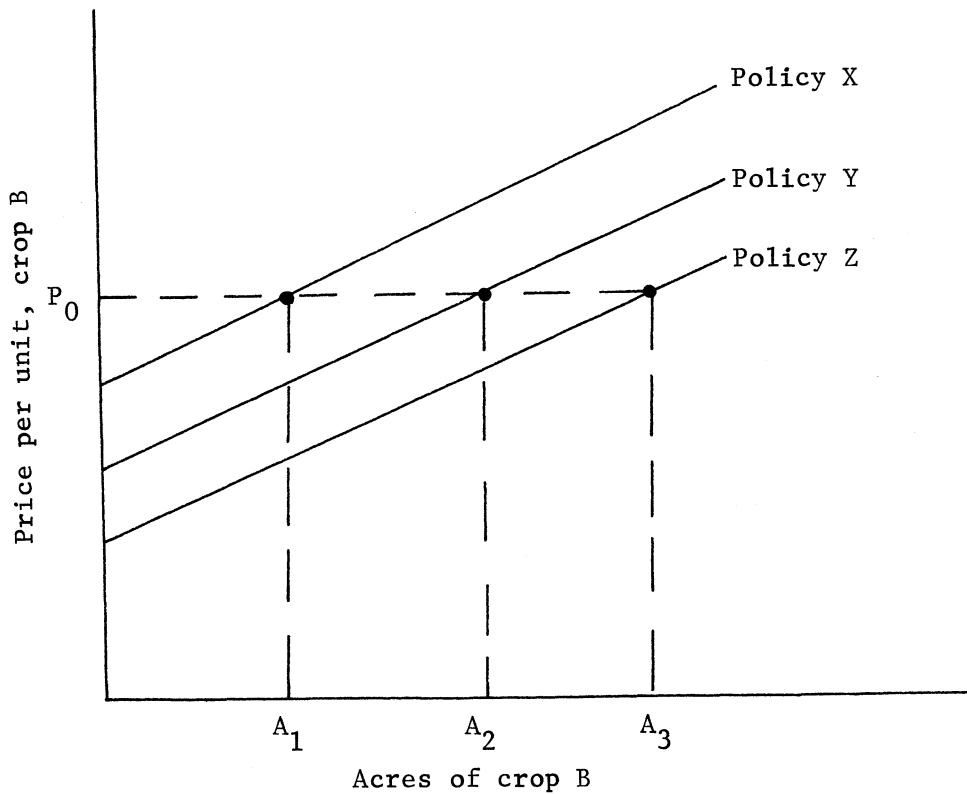


Figure 2. Interaction between price and policy for competing crops.

respective weighted prices are P_c , $0.75 P_c$, and $0.50 P_c$. Thus the weighted price is consistent with the acreage response function, since the decline in weighted price predicts an increase in the acreage of crop B.

Review of Statistical Acreage Response Studies
Incorporating Policy Variables

The pioneering work in developing a systemic framework for the inclusion of policy variables in acreage response functions derived by regression analysis is that of Houck and Subotnik.⁹ To estimate the effects on soybean acreage of changes in both the soybean support rate and in price supports and acreage restrictions of competing crops, the authors developed the concept of "effective support price." The concept may be illustrated by a simple acreage supply function given by

⁹Houck and Subotnik, "The U.S. Supply of Soybeans: Regional Acreage Functions," pp. 99-108.

$$(2.5) \quad A = a_0 + a_1 P$$

with the same assumptions as those for equation (2.4). Assume that a support price PS is offered to farmers only if they reduce acreage to AS (Figure 3),¹⁰ compared to AO which would be harvested without restrictions. The price which would hold acreage to AS without restrictions is PF and is called the "effective support price."¹¹

To find a function which transforms PS into PF by deflating the announced support rate, equation (2.5) is evaluated at two points, PS and PF.¹² At each of the two points:

$$(2.6) \quad a_1 = \frac{AO - a_0}{PS} = \frac{AS - a_0}{PF}$$

which implies that

$$(2.7) \quad PF = \frac{(AS - a_0) PS}{AO - a_0}$$

If $a_0 = 0$ or is small relative to AS and AO, then

$$(2.8) \quad PF = (AS/AO)PS.$$

Houck and Subotnik estimated six regional supply equations for harvested soybean acreage (1946-66) using the principle illustrated by relation (2.8) to estimate policy variables for competing crops such as corn, cotton, and wheat. Policy variables were calculated on the basis of allotted acreage (AS), historical base (AO), and the announced support rate. To adjust PF for provisions of the acreage diversion programs (1961-66), the authors developed a "weighted diversion payment" variable.¹³ The values of the weighted diversion payment variable (DP) reflect changes in eligible diversion acreage and in the payment levels for diversion. The diversion payment variable was calculated as follows:

$$(2.9) \quad DP = \frac{W_1 R_1 + W_2 R_2}{2}$$

where R_1 is the payment for minimum diversion, W_1 and R_2 is the payment for maximum diversion, W_2 . An increase in either factor (W or R), holding the other constant, increases the value of DP. An increase (decrease) in DP indicates that the acreage supply function for the particular crop has shifted to the left (right).

¹⁰Ibid., p. 100.

¹¹Ibid., p. 100.

¹²Ibid., p. 100.

¹³Houck, et al., Soybeans and Their Products: Markets, Models, and Policy, p. 104.

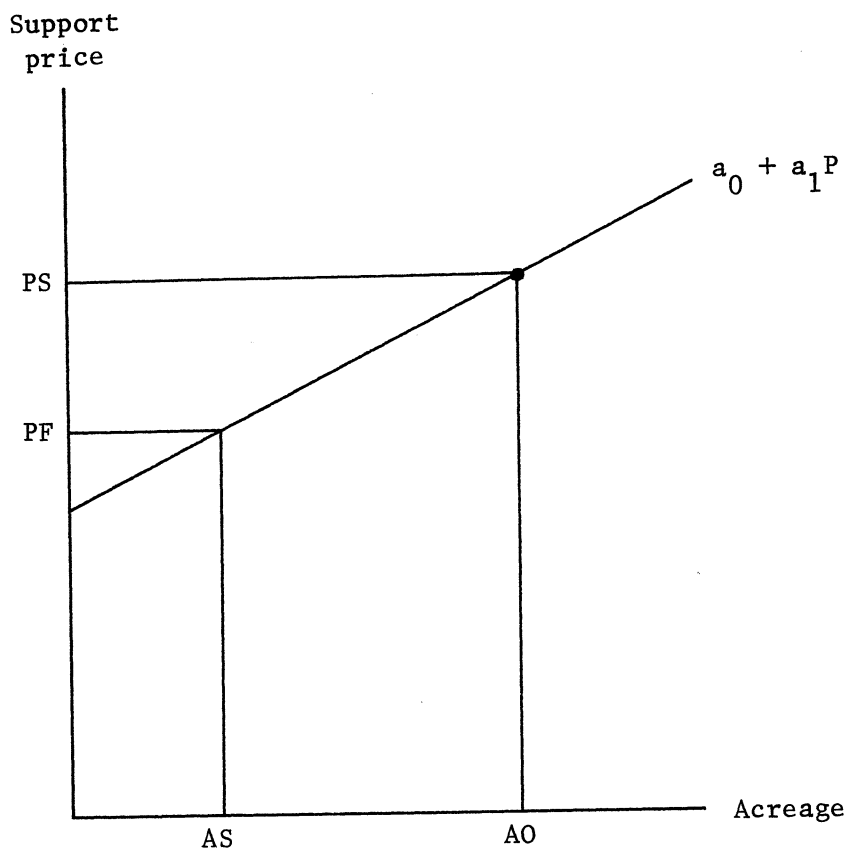


Figure 3. The effective support price.

In their equations, Houck and Subotnik included, in addition to lagged regional acreages both the effective support rates and lagged market price of soybeans and competing crops. The coefficients of multiple determination (R^2) for the regional equations ranged from 0.76 to 0.98 with the R^2 for the aggregate function being approximately 0.96. The standard errors of the estimates were not reported nor were any tests of the equations' ability to predict reported.

The procedures developed by Houck and Subotnik for constructing policy variables are applicable under a system of allotments for which severe penalties are in effect for producing above the allotment. The procedure would need modification, for example, in constructing effective prices for cotton and wheat for the years 1971-74. During these years the penalty on production in excess of the allotment was not sufficient to restrict production to the allotment acreage. Consequently, market prices have some influence on the acreage planted in addition to the support rates.

The manner in which the provisions of the feed grain acreage diversion programs were accounted for need modification for this study. Houck and Subotnik varied the effective support rate (price) for corn in direct proportion to the acreage diverted. Since soybeans were not permitted on the released acreage, variations in the corn acreage diverted should have no influence on soybean acreage (the dependent variable).

The inclusion of both effective support rates and lagged market prices for each crop considered in the acreage response function is likely to present some statistical problems. One would expect lagged market prices and current support prices to be highly correlated since a high lagged market price is likely to be followed by a policy encouraging production and vice versa. Houck and Ryan¹⁴ determined that a change in the market price of corn was associated with a similar change in the effective support rate for the next crop year equal to about 90 percent of the market price change.

Since the publication of Houck and Subotnik's original work in 1969, several studies based on the concept of effective support rates have been reported in addition to the corn study previously referenced.¹⁵ These studies have many common characteristics, namely: (1) market prices have not been considered, (2) the weighted diversion payment variable (DP) and the effective support rate (PF) are both included in the same equation, and (3) those studies which covered the set-aside program have conceptually equated set-aside payments with diversion payments.

Although high R^2 's and relatively low standard errors have been reported in each of the studies, their applicability to the entire spectrum of government programs is limited by the three characteristics noted above. First, the omission of market prices is valid only if they are consistently below support prices. The experience of the last two

¹⁴Houck, J. P. and Mary E. Ryan, "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," American Journal of Agricultural Economics, Vol. 54, No. 2, May 1972, p. 188.

¹⁵Hoffman, Robert G., "Wheat-Regional Supply Analysis," Wheat Situation, Economic Research Service, USDA, August 1973; Abel, Martin E. and Mary E. Ryan, "Corn Acreage Response and the Set-Aside Program," Agricultural Economics Research, Vol. 24, No. 4, October 1972; Abel, Martin E. and Mary E. Ryan, "Supply Response of U.S. Sorghum Acreage to Government Programs," Agricultural Economics Research, Vol. 25, No. 2, April 1973; Abel, Martin E. and Mary E. Ryan, "Oats and Barley Acreage Response to Government Programs," Agricultural Economics Research, Vol. 25, No. 4, October 1973; Penn, J. B., Econometric Policy Models of Commodity Supply Response, unpublished Ph.D. dissertation, Purdue University, August 1973.

years would require a restructuring of the models. In particular, soybean market prices have exceeded the support price in 20 of the last 25 years and the average farm prices for 1971, 1972 and 1973 crops have exceeded the support rate by \$0.78, \$2.15, and \$3.40 per bushel, respectively. Second, since both DP and PF are calculated on the basis of the acreage eligible for diversion, they are likely to be highly correlated. In fact the simple correlation coefficient between DP and PF for corn (1961-70) was calculated to be approximately 0.92. In essence the two variables are both measures of the same policy, and only one needs to be included in the same equation. Third, the concepts of acreage diversion and acreage set-aside are radically different. The former specifically restricts the acreage of a given crop, whereas the latter restricts total acreage and allows the farmer to make his own decision as to the acreage of any given crop. To calculate a diversion payment based on the provisions of the set-aside program under some circumstances leads to highly inaccurate acreage estimates. For example, if a given crop is eligible for set-aside payments and if the market price of that crop has substantially improved with respect to prices of competing crops, the acreage of that crop would expand under the set-aside program. The inclusion of a diversion payment variable (based on the set-aside payments) and the omission of market prices would result in an underestimation of the crop's acreage. The previous studies used the above techniques and obtained reasonable results only because feed grain prices relative to competing crops experienced little change in the first two years of the set-aside program.

The above discussion serves to emphasize that a theoretically sound framework for calculating policy variables needs to be developed. In Chapter III this task will be addressed.

CHAPTER III

THEORETICAL CALCULATION OF POLICY VARIABLES

In this chapter the theoretical framework for the construction of effective price variables including the effects of farm commodity programs for both the controlled crops and for those not directly controlled, such as soybeans, will be developed. Economic theory provides a basis to determine how producers respond to variations in the provisions of a specific program and the replacement of one program by another. If the theoretical response of profit-maximizing farmers to changes in prices and government programs can be determined, these variables can be used as a starting point for analyzing the actual response of producers to these variables.

Theoretical Model

The problem of farm product substitution and the theory of choice may be summarized with reference to Figure 4. Curve PP, a production possibilities curve,¹ shows the possible combinations of products X and Y that may be produced for a given state of technology and a fixed bundle of resources. The curve is drawn concave to the origin indicating that as the production of X (Y) increases, the cost in terms of sacrifices in the output of Y (X) is increasing. This implies that the PP curve in Figure 4 is based on physical production functions for X and Y with decreasing marginal returns and consequently cost functions with increasing marginal costs. A second factor consistent with concave PP curves is heterogeneity in resource quality. For example, if soil type "A" is better suited for X and soil type "B" for Y, a shift from Y to X on "A" will result in a smaller sacrifice in Y than would result if the same shift occurred on "B."

For profit maximization the choice indicator is provided by the farm product price ratios. Maximum profits are attained, with costs or resources fixed in quantity, when the marginal rate of product substitution is inversely equal to the product price ratio.² For products X and Y, the condition of maximum profits is:

¹Also known as "opportunity" or "transformation" curves. For a complete discussion of this concept see Heady, Earl O., Economics of Agricultural Production and Resource Use, Prentice-Hall, Inc., Englewood, N. J., 1952, pp. 201-75.

²Heady, E. O., Economics of Agriculture Production and Resource Use, pp. 240-41.

$$(3.1) \quad \frac{\Delta X}{\Delta Y} = \frac{PY}{PX}$$

or

$$(3.2) \quad (\Delta X)PX = \Delta Y(PY)$$

where PX and PY are the prices of products X and Y .

The choice indicator may be viewed graphically as an iso-revenue line (II in Figure 4) with the slope indicating the ratio of prices between the two products. At the point of tangency (X_0, Y_0) of II with PP the slope of II equals the slope of PP, that is, the equilibrium position given by either equation (3.1) or (3.2) are met.

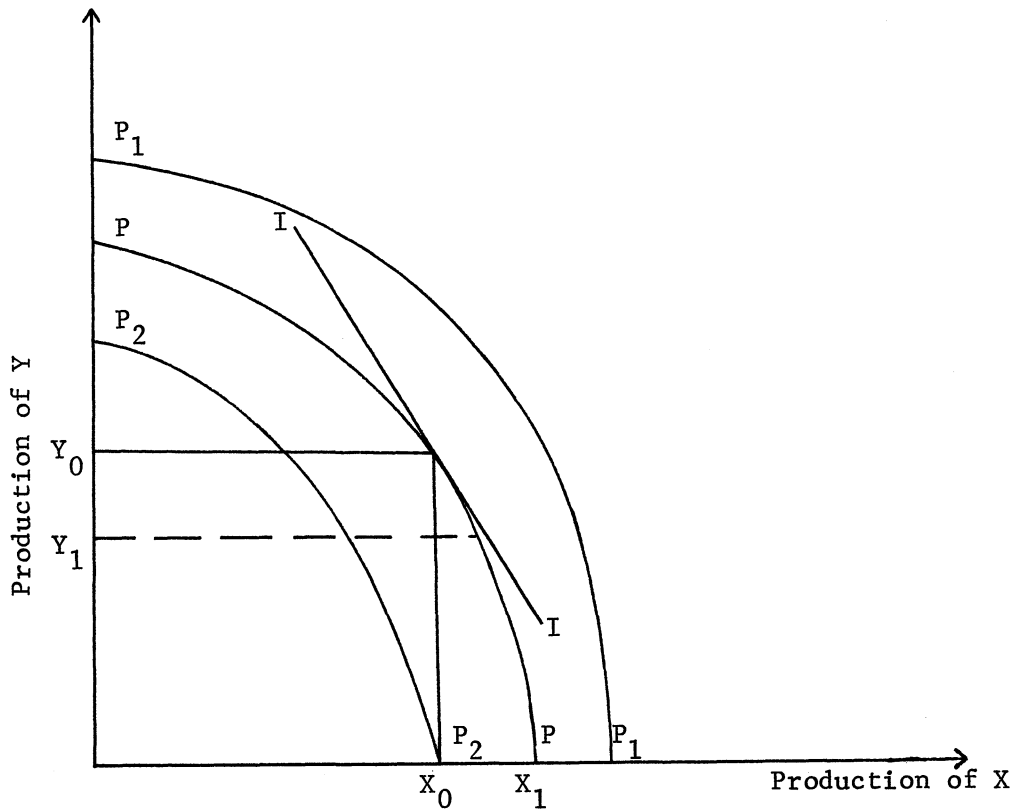


Figure 4. The production possibilities curve.

Farm Policies and the Production Possibilities Curve

Underlying the production possibilities (PP) curve is a given technology and a given bundle of resources. Government programs via acreage controls affect the shape and position of the PP curve. Thus, in addition to the physical conditions underlying the PP curve, there is an institutional or policy factor. The PP curve may be shifted outward to P_1P_1 or inward to P_2P_2 by acreage expansionist or restrictive policies, respectively.³ A policy restricting the production of Y to Y_1 but not restricting the production of X would result in the PP curve Y_1RP . These are but two of the many examples that could be presented. However, they should be sufficient to illustrate the impacts of changing policies on the PP curve.

In addition to affecting the shape and location of the PP curve, policy may be used to change the slope of the choice indicator, that is, the iso-revenue curve, II. If the relevant supply-inducing price of product Y is the loan rate, the policymakers can by increasing it encourage the production of Y at the expense of X and vice versa.

In the past acreage controls, price supports, and various combinations thereof have been used as policy tools to influence aggregative acreage response. The next section will deal with the construction of policy variables under the various farm programs as they applied to the feed grains, cotton and soybeans with particular emphasis on their impact of soybean acreage.⁴

Acreage Allotments

The imposition of, removal of, or variation in acreage allotments for cotton and for corn have had significant impacts on harvested soybean acreage. In 1950 and 1954 when allotments were imposed on cotton and corn acreages, harvested soybean acreage increased 32 and 15 percent, respectively. When allotments on corn were removed in 1951 and 1959, harvested soybean acreage decreased by 1 percent and by 7 percent, respectively.

Except for the cotton allotments of 1971-73, marketing quotas were in effect for cotton with the penalty for production above the allotment severe (50 percent of parity price). Marketing quotas were never imposed

³The PP curve could also be affected by policies concerning the other inputs. If the PP curve is shifted to P_2P_2 via acreage controls but if no marketing quotas are imposed on X and Y, the production-possibilities curve could be shifted back toward PP by increasing the quantity of fertilizers applied, for example.

⁴The details concerning the various programs discussed in this section can be found in Compilation of Statutes Relating to Soil Conservation, Set-Aside, Acreage Diversion, ASCS, USDA, Agriculture Handbook, No. 476, January 1975.

in conjunction with the feed grain acreage allotments. The severe penalties for cotton production in excess of the allotment effectively restricted acreage to the allotment acreage. The construction of policy variables to capture the effects of acreage allotments with or without marketing quotas may be explained with the aid of a diagram (Figure 5). The acreage response curve for the product under allotment is:

$$(3.3) \quad A = a_0 + a_1 P + e$$

where

A = harvested acreage,

P = maximum of the lagged market price or announced support rate on allotted acreage,

a_0, a_1 = estimated parameters, and

e = a disturbance term.

Given a market price, P_m , and assuming that the function $A = a_0 + a_1 P$ in Figure 5 represents the marginal cost of producing the commodity, A_0 acres would be harvested if no acreage controls were imposed. Theoretically, the effectiveness of an acreage allotment in controlling the

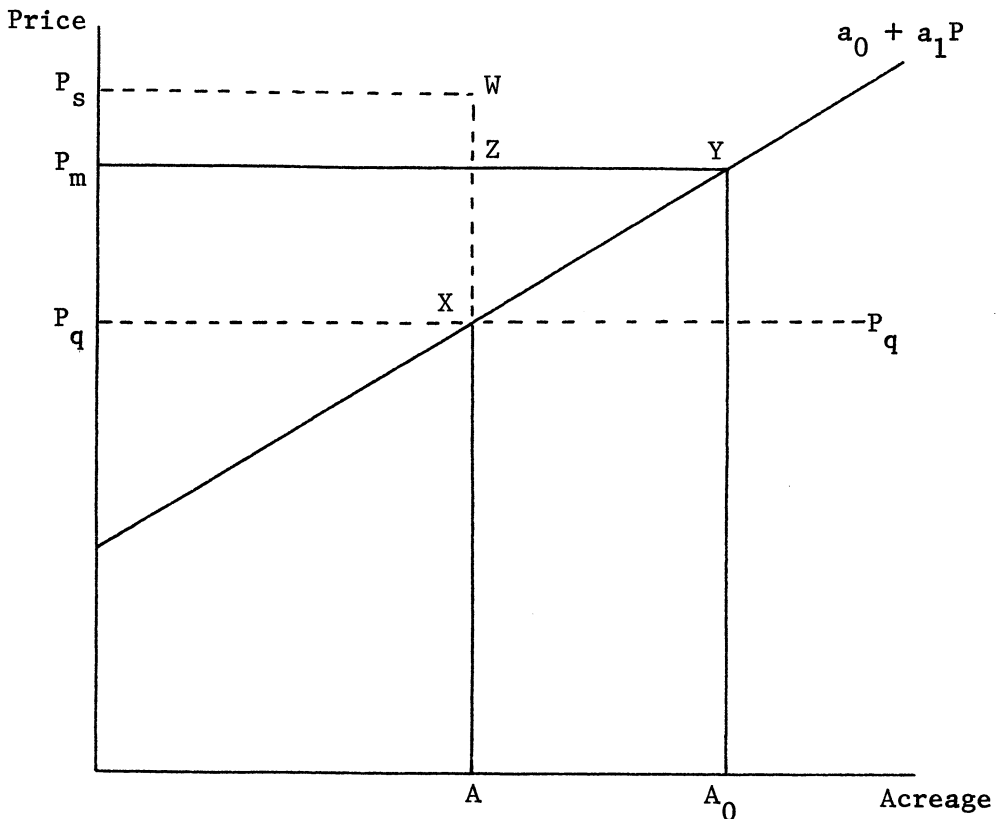


Figure 5. Direct effects of allotments.

production of this particular commodity in the absence of marketing quotas depends upon a comparison of the returns to the fixed factors for production within the allotment as opposed to returns from production above the allotment. With reference to Figure 5 where the acreage allotment is denoted as A at a support price, P_s , and where the expected market price is P_m , this involves a comparison of the area of the rectangle, $P_m ZWP_s$, with that of the triangle, XYZ. If the area XYZ is greater, profit-maximizing producers would not hold acreage to the allotment, A. In the absence of marketing quotas and if P_m exceeds P_s , the effective price (PE) of the commodity is calculated as:

$$(3.4) \quad PE = P_m$$

If the support rate exceeds the market price or is guaranteed on production within the allotment regardless of total acreage, the effective price is calculated as:

$$(3.5) \quad PE = \frac{A}{A_0} (P_s) + \frac{A_0 - A}{A_0} (P_m)$$

If the loan rate guaranteed on production above the allotment is greater than the lagged market price, it replaces P_m in equation (3.5). A historical base acreage (average annual acreage planted in an unrestricted period) serves as a proxy for A_0 .

It is clear from Figure 5 that to hold acreage to the allotment, the penalty for production beyond point A must be sufficiently severe to drive the net price down to at least P_q for that production. In that case the price line becomes $P_s WZXP_q$ (the broken line in Figure 5). The effective price per unit is calculated as:

$$(3.6) \quad PE = \frac{A}{A_0} (P_s)$$

where the variables are defined above. The penalty for excess marketings was 50 percent of the parity price for cotton. The analysis assumes that the penalty was effective. The effective price varies directly with changes in the allotment and the support price for production within the allotment.

The effects on the acreage of an uncontrolled crop such as soybeans with respect to changes in programs for controlled crops may be illustrated with reference to Figure 6, which shows the production possibilities frontier for soybeans and cotton (PP) and the iso-revenue lines I_0 , I_1 , I_2 based on effective cotton and soybean prices. Given the iso-revenue line II, the production of cotton and soybeans in a free market would be C_0 and S_0 , respectively. If cotton production is restricted to C_q by the imposition of an allotment and if the penalty for production in excess of C_q is sufficient to shift II to at least I_1 , soybean production would expand to S_q . The expansionary effect of this policy on soybean acreage is captured by scaling down the cotton price variable in the soybean acreage response function by the factor A/A_0 , as in equation (3.6).

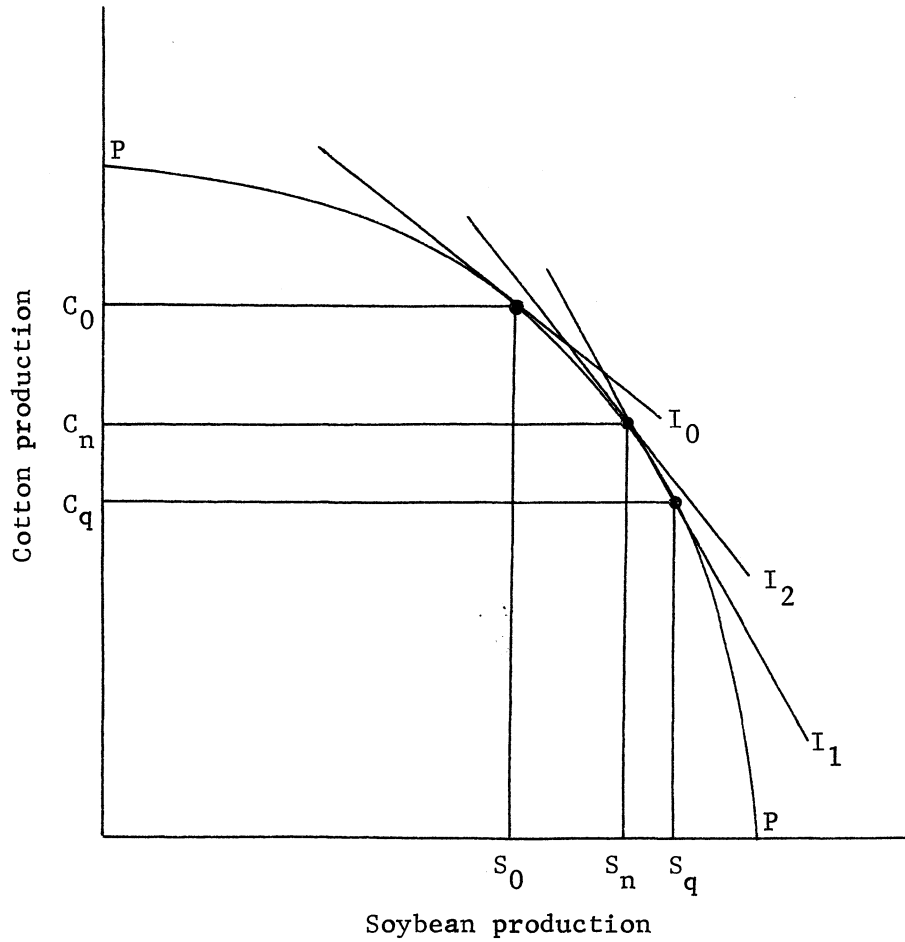


Figure 6. Indirect effects of acreage allotments.

If marketing quotas were not in effect and if the expected market price for cotton was high enough to prevent a shift in I_1 to I_2 , but only to I_2 , the production of cotton and soybeans would be C_n and S_n , respectively. In this case the effective price of cotton would be calculated by equation (3.5) for inclusion in the soybean acreage response function.

Finally, if marketing quotas are not in effect and cotton market prices are greater than cotton support prices, the effective cotton price would be calculated by equation (3.4). That is, no scale factor would be used to adjust cotton prices, and the effective price ratio I_0 would equal the ratio of market prices.

Acreage Diversion Programs

The voluntary feed grain diversion program began in 1961 offering incentives for reducing the production of corn and grain sorghum for the years 1961-70, barley for the years 1962-66 and 1969-70 and cotton for the years 1966-70. Oats were not included in the program. Participation in the feed grain diversion program was voluntary. To participate, a farmer had to divert a specified portion of his base acreage (1959-60 average acreage) to an approved conservation use. To receive direct payments a farmer had to divert a minimum of 20 percent of his base acreage in all years. With the exception of 1967, payments were also made for additional diversion usually up to 40 or 50 percent of base acreage. The payments for the minimum 20 percent diversion (1961-65) and for the additional diversion in all years were generally expressed as a percent of normal yield per acre times the support price for each acre removed from production. In 1966-70 no payment was made for the first 20 percent diverted, but a subsidy of \$0.30 per bushel (for corn as an example) was paid on the basis of projected yield on 50 percent of the base. To aid the readers' understanding, the provisions of a typical acreage diversion program are given in Appendix A.

The cotton program for the years 1966-1968 contained provisions for minimum and maximum acreage diversion as a percentage of the farm allotment. In 1966, producers were required to divert 12.5 percent of their farm allotment to qualify for support payments of 9.42 cents per pound on production from 65 percent of the farm allotment. Up to 35 percent of the farm allotment could be diverted, with a diversion payment of 10.5 cents per pound for projected production from acreage diverted above the minimum 12.5 percent. The 1967 diversion program was the same as 1966 except the direct support payment was raised to 11.53 cents per pound and the diversion payment was raised to 10.78 cents per pound. In 1968, producers were required to divert 5 percent of their farm allotment to qualify for support payments of 12.24 cents per pound on production from 65 percent of the farm allotment. Up to 35 percent of the farm allotment could be diverted, with a diversion payment of 6 cents per pound for projected production from acreage diverted above the minimum 5 percent.

Direct Impact on Feed Grain Acreage

Direct payments for land diversion provide an alternative use for land which producers will take if the returns (profit) from participation in the program exceed those from non-participation. Economic theory provides a basis for identifying the factors which affect the level of participation in the program.

To identify these factors consider the following hypothetical situation:

1. Expected market price (P_m) of corn is \$1.10 per bushel.

2. The payment rate (R_1) for the first 20 percent diversion (W_1) is \$0.60 per bushel on normal yield (100 bushels per acre) from the diverted acres.
3. The payment rate (R_2) for additional diversion (W_2) from 20 to 40 percent is \$0.72 per bushel on normal yield.
4. The producer acts to maximize returns above variable costs which are assumed constant per acre.
5. The base (B) is 100 acres.
6. The support price (P_g) is \$1.20 per bushel.

The price received per bushel produced under the various options is represented by line ABCDN in Figure 7. For maximum diversion the price received is calculated as total payments divided by total production. The total payments consist of (1) the support price on 60 acres, (2) the diversion payment of \$0.60 per bushel on the projected production from 20 acres, and (3) the diversion payment of \$0.72 per bushel on the projected production from the 20 acres of additional diversion. Thus, the total payments are given by:

$$(3.7) \quad \$1.20(60)(100) + \$0.60(20)(100) + \$0.72(20)(100) = \$9,840.$$

Total production from the 60 acres at a yield of 100 bushels per acre is 6,000 bushels. The price received under the program provisions at

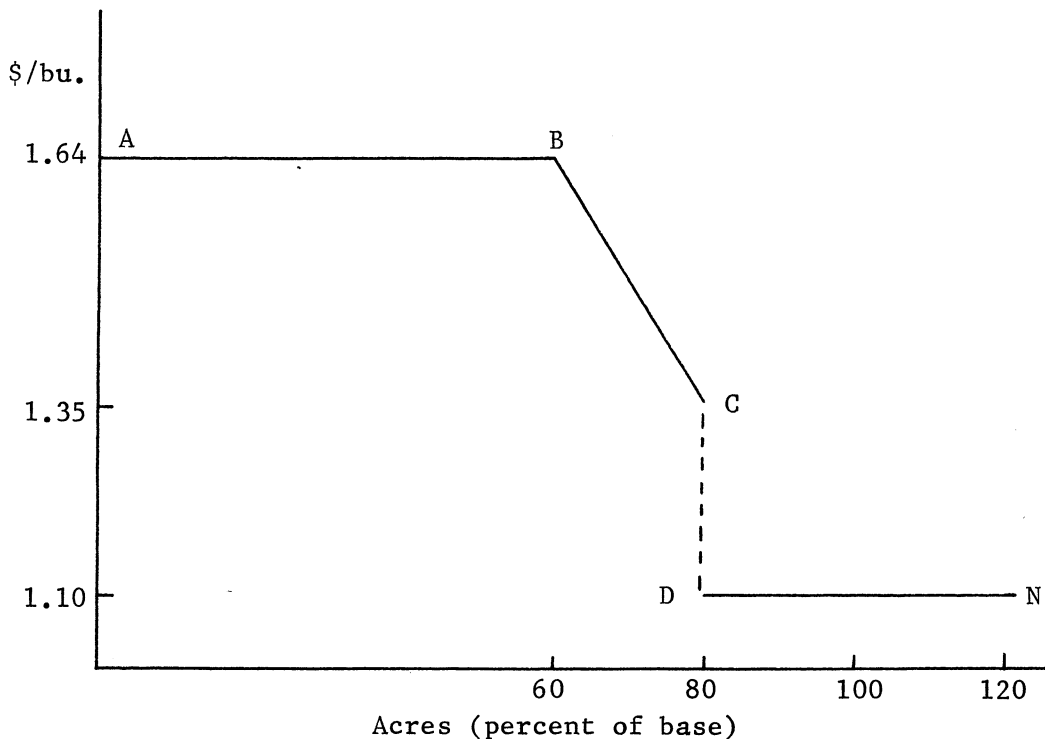


Figure 7. Direct effects of acreage diversion programs.

the maximum diversion is $(\$9,840 \div 6,000)$ or \$1.64 per bushel. Other points on line ABCDN (Figure 7) are calculated in a similar manner. Line AB is drawn under the assumption that the producer plants the acres not diverted.

In Figure 8 these prices are converted to total revenue lines. Line ON with a slope of \$1.10 represents the total revenue received by non-participants. Line EC represents total revenue for producers electing to divert 20 percent. Line EC has a slope of \$1.20 (support price) and the intercept equals the total diversion payment which is $20(100)(\$.60) = \1200 . Line AB is the total revenue for producers diverting 40 percent of base. The slope of AB is \$1.20 and the intercept is $\$1200 + 20(100)(.72) = \2640 . All possible total revenues are given by the line BCDN assuming the producer plants the acres not diverted.⁵

To complete the picture, total variable costs are given by line OX. Under our assumptions the extent of participation depends upon a comparison of the vertical distances between the total revenue lines and the total variable cost line OX. Under this situation, the relevant factors influencing the level of participation under a given cost condition are identified as (1) the level of expected market price which discourages participation as it increases, other things equal, and (2) the acreage eligible for diversion, and (3) the payment rates for various diversion rates.

A weighted diversion payment variable (DP) was used to capture the effects of changes in the diversion program on the acreage response of those crops directly affected. The weighted diversion payment was calculated as:⁶

$$(3.8) \quad DP = \frac{W_1 R_1 + W_2 R_2}{2}$$

where

R_1 is the payment for minimum diversion, W_1

and

R_2 is the payment for maximum diversion, W_2 .

The diversion (and set-aside) payments do not affect the farmer's planting decisions among alternate crops since they are lump sum payments. Thus, they may be ignored when calculating effective prices.

⁵Generally speaking the diverted acres were required to be put to conserving uses with harvesting of crops prohibited. Thus, the diverted acres themselves may be ignored as sources of revenue.

⁶Abel and Ryan, "Corn Acreage Response and the Set-Aside Program," p. 104.

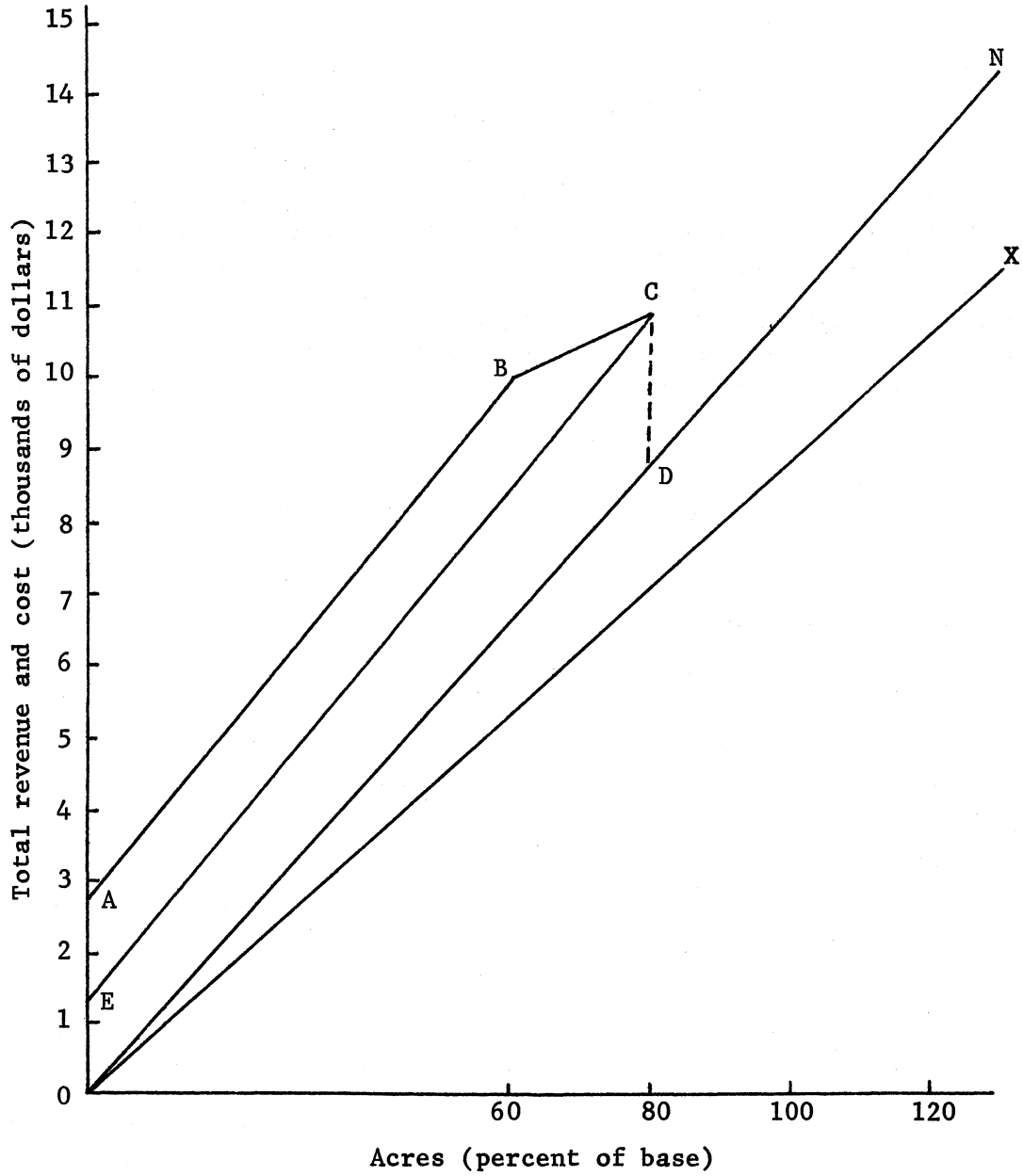


Figure 8. Total revenue possibilities, acreage diversion program.

Increases or decreases in the quantity of feed grain acreage diverted under the 1961-70 Feed Grain Program should have little direct effect on soybean acreage since soybean production was not permitted on diverted acreage. When acreage was taken out of diversion and made eligible for production, soybeans were not substituted for corn since price support payments were not made on that portion of the feed grain base devoted to soybeans.

Acreage Set-Aside Programs

The Agriculture Act of 1970 replaced the acreage diversion programs with a three year set-aside program under which participating farmers were required to set-aside to a conserving use an acreage designated by the Secretary of Agriculture. For corn the set-aside requirements were expressed as a percent of the corn base which was computed as the average acreage planted to corn in 1959-60. In 1972 and 1973 acreage planted to soybeans was considered planted to feed grains. This provision made soybeans more substitutable for corn. In 1972-73, a farmer with a corn base could, after meeting his set-aside requirements, plant all or none of his acreage to either soybeans or corn and still receive set-aside payments. The feature of the set-aside program necessitated adjustments in both soybean and corn prices in 1972-73 and in the corn price in 1971. The provisions of a typical set-aside program are given in Appendix A.

For cotton, producers could set-aside 20 percent of their allotment (2.3 million acres nationally). Since more than one-half of the cotton allotments are outside the soybean production area, and since the possible increase in soybean acreage from cotton set-aside acreage is small relative to the acres set-aside under the feed grain program, the impact of the cotton set-aside program was ignored in computing effective prices. Also in 1971 and following years, marketing quotas were abolished for cotton. Apparently, the removal of marketing quotas more than offset the impact of the set-aside program on cotton acreage since planted cotton acreage increased from 11.9 to 12.4 million acres from 1970 to 1971.

Decreasing (increasing) set-aside requirements has the effect of increasing (decreasing) the acres available for soybeans and competing crops. One may visualize this as a shifting of the production possibilities curve to the left or right as the case may be. To illustrate the calculation of effective prices under the acreage set-aside program using only two crops, Figure 9 is referenced. Suppose that for a given set of circumstances, represented by PP and II, C_1 bushels of corn and S_1 bushels of soybeans would be produced. Now assume that the set-aside requirements are relaxed shifting the production possibilities curve to the right (P'P'). Given a constant price ratio, soybean production would expand to S_2 and corn production to C_2 .

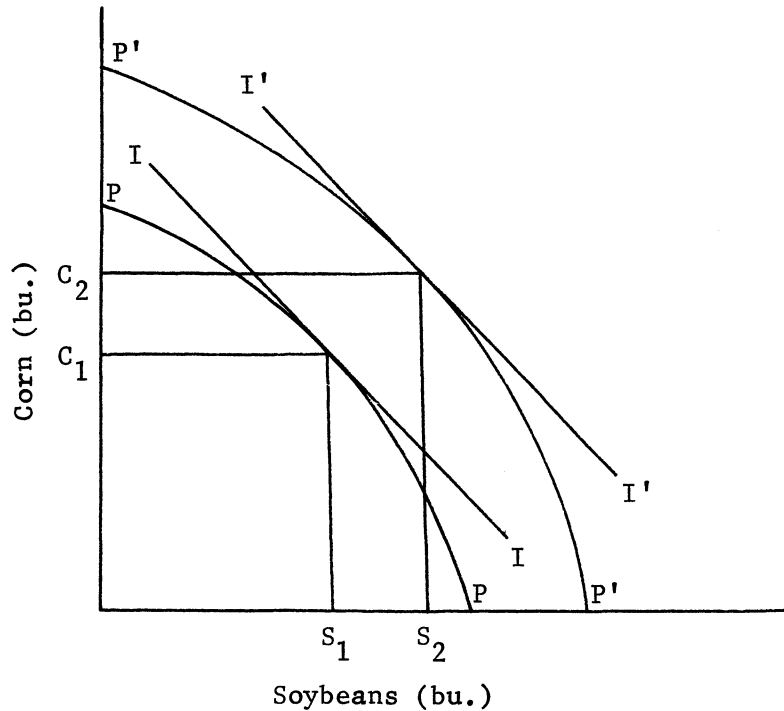


Figure 9. Impact on set-aside program on corn and soybean production.

Calculation of Effective Prices Under Set-Aside Program

To estimate the effect on crop acreages of changing the set-aside provisions, the following procedure was followed. The change in set-aside acreage is calculated as:

$$(3.9) \quad \Delta SA_t = [SA_t - SA_{t-1}]$$

where

SA_{t-1} = previous year acreage set-aside

SA_t = estimated acreage set-aside in current year calculated as the product of the simple average of the minimum and maximum percentages of the base acreage eligible for set-aside times the base acreage.

To estimate the change in soybean acreage (ΔS) and the change in corn acreage (ΔC), the percentage of acres in soybeans (SP) and corn (CP) relative to total acreage in corn and soybeans is assumed to remain relatively constant from year to year. Given SP and CP, S and C are calculated as:

$$(3.10) \quad \Delta S_t = \Delta SA_t \cdot SP_{t-1}$$

and

$$(3.11) \quad \Delta C_t = \Delta SA_t \cdot CP_{t-1}$$

The effective prices are computed as:

$$(3.12) \quad PSE_t = \frac{S_{t-1} + S_t}{S_{t-1}} \cdot PS_{t-1}$$

and

$$(3.13) \quad PCE_t = \frac{C_{t-1} + C_t}{B} \cdot PC_{t-1}$$

where

C_{t-1}, S_{t-1} = lagged corn and soybean planted acreage,

PC_{t-1}, PS_{t-1} = lagged market prices of corn and soybeans, and

B = corn base acreage (average U.S. acreage of corn in 1959-60).

The above formulae may be extended to more than two variables. To derive effective prices for the national model, additions to or subtractions from total acreage were partitioned among soybeans, corn, and oats.

If there is a significant change in relative expected prices, the assumption that SP and CP remain relatively constant is invalidated. To account for such a situation the effective prices computed above will be used to make preliminary projections of soybean and corn acreages. These initial projections will be used to calculate the percentages, SP and CP, from which new effective prices will be determined and new projections made if the percentages SP and CP, based on projected acreages, are substantially different than those based on last year's acreages. The procedure would ultimately base the calculation of effective prices upon current expected acreages rather than the distribution of crop acreages the previous year.

Comparison of Acreage Diversion and Acreage Set-Aside Programs

Previous research involved with evaluating the impacts of the set-aside program have equated the concepts of acreage diversion and acreage set-aside. That this is inconsistent with theory may be illustrated by the aid of Figure 10 showing the familiar acreage response function for crop A ($A = a_0 + a_1P_a + a_2P_c$) with and recalling that P_c is the price of a competing crop, C. Assume that an acreage set-aside program is introduced which would shift A to A' if the total acreage available for

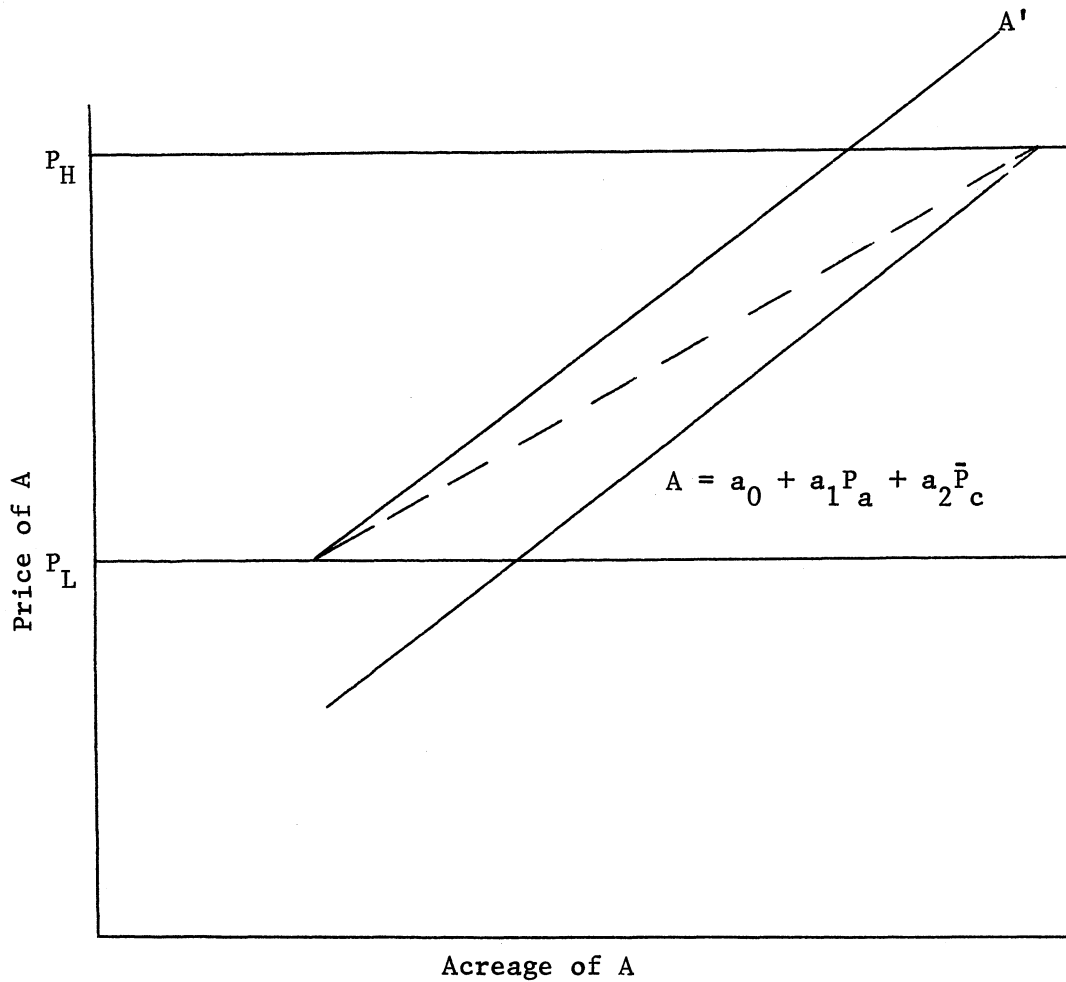


Figure 10. Direct effects of acreage set-aside programs on acreage response function.

set-aside payments is removed from production of crop A. This is basically the effect of an acreage diversion program. However, under the set-aside program no specific crop restrictions were imposed, and the set-aside payments were made regardless of the acreage planted to crop A. Thus, it is reasonable to assume that a profit-maximizing producer would, after setting-aside the specified acreage from his total cropland, adjust his production patterns accordingly. Assuming that the relative variable costs of producing A and C have remained constant, theory suggests that as P_a increases relative to P_c (P_c assumed constant), decreasing acreage would be set-aside from crop A. At some price, P_H , no acreage would be set-aside from crop A, but if the price was sufficiently low relative to P_c , say P_L , the total set-aside would be from crop A. This analysis suggests an acreage response function indicated by the broken line in Figure 10 with expected market prices being crucial in determining crop acreages.

Target Prices

With the enactment of the Agricultural and Consumer Protection Act of 1973, all acreage restrictions for 1974 were abolished at the discretion of the Secretary of Agriculture, and the concept of target or guaranteed prices was implemented. The target prices are guaranteed on production from allotted acres. For example, the cotton allotment is 11.5 million acres for 1974 and the guaranteed price for production within the allotment is \$0.38 per pound. In addition to the guaranteed price for production within the allotment, the loan rate (\$0.20 per pound for cotton) is guaranteed for total production. The wheat and feed grain programs are similar to those for cotton. The calculation of effective prices under the target price program is similar to their calculation under acreage allotments. If the expected market price exceeds the target price (P_T) it is considered to be the effective price. This case is illustrated by Figure 11 in which the expected market price, P_m , exceeds the target price for the allotment, A . The loan rate guaranteed on total production is labeled P_L and the base acreage, A_B .

If the expected market price P'_m is less than P_T , the effective price is calculated as:

$$(3.14) \quad P_E = \frac{A}{A_B} (P_T) + \frac{A_B - A}{A_B} (P'_m).$$

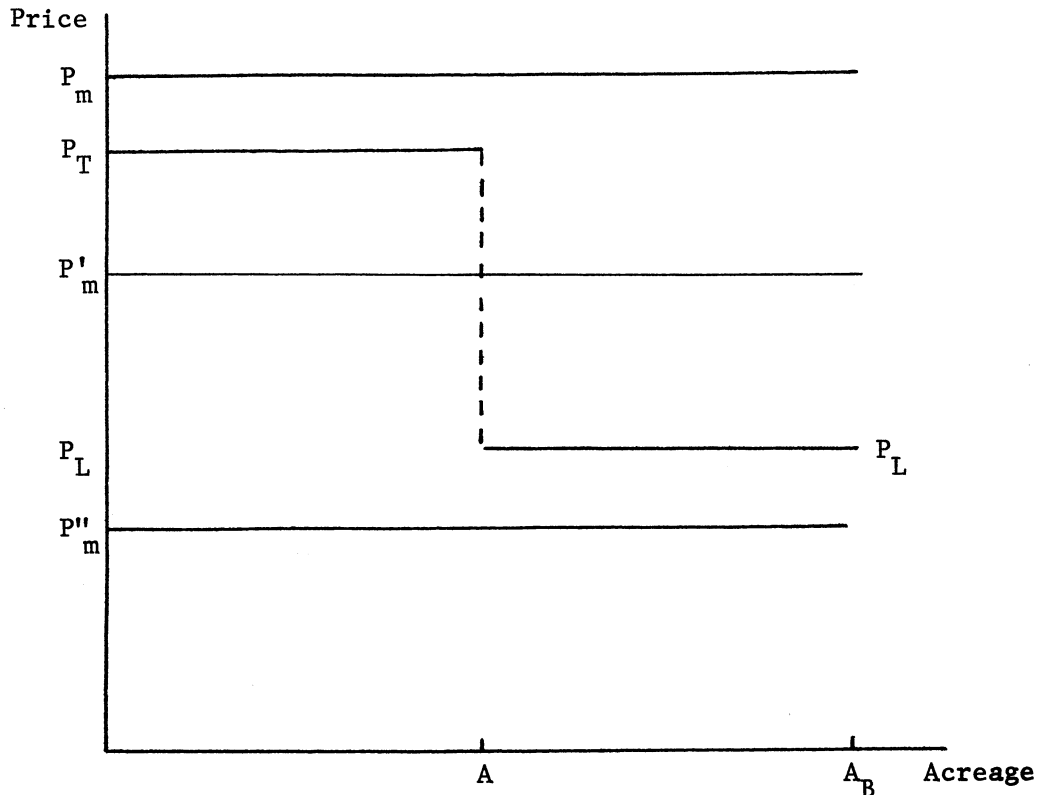


Figure 11. The target price concept.

If the expected market price P''_m is less than P_L , the effective price is calculated as:

$$(3.15) \quad P_E = \frac{A}{A_B} (P_T) + \frac{A_B - A}{A_B} (P_L).$$

No Acreage Restrictions

If a crop is not bound by any acreage restrictions, such as soybeans and oats, the unadjusted supply-inducing price is taken to be the maximum of the lagged market price or the announced support rate. Inclusion of both sets of prices leads to statistical problems of intercorrelation as noted earlier. The exclusion of market prices renders the model inapplicable if they are consistently above the support rate. The exclusion of support prices renders the model inapplicable if they are consistently above market prices or if they remain constant over a period of several years. For example, the soybean support rate has been \$2.25 per bushel since 1969. In view of the tremendous variations in soybean market prices and annual acreages over the 1969-74 period, any model including only soybean support prices would be invalidated. The use of the maximum price avoids these situations described above and enhances the model's applicability.

CHAPTER IV

MODEL SPECIFICATIONS AND CALCULATION OF EFFECTIVE PRICES

In this chapter, after a few comments concerning the geographic distribution of soybean production, the delineation of producing regions, and a glance at production trends within those regions, the specification of the regional and national soybean acreage response models will be presented. In addition to the soybean models, acreage response functions for the feed grains and cotton will be specified for analysis in conjunction with the soybean models. Finally, effective prices for those crops included in the models will be calculated on the basis of the theoretical framework developed in Chapter III.

Regional Distribution of Harvested Soybean Acreage

The U.S. Department of Agriculture has identified six major soybean producing regions. These regions and the acreages harvested within each region and in the U.S. over the years 1948-74 are presented in Table 2.

Corn Belt Region

All five Corn Belt states (Ohio, Indiana, Illinois, Iowa, and Missouri) are major producers of soybeans. As Table 2 shows, soybean acreage has tripled in the Corn Belt since 1948. This expansion has been stimulated by feed grain acreage restriction programs in combination with low prices for oats and hay.

Delta Region

Dramatic increases in soybean acreage occurred in the states of Arkansas, Mississippi, and Louisiana over the years 1948-1970. The overriding factor affecting soybean acreage in the Delta is the cotton acreage allotment. The expansion in soybean acreage resulted from declining acreages of cotton, and the reversal of the trend in soybean acreage in 1971-72 is directly related to the abolition of marketing quotas (and penalties) for cotton by the Agricultural Act of 1970. The approximately one million acre increase in the Delta in 1973 was attributed to wet weather which reduced cotton acreage.

Lakes Region

Soybean acreage increased substantially during the 50's and early 60's but seems to have leveled off at about 4 million acres in 1967 until

Table 2. Harvested soybean acreage, (000's), by region and total, 1948-74

Year	Corn Belt	Delta	Lakes	Atlantic	Plains	Others	Total
1948	8,080	480	983	525	237	377	10,682
1949	7,834	499	851	550	328	420	10,482
1950	9,870	979	1,260	654	558	486	13,807
1951	9,434	1,080	1,245	713	547	596	13,615
1952	9,589	1,391	1,294	714	842	605	14,435
1953	10,241	1,071	1,517	748	699	553	14,829
1954	11,160	1,550	2,174	866	698	599	17,047
1955	11,721	1,931	2,469	977	846	676	18,620
1956	12,413	2,396	2,918	1,301	902	690	20,620
1957	13,038	2,191	2,896	1,331	717	685	20,857
1958	13,990	3,079	3,488	1,440	1,142	854	23,993
1959	13,180	3,505	2,554	1,479	924	989	22,631
1960	13,830	3,541	2,407	1,778	1,026	1,073	23,655
1961	15,930	3,894	2,736	1,915	1,305	1,223	27,003
1962	16,176	4,174	2,645	1,953	1,412	1,248	27,608
1963	16,192	4,801	2,809	1,967	1,479	1,367	28,615
1964	17,223	5,065	3,316	2,076	1,609	1,504	30,793
1965	18,837	5,633	3,766	2,268	2,113	1,832	34,449
1966	19,212	6,396	4,021	2,505	2,244	2,168	36,546
1967	19,807	7,415	4,285	2,879	2,267	3,114	39,805
1968	21,409	7,545	3,856	2,640	2,254	3,400	41,391
1969	20,985	8,126	3,756	2,572	2,046	3,497	41,337
1970	21,773	8,668	3,683	2,585	2,170	3,370	42,249
1971	22,226	8,576	3,408	2,785	1,920	3,746	42,701
1972	24,178	8,181	3,894	3,009	2,025	4,411	45,698
1973	29,710	9,120	5,324	3,616	3,054	5,592	56,416
1974	27,030	8,610	4,875	3,588	2,729	5,678	52,510

Source: American Soybean Association, Soybean Blue Book: Various issues of Agricultural Statistics, United States Department of Agriculture, United States Government Printing Office, Washington, D.C., 1949-1974.

1973 and 1974 in the Lakes region of Michigan, Minnesota, and Wisconsin. The same factors stimulating soybean expansion in the Corn Belt account for the relative modest expansion in soybean acreage in the Lakes region.

Atlantic Region

Soybean acreage in the states of Virginia, Maryland, Delaware, and North and South Carolina increased steadily up to 1967, leveled off and began increasing again during 1970-74. This expansion is partly accounted for by declines in small grains and hay production and by the limitations on corn and cotton acreages.

Plains Region

As in the Lakes region, soybean acreage in the Plains states of Kansas, Nebraska, North Dakota, and South Dakota appears to have leveled off. In fact, until 1973, soybean acreage had been declining in this region since 1967. The soybean and wheat producing areas within the Plains region do not overlap, and consequently, changes in the wheat allotment have not significantly affected soybean acreage.

Others Region

Soybean acreage in the states of Georgia, Kentucky, Tennessee, Alabama, New York, New Jersey, West Virginia, Texas, Oklahoma, Florida, and Pennsylvania has increased steadily since 1948. Of the states listed, the first four are the most important in terms of soybean production. This expansion of soybean acreage is partly due to the limitation on cotton and corn acreage and to the declining acreage of oats.

As Table 3 indicates, the proportion of total soybean acreage harvested in the Southern and Southeastern United States has expanded steadily over the years 1948-74 and has declined in the Corn Belt while holding relatively constant in the Lakes and Plains regions.

The Estimation Model

The preceding theoretical development of effective prices argues that farmers base planting decisions upon expected harvest prices for the various crops. These price expectations are formed from consideration of support rates, loan rates, diversion payments, set-aside payments, allotments, marketing quotas, and expected market prices. Since expected market prices cannot be observed directly, farmers are assumed to base their expectations of market price on last year's market prices. On a regional and national basis, fixed machinery complements, land restrictions, management expertise, and market considerations restrict the amount of yearly adjustment in response to relative price changes. A one-year lag in acreage is included in each equation in recognition of these rigidities that restrict rapid acreage adjustment.

Table 3. Average annual harvested soybean acreage (000's) and regional percentages, 1948-74

Year	Region					
	Corn Belt	Delta	Lakes	Atlantic	Plains	Others
----- Acres -----						
1948-52	8,961	886	1,127	631	502	497
1953-57	11,715	1,828	2,395	1,045	772	640
1958-62	14,621	3,639	2,766	1,713	1,162	1,077
1963-67	18,254	5,862	3,639	2,339	1,942	1,997
1968-72	22,114	8,219	3,719	2,718	2,083	3,685
1973-74	28,370	8,865	5,100	3,602	2,892	5,635
----- Percent -----						
1948-52	71	7	9	5	4	4
1953-57	64	10	13	6	4	3
1958-62	59	15	11	7	5	4
1963-67	54	17	11	7	6	6
1968-72	52	19	9	6	5	9
1973-74	52	16	9	7	5	10

The basic model used is the lagged adjustment type developed by Nerlove.¹ Acreage supply response is assumed to be:

$$(4.1) \quad A_t = a_0 + a_1 P^*_{bt} + a_2 P^*_{ct} + a_3 A_{t-1} + e_t$$

where

A_t = harvested soybean acreage in year t,

A_{t-1} = harvested soybean acreage in year t-1,

P^*_b = expected price of crop A,

P^*_c = expected price of a competing crop, and

e = random disturbance.

¹Nerlove, Marc, "Distributed Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations," Journal of Farm Economics, Vol. 40, No. 2 (May 1958), pp. 301-311.

The expected price of the competing crop will change from region to region, and more than one competing crop price may appear in the equation. The effective prices developed earlier are taken to be estimates of expected prices and the relevant supply inducing prices. Replacing the expected prices in equation (4.1) with effective prices yields the following soybean response function which can be estimated statistically:

$$(4.2) \quad A_t = a_0 + a_1 PE_{bt} + a_2 PE_{ct} + a_3 A_{t-1} + e_t$$

where

PE_b = effective price of crop A, and

PE_c = effective price of competing crop.

Harvested instead of planted acreage was used to avoid the largely unpredictable influences of weather on planted acreage. The relationship between harvested and planted acreage is shown in Figure 12. As the diagram indicates, the relationship is sufficiently stable to permit one

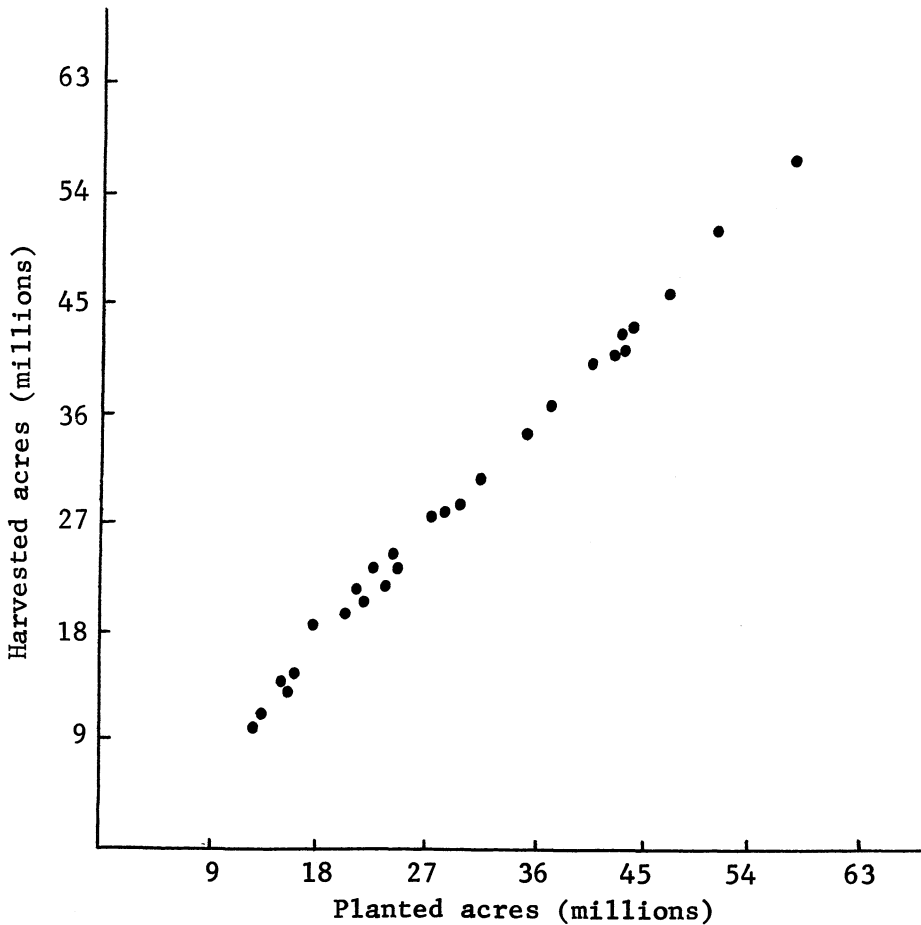


Figure 12. Comparison of planted and harvested soybean acreage, 1948-74.

to utilize harvested acreage as the dependent variable in the acreage response functions. In recent years (1964-74) the ratio of harvested to planted acreage has ranged from 97.1 to 98.5 percent. Given the nature of the relationship between harvested and planted acreage, the only practical difference likely to be observed in the two acreage response functions (harvested versus planted) is in the magnitude of the constant term.

Soybean Acreage Response Equations

Response functions for harvested soybean acreage were estimated by least squares for the six regions. Corn, wheat, cotton, and oats effective prices were initially included in each regional equation. However, in all the regions except the "Others Region," the effective price of only one competing crop was statistically different from zero at the 20% level. In the Corn Belt, Lakes, and Plains regions, the effective price of corn was found to significantly affect harvested soybean acreage. Effective cotton prices significantly affected harvested soybean acreage in the Delta and Others regions. The effective price of oats was significant in the Atlantic and Others regions. Surprisingly, the effective price of corn failed to obtain statistical significance in the Atlantic acreage response equation. However, analysis of acreage trends in the Atlantic region indicate that soybean acreage has expanded almost exclusively at the expense of oats acreage (Figure 13).

A national model of soybean acreage response was formulated on the basis of the statistically significant variables in the six regional equations. The national model includes the effective prices of soybeans, corn, oats, and cotton and soybean acreage lagged one and two years.

U.S. Feed Grains and Cotton Acreage Response Equations

To provide a check on the total projected acreages of soybeans and competing crops against a total land constraint based on lagged acreages and policy changes, an effort was made to determine acreage response equations for corn, oats, and cotton. The equations could also be used in calculating effective prices under the acreage set-aside programs as discussed previously (Chapter III).

Statistical difficulties were encountered in deriving the acreage response functions for the crops competitive with soybeans. The nature of this difficulty may be explained with the aid of Figure 14. In the absence of acreage restrictions, C bushels of corn and K pounds of cotton would be produced given the production possibilities curve, PP and iso-revenue line, II . If, however, acreage restrictions limit the production of corn to C_A and cotton to K_A , the production possibilities curve becomes $C_A K_A$. Now if the changes in the policies regarding corn and cotton production generally take the same direction, the correlation between the acreages and between the acreage of one crop and the price of the other will be positive which is contrary to

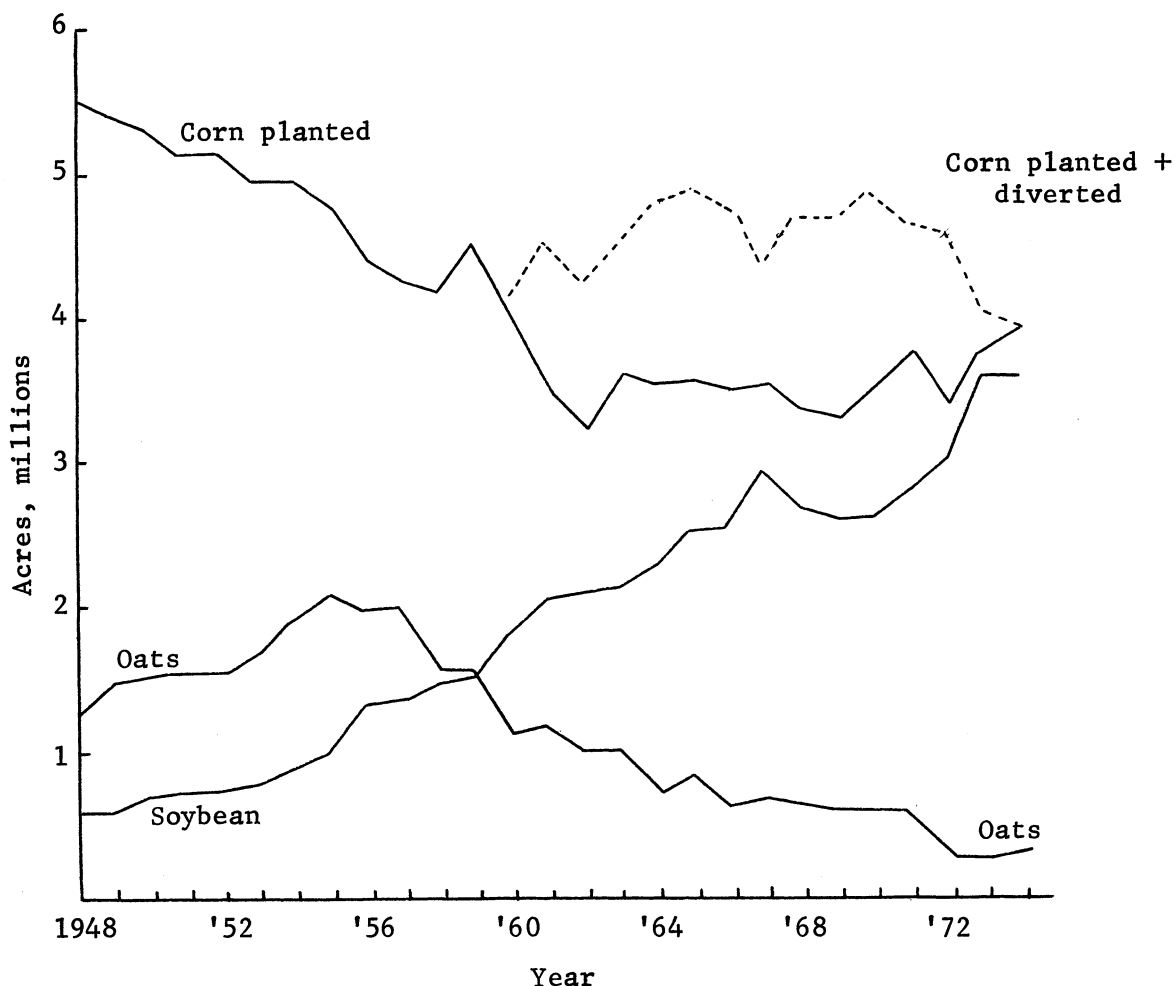


Figure 13. Acreage trends in the Atlantic Region, 1948-74.

economic theory. For example, the respective acreage restrictions may be increased for both crops in the same year encouraging production to expand to C_B and K_B , or, similarly, production may be restricted to C_C and K_C . The line XX becomes the transformation function for the two crops under the above circumstances. Verification of the situation illustrated by Figure 14 is given by the correlation coefficients between crop acreages presented in Table 4.

One observes that corn acreage is positively correlated with oats, barley, cotton, and wheat acreages. Assuming the price and own acreage of each crop is positively correlated, then the prices and acreages of all these crops will be positively correlated. Oats acreage is positively correlated with all acreages except soybeans. Cotton acreage is inversely related to soybean and sorghum acreage. Based on the information above and failing to

develop equations for the individual feed grains with significant coefficients or coefficients having theoretically correct signs, a national acreage response equation for total feed grains was developed.

Acreage response functions characterized by high R^2 's for the individual feed grains have been reported by Houck, Abel, Subotnik and Ryan.² However, the equations as formulated are more descriptive than analytical or predictive for several reasons. For example, the equations include as policy variables both effective support prices and weighted diversion payments. Since these two variables are based on the same acreage restrictions, they are highly correlated. The equations contain dummy and time variables to account for turning points in acreage. For example, the oats equation contains a time variable, and a dummy variable to account for the change in the trend in oats acreage in 1968. All of the referenced equations contain soybean support prices rather than the maximum of the soybean support or expected market price even though soybean market prices have consistently been above the support price. The oats and barley equations included as variables the actual acreages of all wheat planted and of all wheat diverted. These acreages would have to be estimated to use the equations for forecasting purposes. Finally, the authors of the studies treated the acreage diversion and set-aside programs as identical policies. As discussed earlier, the acreage diversion and set-aside programs are different in theory and in practice.

Feed Grain Acreage Response Equation. The equation for the feed grains is of the form:

$$(4.3) \quad G_t = g_0 + g_1 PGE_t - g_2 PSE_t - g_3 PCTE_t - g_4 DPG_t + g_5 G_{t-1} + e_t$$

where

G_t = total harvested feed grain acreage including corn, oats, barley, and sorghum acreages (thousands of acres),

PGE_t = effective price of feed grains (dollars per bushel),

PSE_t = effective price of soybeans (dollars per bushel),

$PCTE_t$ = effective price of cotton (dollars per pound),

DPG_t = weighted diversion payment (dollars per bushel),

G_{t-1} = feed grain acreage lagged one year (thousands of acres),
and

e_t = random disturbance term.

²See footnote 15, Chapter II.

The effective price of wheat was also tested but failed to achieve statistical significance at the 10 percent level.

Cotton Acreage Response Equation. The variables tested in the cotton acreage response function were, in addition to the effective price of cotton, the effective prices of soybeans, grain sorghum, and corn. Of these, the effective prices of cotton and soybeans were significant. The equation is:

$$(4.4) \quad CT_t = c_0 + c_1 PCTE_t - c_2 PSE_t + c_3 DPCT_t + c_4 C_{t-1} + e_t$$

where CT_t and CT_{t-1} are current and lagged cotton harvested acreages (000's), respectively, and $DPCT_t$ is payment rate for expected production from diverted cotton acreage (\$/pound).

Calculation of Effective Prices³

The data used for the specific calculations of effective prices are given in Tables 5 and 6. Market prices are weighted season average prices received by farmers for all grades. Upland cotton prices and U.S. harvested cotton acreage are used. All the effective prices are computed using U.S. prices. The regional soybean functions are estimated using U.S. prices but regional soybean acreages.

Effective Soybean and Corn Prices Under Set-Aside Program (1971-74)

Except for 1972 and 1973, the effective soybean price (PSE) is the larger of the lagged market price or the announced support rate. To illustrate the procedure used to calculate effective soybean and corn prices (PCE) for the Corn Belt, Lakes and Plains regions under the set-aside programs, the data in Table 7 are referenced. Effective prices under the set-aside programs are calculated as:

$$(4.5) \quad PSE = \frac{S_{t-1} + \Delta S_t}{S_{t-1}} \cdot PS_{t-1}$$

and

$$(4.6) \quad PCE = \frac{C_{t-1} + \Delta C_t}{B} \cdot PC_{t-1}$$

³The theoretical basis for the calculation of the various effective prices is given in Chapter III.

Table 5. Price variables for soybeans and cotton, 1948-74

Crop Year	Lagged market prices		Support prices		Cotton allotment ^c as percent of base
	Soybeans (\$/bu.) ^a PS	Cotton (\$/lbs.) ^b PCT	Soybeans ^a PSS	Cotton ^b PCTS	
1948	3.34	0.319	2.18	0.29	1.00
1949	2.27	0.304	2.11	0.27	1.00
1950	2.17	0.318	2.06	0.28	0.63
1951	2.47	0.426	2.45	0.30	1.00
1952	2.73	0.394	2.56	0.31	1.00
1953	2.72	0.345	2.56	0.31	1.00
1954	2.73	0.336	2.22	0.32	0.76
1955	2.46	0.334	2.04	0.32	0.65
1956	2.22	0.344	2.15	0.29	0.62
1957	2.18	0.335	2.09	0.29	0.63
1958	2.07	0.344	2.09	0.31	0.63
1959	2.00	0.345	1.85	0.30	0.62
1960	1.96	0.319	1.85	0.29	0.63
1961	2.13	0.310	2.30	0.32	0.66
1962	2.28	0.337	2.25	0.32	0.65
1963	2.34	0.335	2.25	0.32	0.58
1964	2.51	0.332	2.25	0.33	0.58
1965	2.62	0.307	2.25	0.33	0.58
1966	2.54	0.296	2.50	0.30 ^d	0.58
1967	2.88	0.221	2.50	0.31 ^d	0.58
1968	2.49	0.249	2.50	0.32 ^d	0.58
1969	2.43	0.229	2.25	0.34 ^d	0.58
1970	2.35	0.222	2.25	0.37 ^d	0.61
1971	2.85	0.236	2.25	0.35 ^e	0.41 ^f
1972	3.03	0.315	2.25	0.35 ^e	0.41 ^f
1973	4.37	0.272	2.25	0.35 ^e	0.36 ^f
1974	5.68	0.444	2.25	0.38 ^e	0.39 ^f

^aFats and Oils Situation, Economic Research Service, United States Department of Agriculture, Washington, D.C., 1948-74.

^bCotton Situation, Economic Research Service, United States Department of Agriculture: Various issues of Agricultural Statistics, United States Department of Agriculture, Washington, D.C., 1948-74.

^cCalculated.

^dIncludes payments on projected production within allotment.

^eTotal support on production within allotment.

^fMarketing quotas not in effect.

Table 6. Feed grain price and policy variables, 1948-74

Crop Year	Lagged market prices ^a (\$/bu.)				Crop year support prices ^a (\$/bu.)				Pct. of base eligible for diversion payments ^a		Corn ^a allotment (millions)	U.S. feed grain and cotton harvested acreages (000's) ^a					
	Corn PC	Oats PO	Barley PB	Sorghum PH	Corn PCS	Oats POS	Barley PBS	Sorghum PHS	Minimum	Maximum		Corn C	Oats O	Barley B	Sorghum H	Total feed	
																grain G	Cotton CT
1948	2.16	1.04	1.73	1.83	1.44	0.70	1.09	1.17				76,840	39,280	11,905	7,317	135,342	22,911
1949	1.30	.72	1.16	1.28	1.40	.69	1.09	1.17				77,106	37,794	9,872	6,602	131,374	27,439
1950	1.24	.66	1.06	1.13	1.47 ^b	1.10 ^c	.71	1.10	1.05		46.2 ^h	72,398	39,306	11,155	10,346	133,205	17,843
1951	1.52	.79	1.19	1.05	1.57	.72	1.11	1.22				71,191	35,233	9,424	8,544	124,392	26,949
1952	1.66	.82	1.26	1.32	1.60	.78	1.22	1.33				71,353	37,012	8,236	5,326	121,927	25,921
1953	1.52	.79	1.37	1.58	1.60	.80	1.24	1.36				70,738	37,536	8,680	6,295	123,249	24,341
1954	1.48	.74	1.17	1.32	1.62 ^b	1.22 ^c	.75	1.15	1.28		47.0 ^h	68,668	40,551	13,370	11,718	134,307	19,251
1955	1.43	.71	1.09	1.26	1.58 ^b	1.18 ^c	.61	.95	1.00		49.8 ^h	68,462	39,027	14,523	12,891	135,083	16,928
1956	1.35	.60	.92	.98	1.50 ^b	1.24 ^c	.65	1.02	1.10		42.3 ^h	64,877	33,333	12,852	9,209	120,271	15,615
1957	1.29	.69	.99	1.15	1.40 ^b	1.27 ^c	.61	.94	1.04		37.3 ^h	63,065	34,065	14,872	19,682	131,684	13,558
1958	1.11	.61	.89	.97	1.36 ^b	1.02 ^c	.61	.93	1.02		39.8 ^h	63,549	31,247	14,791	16,524	126,111	11,849
1959	1.12	.58	.90	1.00	1.12	.50	.77	.85				72,091	27,758	14,869	15,406	130,124	15,117
1960	1.05	.65	.86	.86	1.06	.50	.77	.85				71,422	26,588	13,856	15,601	127,467	15,309
1961	1.00	.60	.84	.84	1.20	.62	.93	1.08	0.20	0.40		57,634	23,886	12,806	10,985	105,311	15,634
1962	1.10	.64	.98	1.01	1.20	.62	.93	1.08	.20	.40		55,726	22,377	12,214	11,571	101,888	15,569
1963	1.12	.62	.92	1.02	1.25 ^d	.65	.96 ^f	1.12 ^g	.20	.40		59,227	21,308	11,236	13,326	105,097	14,212
1964	1.11	.62	.90	.98	1.25 ^d	.65	.96 ^f	1.12 ^g	.20	.50		55,369	19,759	10,277	11,742	97,147	14,055
1965	1.17	.63	.95	1.05	1.25 ^d	.60	.96 ^f	1.12 ^g	.20	.50		55,392	18,479	9,144	13,029	96,044	13,615
1966	1.16	.62	1.02	1.00	1.30 ^e	.60	1.00 ^e	1.15 ^e	.20	.50		57,002	17,877	10,250	12,813	97,942	9,552
1967	1.24	.67	1.05	1.03	1.35 ^e	.63	.90	1.20 ^e	.20	.20		60,694	16,110	9,230	14,988	101,022	7,997
1968	1.03	.66	1.00	.99	1.35 ^e	.63	.90	1.20 ^e	.20	.50		55,980	17,708	9,732	13,890	97,310	10,160
1969	1.08	.60	.91	.95	1.35 ^e	.63	1.03 ^e	1.20 ^e	.20	.50		54,574	17,971	9,557	13,437	95,539	11,055
1970	1.15	.59	.89	1.07	1.35 ^e	.63	1.03 ^e	1.20 ^e	.20	.50		57,358	18,638	9,725	13,568	99,289	11,155
1971	1.33	.63	.97	1.14	1.35 ^e	.54	.81	1.24 ^e				64,047	15,772	10,151	16,301	106,271	11,471
1972	1.08	.61	.99	1.05	1.35 ^e	.54	1.10 ^e	1.28 ^e				57,344	13,612	9,707	13,586	94,249	12,984
1973	1.57	.72	1.22	1.37	1.35 ^e	.54	1.01 ^e	1.20 ^e				61,800	14,100	10,500	15,900	102,300	11,970
1974	2.55	1.18	2.13	2.14	1.38 ⁱ	.54	1.13 ⁱ	1.31 ⁱ				65,200	13,300	8,300	13,900	100,700	12,570

^aFeed Situation, Economic Research Service, USDA: Various issues of Agricultural Statistics, USDA, Washington, D.C., 1948-74.

^bLoan rate for commercial corn area.

^cLoan rate for non-commercial corn area.

^dIncludes direct payments of \$0.18 in 1963, \$0.15 in 1964, \$0.20 in 1965.

^eTotal support on 50% of base acreage.

^fIncludes direct payments of \$0.12, \$0.14, and \$0.16 in 1963, 1964, and 1965, respectively.

^gIncludes direct payments of \$0.16 per bushel in 1963, \$0.13 in 1964, and \$0.20 in 1965.

^hApplies to commercial area only.

ⁱGuaranteed payment made on production from allotment if 5-month weighted average market price falls below this target price.

Table 7. Data used in calculating PSE and PCE, 1971-73

Year	Planted acreage (millions)			Percentages		Set-aside (millions)		Est. ^a ΔSA
	(C) Corn	(S) Soybeans	(C+S) Total	CP= C÷(C+S)	SP= S÷(C+S)	Actual	Est. ^a	
1959	82.1 (Base)	-	-	-	-	-	-	-
1970	67.0	43.1	110.1	.61	.39	26.1 (Diversion)	-	-
1971	74.1	43.5	117.6	.63	.37	14.1	16.4 20.5 min	+ 9.7 - 6.4
1972	66.8	46.9	113.7	.59	.41	24.4	28.7 max 00.0 min	-14.6 +24.4
1973	-	-	-	-	-	5.7	8.2 max	+16.2

^a Estimated set-aside = percent of base eligible for set-aside payments multiplied by 82.1 million acres. Estimated ΔSA = actual set-aside in the previous year less estimated set-aside for the current year.

where

$$\Delta S_t = SP_{t-1} \cdot \Delta SA_t$$

$$\Delta C_t = CP_{t-1} \cdot \Delta SA_t$$

C_{t-1}, S_{t-1} = lagged corn and soybean planted acreages,

PC_{t-1}, PS_{t-1} = lagged corn and soybean market prices,

CP_{t-1}, SP_{t-1} = lagged percentage of total corn and soybean acreage in corn and soybeans,

ΔSA_t = estimated total corn and soybean set-aside acreage, and

B = corn base = 82.1 million acres in 1959.

1971. The set-aside program of 1971 required participants to set-aside an acreage equal to 20 percent of the corn base. Thus, 1971 set-aside is estimated to be $.20(82.1) = 16.4$ million acres. This represented a net gain of 9.7 million acres of corn land over the 26.1 million acres diverted in 1970. The effective corn price was calculated as:

$$(4.7) \quad PCE = \frac{67.0 + .61 (9.7)}{82.1} \quad 1.33 = \$1.18/\text{bu.}$$

Since soybeans were not considered as acreage planted to feed grains in 1971, PSE was the lagged market price since it exceeded the soybean support price.

1972. In 1972 the required minimum set-aside was increased to 25 percent of base acreage. In addition, two other plans (A and B) were offered for additional set-aside. Plan A offered payments on additional set-aside of 10 percent; Plan B offered a higher payment than Plan A for the additional 10 percent set-aside, but corn acreage was restricted to 80 percent of 1971 plantings for the full 10 percent additional set-aside.

To calculate PCE and PSE for 1972, the effective prices under the maximum and minimum provisions were calculated and then averaged. Under the minimum provision, the estimated change in set-aside acreage is $\Delta SA = -6.4$ million acres. Thus,

$$(4.8) \quad PCE = \frac{74.1 + .63 (-6.4)}{82.1} \quad \$1.08 = \$0.92$$

and

$$(4.9) \quad PSE = \frac{43.5 + .37 (-6.4)}{43.5} \quad \$3.03 = \$2.88.$$

The other two plans for additional diversion were averaged to obtain the effective prices under the maximum provisions. Under the maximum provisions the estimated change in set-aside is $\Delta SA_t = SA_{t-1} - \text{est. } SA_t = 14.1 - (0.35)(82.1) = -14.6$ million acres.⁴ Thus PCE for Plan A is:

$$(4.10) \quad PCE = \frac{74.1 + .63(-14.6)}{82.1} \quad \$1.08 = \$0.85$$

Under Plan B corn acreage in 1972 was restricted to 80 percent of 1971 planted corn acreage or $.80(74.1) = 59.3$ million acres. The effective price of corn under Plan B is:

$$(4.11) \quad PCE = \frac{59.3}{82.1} \quad \$1.08 = \$0.78.$$

Averaging PCE under the two plans for additional diversion under the maximum provisions gives $PCE = \$0.82$. The two plans are averaged for reasons of simplicity and the lack of a better operational procedure.

Under Plan A for additional diversion PSE is calculated as:

$$(4.12) \quad PSE = \frac{43.5 + 0.37(-14.6)}{43.5} \quad \$3.03 = \$2.67.$$

Under Plan B, PSE is calculated on the basis of the difference between total acreage (C+S) in 1971 less the increased estimated set-aside (14.6 million acres) and the maximum corn acreage permitted (59.3 million acres). Thus,

$$(4.13) \quad PSE = \frac{116.8 - 14.6 - 59.3}{43.5} \quad \$3.03 = \$3.00.$$

Averaging the two plans for maximum diversion gives $PSE = \$2.84$.

Averaging the minimum and maximum provisions gives the effective prices for 1972:

$$(4.14) \quad PCE = \frac{0.92 + 0.82}{2} = \$0.87$$

and

$$(4.15) \quad PSE = \frac{2.88 + 2.84}{2} = \$2.86$$

1973. The set-aside program for 1973 contained two options. Under option A, a minimum set-aside of 10 percent of corn base is required; under option B, no set-aside is required but corn plantings are restricted to 1972 acreage or 66.8 million acres.

⁴In 1971, the estimated set-aside was 16.4 million acres. The actual set-aside in 1971 was 14.1 million acres which is used in estimating the expected set-aside in 1972.

Under option A, the estimated change in set-aside is: $\Delta SA = 24.4 - 0.10(82.1) = 16.2$ million acres. By the formula given earlier PSE and PCE were calculated as:

$$(4.16) \quad PSE = \frac{46.9 + .41 (16.2)}{46.9} \quad 4.37 = \$4.98$$

and

$$(4.17) \quad PCE = \frac{66.8 + .59 (16.2)}{82.1} \quad 1.57 = \$1.46$$

Under option B, corn acreage is restricted to 66.8 million acres. Therefore:

$$(4.18) \quad PSE = \frac{46.9 + .41 (24.4)}{46.9} \quad 4.37 = \$5.29$$

and

$$(4.19) \quad PCE = \frac{66.8}{82.1} \quad 1.57 = \$1.27.$$

Averaging option A and B provisions gives the effective prices for 1973:

$$(4.20) \quad PSE = \frac{4.98 + 5.29}{2} = \$5.14$$

and

$$(4.21) \quad PCE = \frac{1.46 + 1.27}{2} = \$1.37.$$

1974. Provisions of the 1974 feed grain program permitted unrestricted production of feed grains and soybeans. The national feed grain allotment was 89 million acres. The allotment does not restrict the acreage farmers may plant, but is the basis for calculating deficiency payments to farmers should average farm prices for the first 5 months of the marketing year fall below target prices. Since no production restrictions were in effect and market prices during the 1973-74 marketing year exceeded target prices and loan rates for soybeans, feed grains, and cotton, the effective prices for these crops in 1974 are equal to the lagged market prices of the 1973-74 marketing season.

Effective Corn Prices, 1948-70

For the years 1948-60, with the exception of 1950 and 1954-58, the effective corn price for inclusion in the soybean acreage response equations is the larger of the lagged market price or the current support rate. The effective price of corn was calculated as follows for the years 1950, 1954-58 in which acreage in the commercial corn area was restricted by allotments:

$$(4.22) \quad PCE = \frac{A}{B} + Q \cdot PC_{t-1}$$

where

- PC_{t-1} = the lagged market price which exceeded support rates for these years (dollars per bushel),
- A = the acreage allotment for the commercial area,
- B = base acreage (average acreage planted in 1948-49 for 1950 calculation; average planted acreage in 1951-53 for 1954-58 calculations), and
- Q = percent of total corn acreage in the non-commercial area for the base years.

For the years of the corn acreage diversion program (1961-70), the effective price of corn equaled the lagged market price of corn although support rates exceeded market prices during these years. To capture the impact of market price and government programs with respect to corn on soybean acreage, previous studies have included both support rates and diversion payment variables for corn in acreage response functions for soybeans. There are several problems with this approach. A priori, diversion payment levels and soybean acreage should be uncorrelated since soybeans could not be planted on diverted acreage. The simple correlation between support rates and diversion payment rates during 1961-70 was 0.92. The two variables are both measures of the same policy and create intercorrelation problems in estimation. With the indication of the set-aside program in 1971 and the target price concept in 1974, market prices took on increased importance. Based on these reasons, the lack of correlation between diversion payments and soybean acreage, the intercorrelation problem, and increased importance of market prices, corn support and diversion payment rates were not used in calculating the effective price of corn variable during the years 1961-70.

Effective Oats Prices

Except for the years 1971-73, the effective price of oats is considered to be the larger of the lagged market price or the announced support rates. During 1971-73, oats prices were adjusted for changes in set-aside provisions similar to soybeans using the equation:

$$(4.23) \quad POE = \frac{O_{t-1} + \Delta O_t}{O_{t-1}} PO_{t-1}$$

where

- O_{t-1} = planted oat acreage last year,

ΔO_{t-1} = estimated change in oat acreage due to change in set-aside provisions, and

PO_{t-1} = market price of oats last year.

The estimated change in oat acreage planted (ΔO_t) is determined by changes in the set-aside provisions using the same procedure developed for soybeans. Since market prices for oats exceeded support rates during 1971-73, lagged market prices were used.

Effective Cotton Prices

For the years 1948-49 and 1951-53 the effective cotton price is considered to be the larger of the lagged market price or the announced support rate. For the years 1950 and 1954-70 in which acreage allotments and marketing quotas were in effect, the effective cotton price was computed as:

$$(4.24) \quad PCTE = \frac{A}{B} PCTS$$

where

A = acreage allotment,

B = base acreage (average acreage for 1948-49 for 1950 calculations; average acreage in 1951-53 for remaining calculations, and

PCTS = announced support rate for cotton (dollars per pound).

During the years 1966-68 an acreage diversion program for cotton was in effect. In 1966, 10.5 cents per pound was paid for expected production from diverted acres in excess of 12.5 percent of the farm allotment, up to a maximum of 35 percent of the farm allotment. The same percentages applied in 1967, but the payment rate was increased to 10.78 cents per pound. In 1968, 6 cents per pound was paid for expected production from diverted acres in excess of 5 percent of the farm allotment, up to a maximum of 35 percent of the farm allotment. The impact of these diversion payments on cotton acreage harvested was captured by the cotton diversion payment variable (DPCT) calculated as:

$$(4.25) \quad DPCT = \frac{W_1 + W_2}{2} R$$

where

DPCT = diversion payment for cotton (\$/lb.),

W_1, W_2 = minimum and maximum diversion as percentage of farm cotton allotment, and

R = payment rate for expected production from diverted acres (\$/lb.).

For the years 1971-73, in which allotments were in effect but marketing quotas were not, the effective price of cotton was calculated as:

$$(4.26) \quad PCTE = \frac{A}{B} PCTS + \frac{B - A}{B} PCT_{t-1}$$

where A, B, and PCTS are defined above and PCT_{t-1} is the lagged market price of cotton which exceeded the support rates for these years. In 1974, with no acreage control and 1973-74 marketing season market prices above the target price, the effective price of cotton was equal to the lagged market price.

Effective Prices for Total Feed Grains Acreage Response Equation

The effective price for the four feed grains taken together (corn, oats, barley, and sorghum) is calculated as follows:

$$(4.27) \quad PGE = PCE \cdot CP_{t-1} + POE \cdot OP_{t-1} + PBE \cdot BP_{t-1} + PHE \cdot HP_{t-1}$$

where PCE, POE, PBE, and PHE are the effective prices of corn, oats, barley, and sorghum which are calculated by the procedures explained above, and CP_{t-1} , OP_{t-1} , BP_{t-1} , and HP_{t-1} are the respective percentages of last year's total feed grain acreage. In addition, a weighted diversion payment variable (DPG) was calculated as follows:

$$(4.28) \quad DPG_t = (DPC_t) (CP_{t-1}) + (DPB_t) (BP_{t-1}) + (DPH_t) (HP_{t-1})$$

where

DPC = weighted diversion payment for corn,

CP = average corn acreage in 1959-60 as a percent of total feed grain average acreage in 1959-60 (the base years for the acreage diversion program). CP is a constant,

DPB = weighted diversion payment for barley,

BP = base acreage of barley as percent of total feed grain base (a constant),

DPH = weighted diversion payment for sorghum,

HP = base acreage of sorghum as percent of total feed grain base (a constant).

The weighted diversion payments were calculated as:

$$(4.29) \quad DPC = \frac{(W_1 PR_1) + (W_1 PR_1 + W_2 PR_2)}{2}$$

where

W_1 = minimum diversion as percent of base acreage,

PR_1 = payment rate (dollars per bushel) on W_1 ,

W_2 = percent of base eligible for additional diversion payments,
and

PR_2 = payment rate on W_2 .

For example, in 1961 for corn, $W_1 = 0.20$, $W_2 = 0.20$, $PR_1 = \$0.60$ per bushel and $PR_2 = \$0.72$ per bushel and

$$(4.30) \quad DPC = \frac{(.20)(.60) + (.20)(.60) + (.20)(.72)}{2} = \$0.192 \text{ per bu.}$$

In a similar manner DPH was calculated to be \$0.17 per bushel while DPB was zero. From these data DPG was calculated as:

$$(4.31) \quad DPG = (0.192) \frac{82.1}{151.0} + (0.17) \frac{19.5}{151.0} = \$0.126 \text{ per bushel.}$$

The variable DPG explains 84 percent of the variation in total feed grain acreage diverted, and the validity of this method of estimating diverted acres is demonstrated by the plot of DPG versus diverted acres shown in Figure 15. The diversion payment variable was included for the years 1961-70 since, as explained in Chapter III, the acreage diversion programs directly affected feed grain acreage.

Production Cost Index

All of the effective prices were adjusted by a production cost index. Recent increases in production costs have distorted historical output price relationships that existed during the 1950's and 1960's, when cost changes were relatively small and consistent from year to year. Since soybeans, corn, and cotton have production costs composed of different proportions of fertilizer, labor, fuel, supplies, etc., production costs become an important variable in relative profitability of these crops when the price of some production inputs increase more rapidly than others. For example, soybeans do not need nitrogen fertilizer, whereas corn and cotton are heavy users of nitrogen. Since nitrogen fertilizer has about tripled in price since 1972, a soybean-corn output price ratio such as 2:25 which led to increased corn production in 1970 may lead to reduced corn production in 1975. Therefore, to account for these relative changes in production costs, the effective prices of corn, oats and feed grains were divided by a production cost index for corn. The effective prices of soybeans and cotton were divided by the production cost index for soybeans and cotton, respectively.

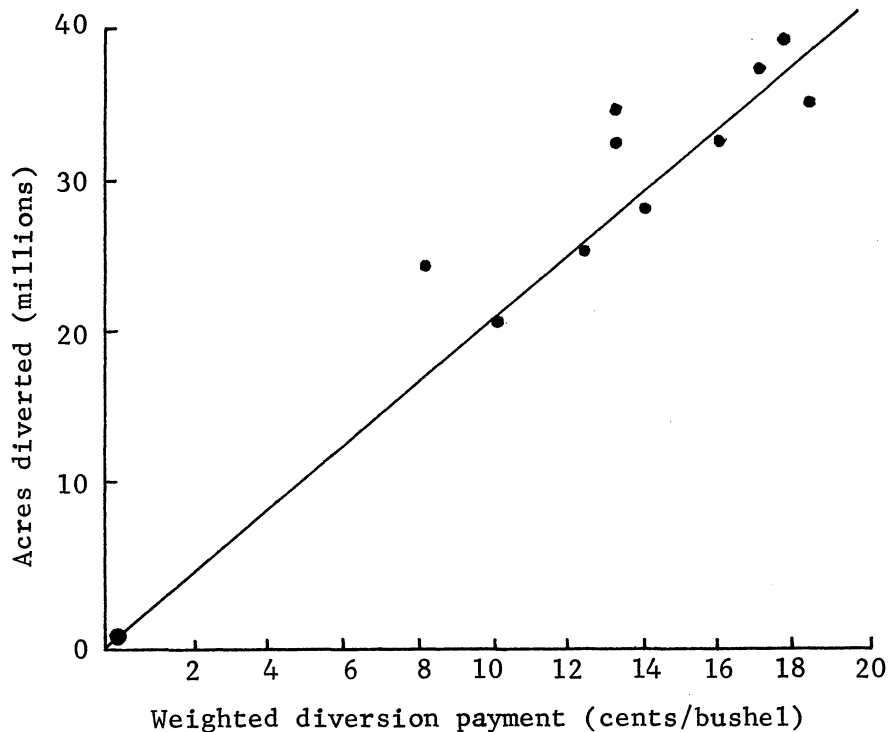


Figure 15. Relationship between feed grains acres diverted and weighted diversion payment, 1961-70.

The production cost indexes for soybeans, corn, and cotton were developed using 1970 production cost budgets developed by USDA.⁵ The variable costs from these budgets were aggregated into six categories: motor supplies, farm supplies, fertilizer, seed, interest, and wages. Relative percentages of production costs by category were computed for corn, soybeans, and cotton. These proportions by crop, along with the indexes for these production categories published in Agricultural Prices, were used to develop a production cost index for each crop for the years 1948-75, using 1967 as a base.

The effective prices, production cost indexes and other policy variables used in obtaining the acreage response equations are presented in Table 8.

⁵ Selected U.S. Crop Budgets: Yields, Inputs, and Variable Costs, USDA, ERS, April 1971, Volumes II and V. The specific budgets used were: corn for grain, East Central Illinois, area Q, Volume II; soybeans, East Central Illinois, area Q, Volume II; and cotton, Dryland cotton, Rolling Plains Region, Area H, loam soils, 2x2 ship row, Volume V.

Table 8. Effective prices and policy variables, 1948-74

Year	Effective prices					Production cost indexes			Diversion payment	
	Soybeans	Corn	Oats	Feed grains	Cotton	Soybeans	Corn	Cotton	Cotton	Feed grains
	PSE	PCE	POE	PGE	PCTE	1967=100			DPCT	DPG
----- \$/bu. -----					----- 1967=100 -----			\$/lb.	\$/bu.	
1948	3.34	2.16	1.04	1.18	0.290	66.9	67.9	69.7	0	0
1949	2.27	1.40	0.72	1.18	0.270	65.7	67.6	70.8	0	0
1950	2.17	1.09	0.71	1.08	0.176	65.0	66.8	70.5	0	0
1951	2.47	1.52	0.79	1.19	0.300	70.0	72.0	76.0	0	0
1952	2.73	1.66	0.82	1.37	0.310	74.7	76.1	80.6	0	0
1953	2.72	1.52	0.80	1.31	0.310	74.5	76.1	79.5	0	0
1954	2.73	1.31	0.75	1.34	0.243	73.1	75.2	78.4	0	0
1955	2.46	1.32	0.71	1.18	0.208	73.8	75.5	78.1	0	0
1956	2.22	1.12	0.65	1.07	0.180	74.5	76.1	79.2	0	0
1957	2.18	0.99	0.69	1.07	0.183	76.9	78.1	80.9	0	0
1958	2.09	0.89	0.61	0.93	0.195	78.1	79.0	82.2	0	0
1959	2.00	1.12	0.58	0.98	0.186	80.7	81.3	83.9	0	0
1960	1.96	1.06	0.65	0.92	0.183	82.6	82.8	85.0	0	0
1961	2.30	1.00	0.62	0.89	0.211	83.8	84.0	86.3	0	0.126
1962	2.28	1.10	0.64	0.97	0.208	85.4	85.4	87.4	0	0.142
1963	2.34	1.12	0.65	0.96	0.186	87.6	87.2	88.8	0	0.084
1964	2.51	1.11	0.65	0.97	0.191	89.0	88.3	89.9	0	0.134
1965	2.62	1.17	0.63	1.00	0.191	92.4	91.3	92.6	0	0.134
1966	2.54	1.16	0.62	1.01	0.174	96.9	95.3	95.9	.025	0.185
1967	2.88	1.24	0.67	1.05	0.180	100.0	100.0	100.0	.026	0.102
1968	2.50	1.03	0.66	0.96	0.186	109.0	105.0	104.9	.012	0.161
1969	2.43	1.08	0.63	0.96	0.197	116.9	111.1	110.9	0	0.179
1970	2.35	1.15	0.63	1.01	0.226	123.6	117.5	116.4	0	0.172
1971	2.85	1.18	0.63	1.15	0.264	130.0	123.3	121.6	0	0
1972	2.86	0.87	0.61	0.87	0.304	136.9	129.4	127.3	0	0
1973	5.14	1.37	0.72	1.32	0.297	150.6	142.6	137.7	0	0
1974	5.68	2.55	1.18	2.28	0.444	178.3	176.1	164.8	0	0

CHAPTER V

EMPIRICAL RESULTS

The results and evaluation of the regional and national models for soybean acreage response and the national models for cotton and feed grain acreage response are presented in this chapter. All of the estimated coefficients and projections are based on national level effective prices which were calculated using national acreages, allotments, set-aside acreage, etc. The coefficients of the regional soybean equations were obtained using national prices but regional acreage estimates. The national soybean, feed grains, and cotton equations were estimated using national prices and acreages. All effective prices were adjusted by the appropriate production cost index.

Regional Soybean Acreage Response Equations

The results of the estimated regional supply equations are shown in Table 9. The most significant variable in terms of affecting acres of soybean harvested was the lagged acreage variable in each equation. The effective price of soybeans had the expected positive sign in all regions and was statistically significant at the 1 percent level in all equations except the Delta.

The effective price of corn had a significant impact in the Corn Belt, Lakes, and Plains regions. Increases in effective corn prices produced significant reductions in soybean acreage harvested. In the Atlantic and Others regions, the effective price of oats entered the model as the crop affecting the acreage of soybeans harvested. An analysis of acreage trends in these two regions revealed that the expansion of soybean acreage has come almost entirely at the expense of oat acreage. In the Delta region, changes in the effective cotton price significantly affected harvested soybean acreage.

National Soybean Acreage Equation

The equation for the national model based on data from 1948-1974 is:

$$(5.1) \quad TA_t = 7888.0 + \underset{(6.14)}{6625.6} PSE_t - \underset{(-1.67)}{4700.3} PCE_t - \underset{(-2.03)}{14883.0} POE_t \\ - \underset{(-1.04)}{8760.5} PCTE_t + \underset{(14.06)}{0.8199} TA_{t-1}$$

where TA = U.S. harvested soybean acreage (thousands of acres); the other variables are defined in Table 9. The numbers in parentheses

Table 9. Regional soybean acreage response equations, 1948-1974^a

Region	Dependent variable	Independent variables				Constant	R ²	S.E.	
		PSE _t	PCE _t	POE _t	PCTE _t				
Corn Belt	CBA _t	3070.4 (4.92)	-5515.5 (-6.09)			0.8687 (19.62)	1620.0	0.979	916.2
Lakes	LA _t	1174.2 (7.32)	-1816.7 (-7.89)			0.7772 (13.14)	- 76.8	0.964	239.3
Plains	PA _t	529.1 (3.54)	- 793.9 (-3.76)			0.8491 (10.80)	-116.8	0.927	222.5
Delta	DA _t	320.6 (1.91)			-5886.3 (-3.86)	0.9498 (31.84)	1068.0	0.989	327.2
Atlantic	AA _t	353.7 (4.31)		-1547.2 (-4.39)		0.8287 (13.85)	613.9	0.985	123.7
Others	OA _t	603.6 (4.50)		-2343.2 (-4.86)		0.9434 (21.14)	397.4	0.987	194.7

^aThe values in parentheses are t-values of the regression coefficients.

Variables and Region Descriptions

CBA, LA, PA, DA, AA, OA = Harvest acreage by region, in thousands of acres

PSE = Effective soybean price, \$/bu.

PCE = Effective corn price, \$/bu.

POE = Effective oats price, \$/bu.

PCTE = Effective cotton price, \$/lb.

A_{t-1} = Harvested acreage by region the previous year, in thousands of acres

Corn Belt = Ohio, Indiana, Illinois, Iowa, Missouri

Lakes = Michigan, Minnesota, Wisconsin

Plains = Kansas, Nebraska, North Dakota, South Dakota

Delta = Arkansas, Mississippi, Louisiana

Atlantic = Virginia, Maryland, Delaware, North Carolina, South Carolina

Others = Georgia, Kentucky, Tennessee, Alabama, New York, New Jersey, West Virginia, Texas, Oklahoma, Florida, Pennsylvania

beneath the coefficients are the t-test values. The R^2 for the equation is 0.989, with a standard error of 1,523,000 acres or 5.32 percent of the mean acreage. All of the variables have the theoretically expected sign. The effective price of soybeans and lagged soybean acreage are statistically significant at the 1 percent level. Actual and predicted harvested soybean acreage from equation (5.1) is compared in Figure 16.

National Feed Grains Acreage Response Equation

The equation for feed grain acreage response is:

$$(5.2) \quad G_t = 46670.0 + 26977.0 \text{ PGE}_t - 1062.4 \text{ PSE}_t - 69823.0 \text{ PCTE}_t \\ \quad \quad \quad \quad \quad (3.52) \quad \quad \quad (-0.34) \quad \quad \quad (-2.44) \\ \quad \quad \quad - 69823.0 \text{ DPG}_t + 0.4970 G_{t-1} \\ \quad \quad \quad \quad \quad (-2.96) \quad \quad \quad (4.44)$$

where

- G_t = harvested feed grain acreage, thousands of acres,
- PGE_t = effective price of feed grains, dollars per bushel,
- PSE_t = effective price of soybeans, dollars per bushel,
- PCTE_t = effective price of cotton, dollars per pound,
- DPG_t = weighted diversion payment for feed grains, 1961-70, and
- G_{t-1} = harvested feed grain acreage previous year.

The equation explains 90 percent of the variation in feed grain acreage with a standard error of the estimate of 5.45 million acres or 4.8 percent of mean acreage. All of the coefficients have the anticipated sign and are statistically significant at the 5 percent level with the exception of the effective price of soybeans as indicated by the t-values under the estimated coefficients. The soybean price variable was retained in equation (5.2) since additional analyses, using data bases not including 1971-74, indicated soybean prices were positively correlated with feed grain acreage. However, as 1971 thru 1974 data were added to the model, the coefficient on soybean price became negative and increased in absolute value from year to year. This is a reflection of the increased role of prices in determining planting decisions since 1971. Agricultural policy is expected to be heavily determined by market prices during the next few years, therefore the soybean price variable was retained in equation (5.2). The ability of equation (5.2) to predict harvested feed grain acreage is shown in Figure 17.

National Cotton Acreage Response Equation

The equation for cotton acreage response is:

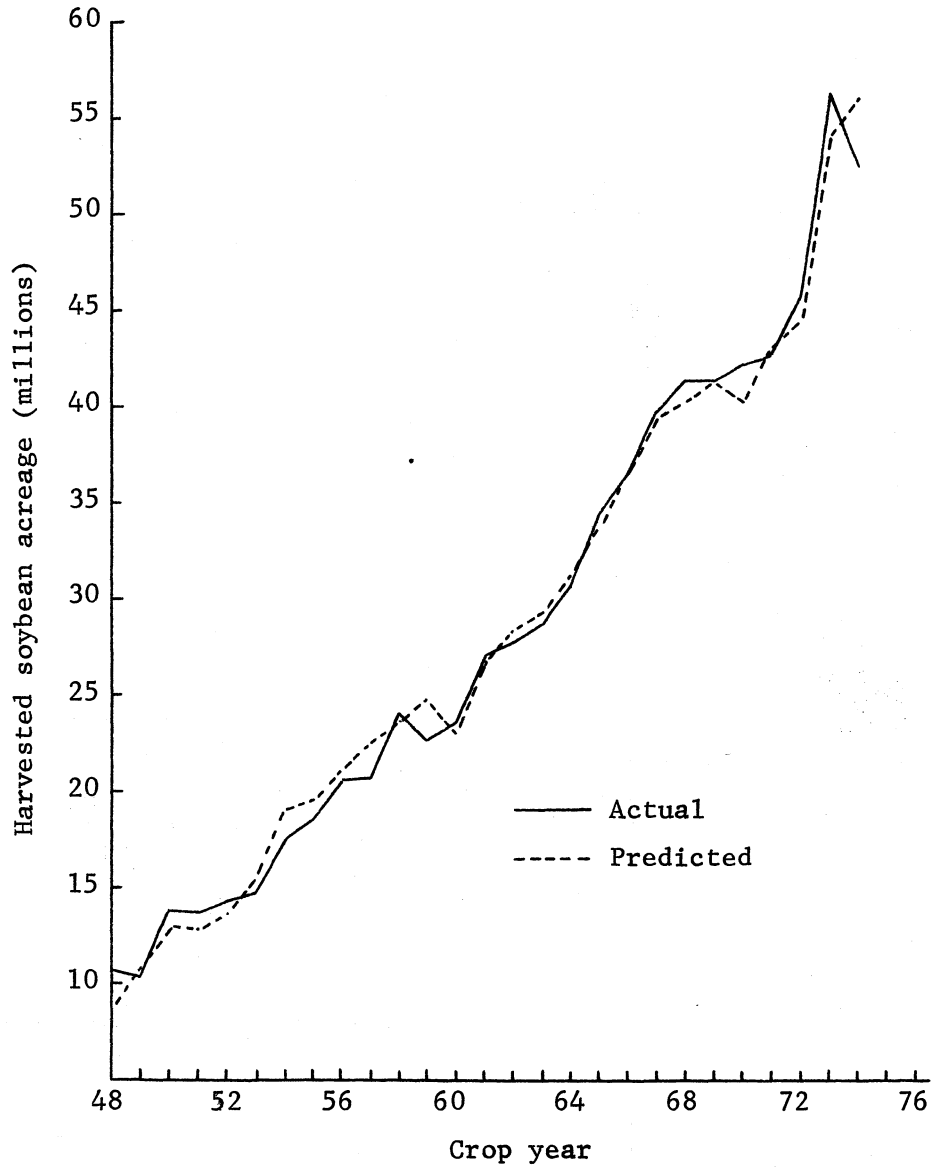


Figure 16. Actual and predicted harvested soybean acreage by the national model, 1948-74.

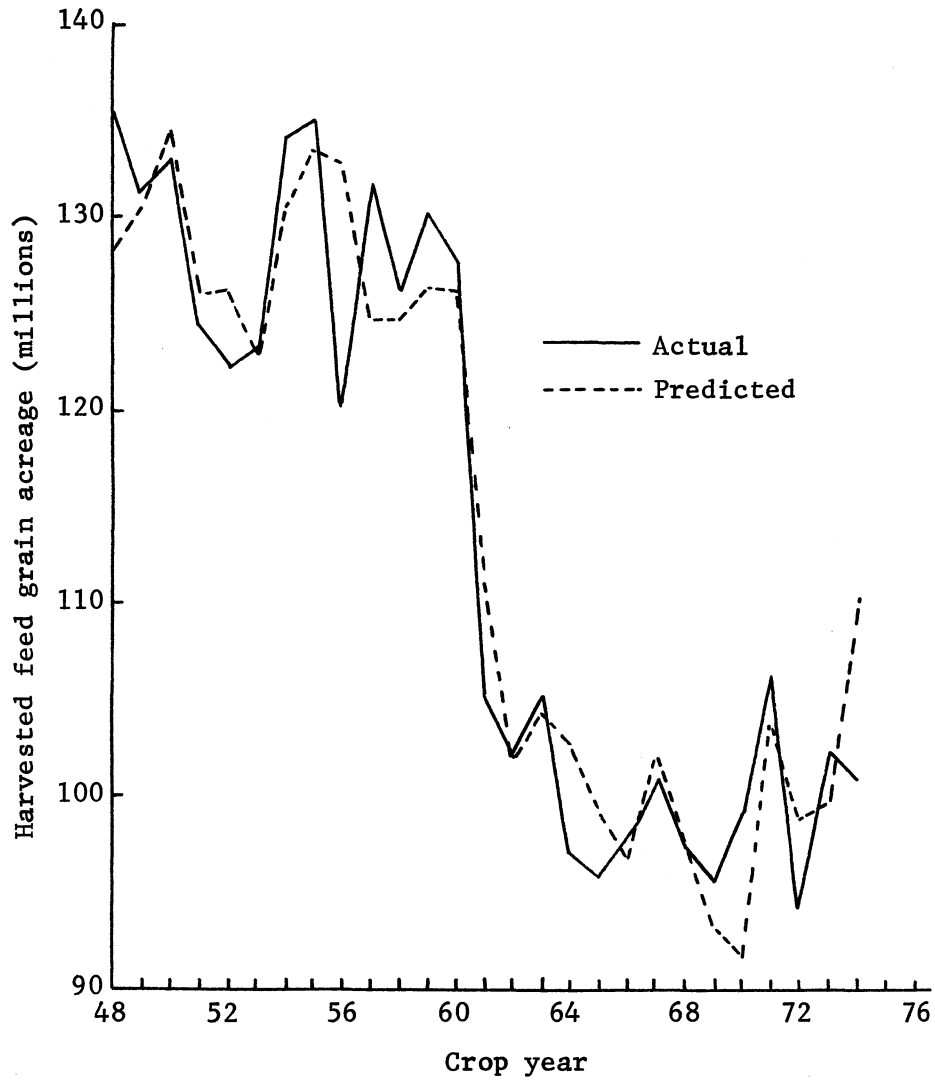


Figure 17. Actual and predicted harvested feed grain acreage, 1948-74.

$$(5.3) \quad CT_t = 152.2 + 63643.0 \text{ PCTE}_t - 1846.8 \text{ PSE} - 42671.0 \text{ DPCT} \\ \quad \quad \quad (7.94) \quad \quad \quad (-2.21) \quad \quad \quad (-0.88) \\ \quad \quad \quad + 0.3051 \text{ CT}_{t-1} \\ \quad \quad \quad (3.38)$$

where

- CT_t = U.S. harvested cotton acreage, thousands of acres,
 PCTE_t = effective price of cotton, dollars per pound,
 PSE_t = effective price of soybeans, dollars per bushel, and
 DPCT_t = diversion payment for cotton, dollars per pound.

The equation explains 93 percent of the variation in cotton acreage with a standard error of the estimate of 1.553 million acres or 9.86 percent of average cotton acreage between 1948 and 1974. A comparison of actual and predicted acreages for cotton is presented in Figure 18. The t-values below the estimated coefficients indicate that all the variables except diversion payments (DPCT) are statistically significant at the 5 percent level. The effects of a \$0.10 increase in the effective prices on harvested cotton acreage are:

PCTE: 6,364,300 acres, and

PSE: 184,680 acres.

Although not statistically significant, the diversion payment variable (DPCT) indicates that harvested cotton acreage in 1966, 1967, and 1968 was reduced in response to cotton diversion payments.

Acreage Supply Elasticities

Short-run and long-run direct and cross price elasticities were computed at the data means to determine the relative price effects on soybean acreage. These estimates are presented in Table 10. These elasticity estimates should be used cautiously. Elasticity estimates calculated at recent price and acreage levels would be considerably different than those presented in Table 10. In addition, subsequent analysis indicated that the coefficients of the equations varied considerably from year to year depending upon the data base used to estimate the equations. Since the equations were developed primarily for projection purposes, and not to determine the structural supply functions, these estimates should be used carefully.

The short-run elasticity estimates of Table 10 appear reasonable and are similar to estimates obtained by Vandenborre, Heady and Rao,

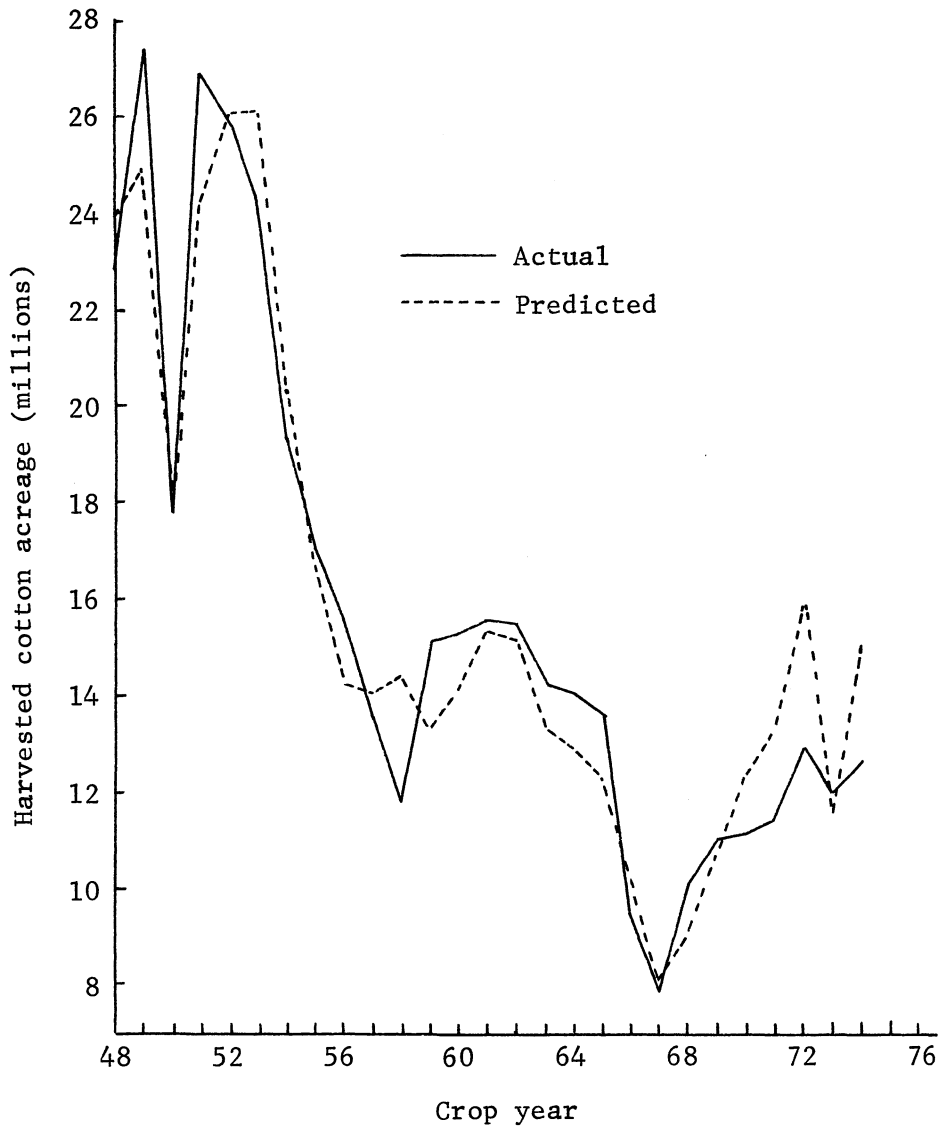


Figure 18. Actual and predicted harvested cotton acreage, 1948-74.

Houck, Ryan and Subotnik, and Penn.¹ The elasticity estimates of this study generally fall in between the estimates obtained by Houck, et al.,

¹R. J. Vandenborre, Economic Analysis of Relationships in the International Vegetable Oil and Meal Sector, University of Illinois Department of Agricultural Economics Research Report 106, July 1970; Earl Heady and V. Y. Rao, Acreage Response and Production Supply Functions of Soybeans, Iowa Agriculture and Home Economics Experiment Station Research Bulletin 555, September 1967; James P. Houck, Mary E. Ryan, and Abraham Subotnik, Soybeans and Their Products: Markets, Models, and Policy, University of Minnesota Press, 1972; J. B. Penn, Econometric Policy Models of Commodity Supply Response, unpublished Ph.D. dissertation, Purdue University, 1973.

Table 10. Short-run and long-run acreage supply elasticities for soybeans, cotton, and feed grains estimated at data means for 1948-74

Crop Region	Effective price					Effective price				
	Soybeans	Corn	Oats	Cotton	Feed Grains	Soybeans	Corn	Oats	Cotton	Feed Grains
	----- Short-run elasticities -----					----- Long-run elasticities ^b -----				
Soybeans										
Corn Belt	0.55	-0.50	-	-	-	4.21	-3.75	-	-	-
Lakes	1.19	-0.63	-	-	-	5.33	-4.04	-	-	-
Plains	1.10	-0.81	-	-	-	7.31	-5.37	-	-	-
Delta	0.21	-	-	-0.35	-	4.23	-	-	-6.73	-
Atlantic	0.57	-	-0.68	-	-	3.32	-	- 3.97	-	-
Others	0.94	-	-1.01	-	-	16.68	-	-17.70	-	-
U.S. ^a	0.68	-0.24	-0.42	-0.08	-	3.78	-1.31	- 2.32	-0.43	-
Feed grains, U.S.	-0.03	-	-	-0.14	0.30	-0.05	-	-	-0.31	0.59
Cotton, U.S.	-0.34	-	-	1.02	-	-0.50	-	-	1.48	-

^aThese estimates are based upon the estimated coefficients of the national soybean acreage response equation (5.1).

^bThe general form of the response function is: $A_t = b_0 + b_1PA_t + b_2PS_t + b_3A_{t-1}$ where A = harvested acreage of crop A; PA = effective price of crop A; PS = effective price of crop S; and t = year from 1948 to 1974. The procedure developed by Nerlove was used to calculate the long-run elasticities. The long-run acreage direct elasticities were computed as: $b_1/1-b_3 \cdot \overline{PA}_t/\overline{A}_t$. The long-run acreage cross elasticities were computed as: $b_2/1-b_3 \cdot \overline{PS}_t/\overline{A}_t$.

using 1946-66 data and Penn using 1954-70 data. The Houck, et al., and Penn acreage response equations included both market price variables and policy variables, whereas the current study combined these two variables; therefore, the results are not directly comparable.

In general, the supply elasticities on soybean acreage relative to effective soybean prices appears to be 0.7, ranging from a low of 0.2 in the Delta region to a high of 1.19 in the Plains region. Soybean acreage appears to be more responsive to soybean prices in the "marginal" producing areas of the Lakes, Plains, and Others regions compared to the two major producing regions - the Corn Belt and Delta. In each region, soybean acreage harvested is very sensitive to the price of the crop competing for production resources. In the Corn Belt and Plains region, soybean acreage responds almost equally to a given percentage change in soybean and corn prices. In the Delta, Atlantic, and Others regions, soybean acreage is more responsive to a price change in the competing crop than in soybean prices. In the Delta, soybean acreage is more sensitive to cotton prices than soybean prices. In the Atlantic and Others regions, soybean acreage is very responsive to oat prices.

The relative magnitudes of the direct and cross price acreage supply elasticities emphasize the close interrelationships among these crops. These estimates suggest that comprehensive agricultural programs dealing with all the feed grains, soybeans, and cotton need to be considered to avoid undesirable acreage responses in crops omitted from piece-meal legislation. Also, any government program of loan rates, support prices, target prices, etc. must keep these relative rates or prices among crops in proper alignment, or undesirable shortages or surpluses will develop.

The elasticity of cotton acreage with respect to the effective price of cotton was estimated to be 1.02. More than any other crop considered in this study, this estimate is largely dependent upon government program changes. In most years, the effective cotton price variable is significantly affected by the support rate and allotment as a percentage of base acreage. The elasticity estimate would be larger for a more recent time period due to higher cotton prices and smaller cotton acres. Our estimate is considerably larger than the 0.23 estimate obtained by Penn² in a similar study and Nerlove's estimate of 0.67 using data ending in 1930.³ A more recent study by Martin⁴ estimated the U.S. price elasticity

²J. B. Penn, Econometric Policy Models of Commodity Supply Response, unpublished Ph.D. dissertation, Purdue University, August 1973.

³Marc Nerlove, The Dynamics of Supply: Estimation of Farmers' Response to Price, The John Hopkins Press, 1958.

⁴Marshall A. Martin, "The Income Distribution Impacts of the Adoption of Mechanical Harvesting of Cotton in the United States," unpublished M. S. thesis, Purdue University, December 1972.

of supply to be 1.28. Blakley⁵ estimated the short-run acreage elasticity for cotton to be 0.75 using data from the non-allotment years of 1944-49 and 1951-53.

The feed grain acreage supply elasticity was estimated to be 0.30. A 10 percent increase in the weighted effective price of feed grains should increase harvested feed grain acreage by 3.0 percent. Since corn acreage is about 60 percent of feed grain acreage, this elasticity estimate is largely influenced by the responsiveness of corn acreage to changes in corn prices. The 0.30 feed grain acreage elasticity is consistent with the corn acreage elasticity estimates of 0.2, 0.23, and 0.22 obtained by Houck and Ryan, Penn, and Nerlove⁶ respectively.

The long-run acreage response to changes in effective prices is presented in the lower half of Table 10. These estimates were computed using the technique developed by Nerlove. All the estimated regression coefficients on lagged acreage were between 0 and 1, therefore the long-run acreage elasticities are all more elastic than the short-run elasticity estimates. In general, these estimates indicate acreage response to a given price change will be considerably greater in the long-run than in the short-run. Of the crops considered, only the feed grains has an inelastic supply response in the long-run.

Evaluation of Model Projections

The major objective of this study was to develop an equation(s) that could project harvested soybean acreage six to fourteen months in advance. Therefore, considerable time was spent evaluating the ability of the model to project outside the data base used to estimate the supply response functions. To accomplish this evaluation, four alternative sets of projections were made. The key differences among these projections are the projection time length and the equations and data used.

The four projection models are labeled, for discussion purposes, by the length of the projection period. The four projection periods are six, ten, twelve and fourteen months in advance of actual harvest of soybeans in October. The mechanics of the projection procedure for each model follow.

⁵Leo V. Blakley, Quantitative Relationships in the Cotton Economy with Implications for Economic Policy, Oklahoma Agr. Exp. Sta. Bul. T-95, May 1962.

⁶J. P. Houck and M. E. Ryan, "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," AJAE, Vol. 54, No. 2, May 1972, p. 190; J. B. Penn, Econometric Policy Models of Commodity Supply Response, unpublished Ph.D. dissertation, Purdue University, August 1973, p. 63; Marc Nerlove, The Dynamics of Supply: Estimation of Farmers' Response to Price, Baltimore, John Hopkins Press, 1958, p. 205.

The projections made six and ten months in advance of harvest are based on information available up through October of the preceding crop year. The six month projection is made in April and the 10 month projection in January. For example, the six month projection of 1967 harvested soybean acreage is made in April 1967 based on the equation estimated from data available from 1948 through October 1966. The effective prices used in projecting 1967 acreage are based on announced government programs, market prices from October 1966 through March 1967, input production cost indexes as of March 1967, and harvested soybean acreage in 1966. The projection for 1968 is made in the same manner, except the equation used includes data from 1948 through 1967. Therefore, each projection is made outside the original data base, and the equation is re-estimated including the previous year before the projection for the subsequent year is made. The same procedure is used to make the 10 month projection except market prices are for the months of October, November, and December of the previous year.

The 12 and 14 month projections were made in October and August respectively using futures prices to approximate market prices. The projections were made as follows: the projection for year $t+1$ is made in August (October) of year t using an average of the March futures prices of year $t+1$;⁷ the indexes of production costs in July of year t ; the July indications for soybean acreage to be harvested in year t ; and the equation based on data through crop year $t-1$. The equation is re-estimated to include data through year t before the projections for year $t+2$ are made.

In an attempt to determine the "best" data base, two alternative data bases were tested in projecting harvested soybean acreage. The first model added each new data observation to the base without dropping off the oldest data observation. The second model added the newest data observation and dropped off the oldest. Using the 1966-74 projection period as a test period in terms of ability to forecast, the two models performed about equally with a slight edge going to the first model. Therefore, all the projections are based on a data base starting with 1948. In both models, the magnitude of the parameter estimates changed substantially from year to year although this did not affect their ability to project harvested acreage. This phenomenon is not of concern in terms of projecting acreages, but it does suggest caution in using the estimated individual coefficients to determine specific effects on harvested soybean acreage. Likewise, the variability of the estimated coefficients should be kept in mind when using the acreage supply elasticities presented earlier.

Actual harvested soybean acreage and projected acreage 6, 10, 12, and 14 months in advance are presented in Table 11 and Figure 19. The goodness of these projections depends upon the decisions to which they lead. However, since information on the gains or losses associated with a particular decision are not available, several other tests are often

⁷The mid-month and end-of-month closing prices for the March futures were used to determine the average price during August and October.

Table 11. Actual and projected harvested soybean acreage by national equation, 1967-75

Year	Actual	Projected ^a			
		6 mo.	10 mo.	12 mo.	14 mo.
----- (000's) -----					
1967	39,805	38,460	38,642	38,525	39,158
1968	41,391	41,719	41,882	41,772	41,863
1969	41,337	42,512	42,435	42,082	42,536
1970	42,249	41,288	40,864	41,717	42,047
1971	42,701	43,283	43,391	41,992	41,348
1972	45,698	44,754	44,687	45,464	45,256
1973	56,416	53,604	50,659	49,211	49,218
1974	52,510	59,733	60,015	58,075	61,897
1975	53,590 ^b	51,055	53,257	59,158	56,667

^aSee text for discussion of projection procedures.

^bIndicated July 1975.

used for projection evaluation. One of these tests is Theil's inequality coefficient (U).⁸ A U value of zero indicates the model projects perfectly, while at unity the model gives the same results as a naive no change model. Other tests of forecast accuracy are tracking ability, magnitude of over and under estimation, and average error as a percentage of mean acreage. These various tests of the forecasting ability of the national soybean acreage response function are presented in Table 12.

One conclusion is obvious from inspecting Tables 11 and 12 and Figure 19. The model projected considerably better for the years 1967-72 compared to 1973-75. Like most projection models, the price controls of 1973, inflation in 1974-75, and the relaxation of controls on agricultural production in 1973 made projection for the years 1973, 1974, and 1975 difficult. Given these several substantial changes, the model results are not as poor as they might first appear. For example, the acreage change from 1972 to 1973 amounts to a 23 percent increase, and the model correctly anticipated this change to a large degree. The largest previous change from year to year was 7 percent between 1971 and 1972. In 1974, farmers originally planned to harvest 54 million acres of soybeans, but because of poor planting conditions during May and June, were only able to plant enough acres to harvest 52.5 million acres. Had farmers been able to harvest 54 million acres in 1974, the projection error in 1974 would have been considerably smaller and the direction of

⁸Henri Theil, Applied Economic Forecasting, Rand McNally and Company, Chicago, 1966.

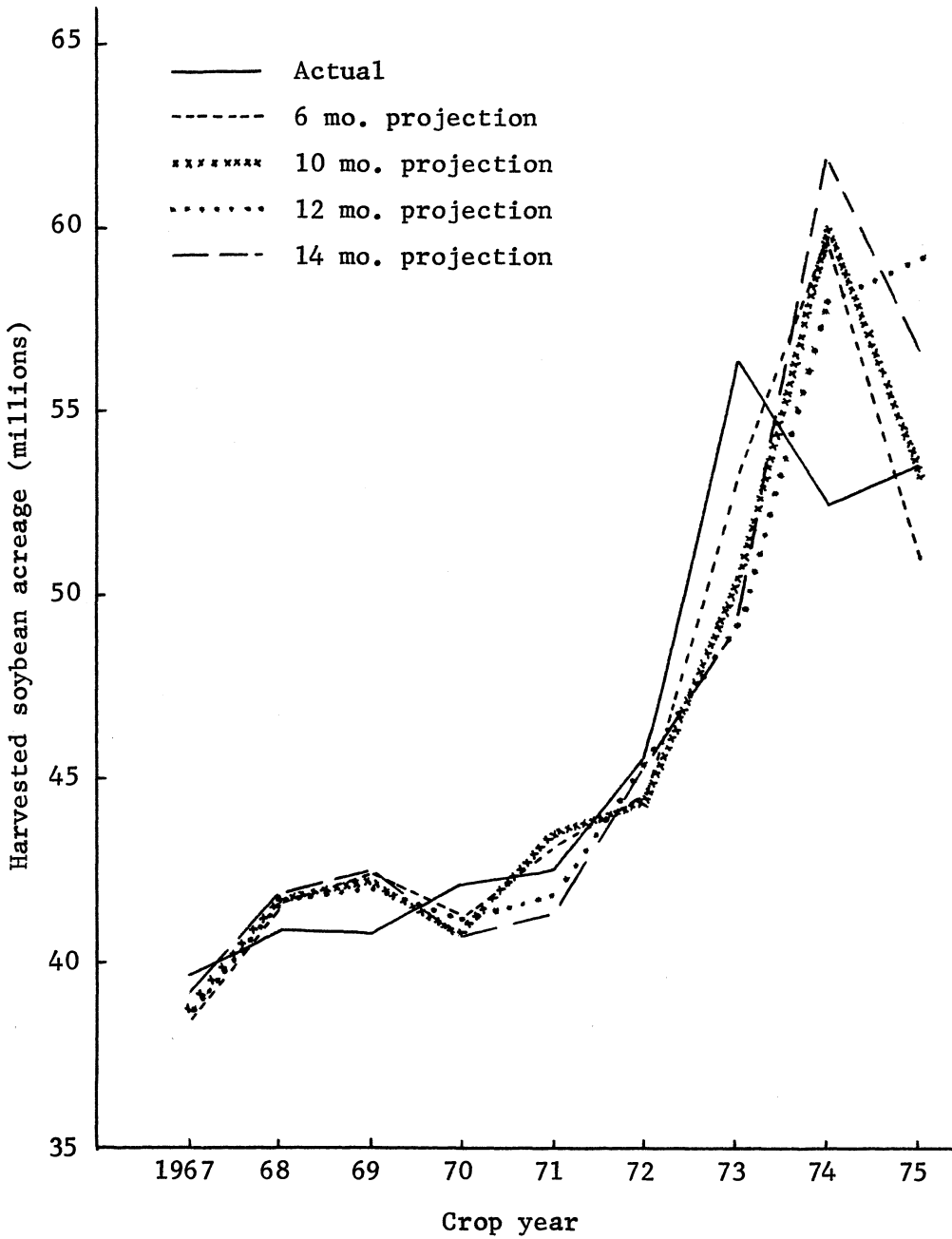


Figure 19. Actual and projected harvested soybean acreage, 1967-75.

Table 12. Summary measures of projection ability of national soybean acreage response model

Description of measure	Unit	Projection period (months)				Projection period (months)			
		6	10	12	14	6	10	12	14
		-- 1967-75 time period --				-- 1967-72 time period --			
Theil U coefficient		.686	.788	.873	.995	.490	.520	.375	.424
Average projection error	thou. acres	1,989	2,159	2,469	2,661	889	973	647	715
Average projection error as percentage of mean	%	4.3	4.7	4.9	5.8	2.1	2.3	1.5	1.7
Maximum underestimate	thou. acres	2,812	5,757	7,205	7,198	1,345	1,385	1,280	1,353
Maximum overestimate	thou. acres	7,223	7,505	5,568	9,387	1,175	1,098	745	1,199
Number of times direction of change projected: ^a									
Correct		5	5	4	5	3	3	3	3
Incorrect		3	3	4	3	2	2	2	2

^aSee discussion in text.

acreage change between 1974 and 1975 would have been correctly projected by the model.⁹

Several additional observations concerning the projections are worth noting. First, the accuracy of the projections decline significantly as the projection period is increased from 6 to 14 months. In fact, the 14 month projection, according to the U coefficient, is no better than assuming no change in acreage from last year. Second, the model does not appear to consistently over or under estimate harvested acreage. Third, as with most Nerlove type models, the model does not perform well in picking up turning points.

Despite the above results and discussion, this model compares favorably with a number of similar studies referenced in Chapter II. The coefficient of determination of the national soybean response function estimated over the time period 1948-1974 was 0.989 and the comparison of actual and predicted values over this time period presented in Figure 16 would suggest that the model would project soybean acreage quite accurately. To illustrate the difference between predicting within the data base and projecting outside the data base, the Theil U coefficient was calculated for the years 1967 through 1974. Using the national soybean acreage response equation (5.1) estimated using data between 1948 and 1974, a U-coefficient of 0.46 was obtained for the years 1967-74. In contrast, a U-coefficient of 0.65 was obtained for the same years using the 6 month projection model which projects outside the estimation data base. Previous acreage response studies would probably find a similar decline in projection accuracy if a true test of the model's projection ability was performed over a number of years.

Six, ten, twelve, and fourteen month projections of feed grain and cotton acreage were made using the same procedures developed for soybeans. These projections are presented in Tables 13 and 14. Like soybeans, the models project quite well until 1974. The estimates for 1974 and 1975 over-estimate feed grain and cotton acreage substantially. This over-estimation may be due in part to increased wheat acreage the last two years reducing feed grain acreage. In addition, the production cost deflators may not have picked up the full impact of increased production cost. The magnitude of the projection errors in feed grain and cotton acreage indicate additional refinement of these equations is needed before they are used for projection purposes.

Use of Models

The models developed in this study are designed to help decision-makers, both private and public, by providing another means of projecting soybean, feed grain, and cotton harvested acreage. They should be used

⁹ Because of these conditions, the direction of change between 1974 and 1975 projected by the model is assumed to be correct as reported in Table 12.

Table 13. Actual and projected U.S. harvested feed grain acreage, 1967-75

Year	Actual	Projected ^a			
		6 mo.	10 mo.	12 mo.	14 mo.
----- (000's) -----					
1967	101,020	106,066	106,311	104,537	- ^c
1968	97,310	95,086	95,086	98,259	-
1969	95,539	91,318	91,070	93,014	-
1970	99,289	90,806	90,592	91,350	-
1971	106,270	112,804	112,501	110,008	-
1972	94,249	107,950	108,051	111,419	111,803
1973	102,300	101,791	100,819	106,103	105,719
1974	100,700	111,407	111,704	99,637	109,881
1975	104,308 ^b	116,543	117,114	129,062	122,878

^aSee text for discussion of projection procedures.

^bIndicated July 1975.

^cFor years 1966-70, estimates of sorghum acreage were not available in August.

Table 14. Actual and projected U.S. harvested cotton acreage, 1967-75

Year	Actual	Projected ^a			
		6 mo.	10 mo.	12 mo.	14 mo.
----- (000's) -----					
1967	7,997	8,398	8,304	9,663	8,757
1968	10,160	10,166	10,166	9,575	9,453
1969	11,055	12,408	12,546	11,967	11,939
1970	11,155	14,249	14,398	13,952	14,184
1971	11,471	15,088	15,286	17,229	16,837
1972	12,984	16,785	16,782	18,163	18,306
1973	11,970	11,750	13,516	14,354	14,213
1974	12,670	24,042	17,408	32,465	29,514
1975	9,338 ^b	12,031	14,027	13,596	17,110

^aSee text for discussion of projection procedures.

^bIndicated July 1975.

as only one of several tools in making acreage projections. Modifications of the projection procedures and variable levels in actual use might be indicated from other informational sources which cannot be incorporated in a mechanical projection procedure. These considerations could improve the projection ability of the models.

These models have several limitations. Although they are designed to incorporate changes in government policy, they assume an unchanged structure in production techniques. If production practices change substantially, an attempt should be made to include these changes in the models. These models are designed to be re-estimated each year before projections for the coming year are made. And finally, as several other researchers have indicated and recent experience has demonstrated, "models are to be used and not believed."

APPENDIX A

SUMMARY OF PROVISIONS

OF THE 1969-71

FEED GRAIN PROGRAMS

Table 1. Summary of provisions of the 1969-71 feed grain programs

Item	1969 Program			1970 Program			1971 Program		
	Price support loan	Price support payment	Total support	Price support loan	Price support payment	Total support	Price support loan	Set aside payment	Guarantee support
<u>Price support</u>									
Corn, per bu.	\$1.05	\$0.30	\$1.35	\$1.05	\$0.30	\$1.35	\$1.05	Corn & sorghum : Difference be- :tween Oct.-Feb.: \$1.35	\$1.35
Grain sorghum, per cwt.	1.61	.53	2.14	1.61	.53	2.14	1.73	average price : 2.21	2.21
Oats, per bu.	.63	.00	.63	.63	.00	.63	.54	received & the : --	--
Barley, per bu.	.83	.20	1.03	.83	.20	1.03	.81	price guarantee: --	--
Production eligible for price support	Price support loan on total production	Price support payment on projected production of the smaller of the acreage planted to feed grains or 50% of base		Price support loan on total production	Price support payment on projected production of the smaller of the acreage planted to feed grains or 50% of base		Price support loan on total production	Set-aside payment on production from 50% of the base. Payment made if planted to feed grains, some other crop or left idle.	
<u>Preliminary or Advance Payment</u>		50% of payment for additional diversion only (no advance on price support payment)			None			Preliminary set-aside payment made soon after July 1 depending on set-aside percentage: ¹	
Corn							20%		
Grain sorghum							\$0.32 per bu. 0.29 per bu.		
Yield used for determination of payments	Projected for 1969 (Based on 1963-67 average adjusted for trend)			Projected for 1970 (Based on 1964-68 average adjusted for trend)			Based on yield established for the farm for the preceding year with necessary adjustment to be fair and equitable.		

¹If the final set-aside payment proves to be less than the preliminary payment, producers will not be asked for a refund. If set-aside percentage is less than 20%, the preliminary payment will be reduced proportionately.

Source: Feed Situation, ERS, USDA, February 1971, p. 14.

Table 1. Continued

Item	1969 Program			1970 Program			1971 Program		
	Price support loan	Price support loan	Total support	Price support loan	Price support loan	Total support	Price support loan	Set aside payment	Guarantee support
<u>Acreage Diversion or Set Aside</u>									
Grains included	Corn, grain, sorghum and barley			Corn, grain sorghum and barley			Corn and grain sorghum		
Base period	1959 and 1960			1959 and 1960			1959 and 1960		
<u>Acreage to be diverted</u>									
Minimum ²	20% of base			20% of base			Set-aside 20% of base no additional diversion for payment ⁵		
Maximum	50% of base (or 25 acres if larger) ^{3,4}			50% of base (or 25 acres if larger) ^{3,4}					
<u>Limitation on acreage planted</u>	Not more than 80% of base plus eligible substitution			Not more than 80% of base plus eligible substitution			No limitation after meeting set-aside requirement and maintaining conserving base.		
<u>Payment rates for acreage diversion</u>	County total support rate times:			County total support rate times:					
First 20% diverted	No payment (except small farms)			No payment (except small farms)			No direct payment--set-aside payment considered payment for required set-aside		
Diversion of 20 to 50%	45% of projected production			40% of projected production			No additional diversion for payment		

²Minimum diversion to be eligible for diversion payments and price support.

³Maximum acreage that can be diverted: no payment for minimum (required) diversion except on "small farms."

⁴Producers could divert for payment up to 25 acres if no feed grains are planted.

⁵Set-aside percentage tentatively set at 20%. Final determination will be announced prior to sign-up.

Table 1. Continued

Item	1969 Program			1970 Program			1971 Program		
	Price	Price	Total	Price	Price	Total	Price	Set	Guarantee
	support	support	support	support	support	support	support	aside	support
	loan	payment	support	loan	payment	support	loan	payment	support
Small producer -	May divert entire acreage.			May divert entire acreage.			No special provision, Un-		
25 acres of feed	Payment on first 20% based			Payment on first 20% based			like 1970, producers re-		
grains or less	on 20% of projected produc-			on 20% of projected produc-			ceive set-aside payment		
	tion; additional diversion			tion; additional diversion			even if no feed grains are		
	based on 40% of projected			based on 40% of projected			planted.		
	production ⁶			production ⁶					

⁶ Producers with bases of 26 through 125 acres may elect to have the base temporarily reduced to 25 acres and be paid as a small producer, provided no corn, grain sorghum or barley is planted.