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ANALYZING THE IMPACT OF GOVERNMENT PROGRAMS ON CROP ACREAGE
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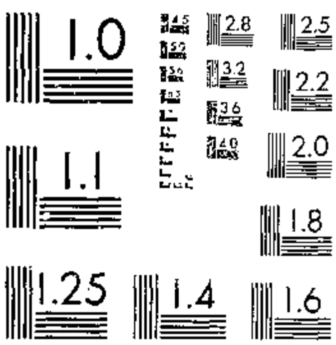

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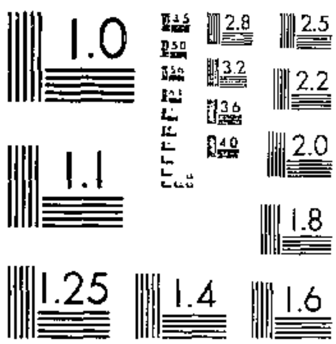

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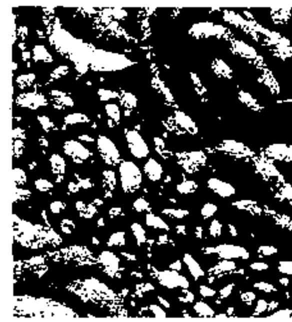
Analyzing the Impact of Government Programs on Crop Acreage



Technical Bulletin No. 1548

U.S. Department of Agriculture, Economic Research Service
In cooperation with The University of Minnesota Agricultural Experiment Station

NALYZING THE IMPACT OF GOVERNMENT PROGRAMS ON CROP ACREAGE, by James P. Houck
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ABSTRACT

This study develops and applies the concept of "effective support prices." overnment-announced price supports for agricultural crops adjusted to reflect he stringency of acreage controls imposed on growers as a condition for btaining price supports. Effective support prices are used as a means of stimating the impact of Government programs on planted acreages of seven ajor U.S. field crops. Also, where applicable, the study shows that ffective diversion rates are strongly but inversely related to plantings of he crops. Market price influences became increasingly important in the eventies.

Keywords: Acreage, diversion, barley, commodities, corn, cotton, grain orghum, Government programs, oats, price supports, soybeans, supply analysis, heat.

Washington, D.C. 20250

August 1976

PREFACE

This is a summary report of research sponsored largely by the Economic Research Service (ERS) of the U.S. Department of Agriculture. Overall supervision was provided by the Commodity Economics Division of ERS and, before 1972, by the former Economic and Statistical Analysis Division. Much of the work was done at the University of Minnesota's Department of Agricultural and Applied Economics, including formulation of the general economic model and the empirical analysis of the four feed grains and soybeans.

The overall report was compiled at the University of Minnesota by James P. Houck.

The research on wheat was conducted by former ERS economist Robert G. Hoffman, and the cotton analyses were carried out by ERS economist J. B. Penn. Although not listed as an author for this report, Abraham Subotnik of Technion Institute of Technology in Israel made several very important contributions to this research.

The authors of this report believe that this research represents a further example of useful collaboration between the USDA and the Land-Grant College system in the economic analysis of agricultural policy and programs. Errors of fact and judgement are the sole responsibility of the authors as individuals.

CONTENTS

SUMMARY

This study suggests and analyzes a relatively simple method for incorporating the effect of Government programs into analyses of acreage response. "Effective support prices" are derived by adjusting Government-announced price supports for agricultural crops to reflect the stringency of acreage controls imposed on growers as a condition for obtaining the price supports. These prices are used as a means of estimating the impact of Government programs on planted acreages of field crops.

The estimates show that effective support rates are directly and significantly related to acreage planted. Where applicable, effective diversion rates also are strongly but inversely related to plantings of the commodities in question. Market price influences become increasingly important in the seventies.

Separate acreage response studies are given for seven major U.S. field crops which have been heavily influenced by Government policy since the fifties. These crops include corn, grain sorghum, barley, oats, wheat, soybeans, and cotton.

Substitute supply relationships among alternative commodities, especially corn and soybeans, are captured by using effective support rates in some cross-commodity specifications. But, this is not possible in all cases, and the planted acreage of substitute crops is used in some instances. Other economic and policy-related factors which influence acreage changes in each of the seven crops appear in various equations and are also discussed.

Analyzing The Impact of Government Programs On Crop Acreage

by James P. Houck, Martin E. Abel, Mary E. Ryan,

Paul W. Gallagher, Robert G. Hoffman, and J. B. Penn[1]

INTRODUCTION

The economic analysis of supply relationships for agricultural products is generally much less complete than for comparable demand relationships. Even though great advances have been made in the theoretical and statistical apparatus available for supply analysis, empirical applications to the major U.S. field crops have not been fully satisfactory. Part of the problem is inherent in the nature of agricultural production processes: (1) Time is required between the production decisions and actual harvesting; (2) weather risks and other environmental hazards are always present; (3) production and supply adjustments within crop years are generally not possible; and (4) changing price relationships among alternative crop and livestock enterprises as well as among productive inputs complicate the decisionmaking processes of farmers. Uncertain longrun economic and social expectations of farmers add further complexity to supply analysis.

Moreover, for several important crops, a central problem in supply analysis since World War II has been to account for, and somehow measure, the impact of changing Government programs. The purposes of this report are first to present a general discussion of one particular economic framework for estimating U.S. agricultural crop supply functions in the presence of Government programs and second to summarize several illustrative empirical studies using this framework.

If the impact of Government programs on commodity supply response can be estimated, then predicting, projecting, and analyzing alternative policies for the affected agricultural products can be improved. In addition, this study about the effects of recent Government programs on several specific crops may be useful for analysis of other crops and programs in the future. Because

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1/ Houck and Abel are professors in agricultural economics at the University of Minnesota; Ryan is an assistant professor there; Gallagher and Penn are agricultural economists with the Commodity Economics Division, Economic Research Service (ERS); and Hoffman (formerly with ERS) is an agricultural economist at the Treasury Department.

economic and political conditions change rapidly, the main value of this work will be to illustrate a rather generalized method of analysis in estimating supply response when Government intervention is important. The various commodity studies discussed here will show the broad applicability of the methodology. These individual commodity studies are drawn from ongoing and completed research by the various authors. Some of the analyses are reported in more detail in other publications (3, 4, 5, 6, 10, 11, 12, 13, 14, 15). 2/

Farm supply behavior in the fifties, sixties, and early seventies was consistently tempered by Government programs designed to deal with surplus production, actual or potential. The analyses, ideas, and empirical estimates presented here also reflect that experience. Subsequently, record high crop prices and worldwide supply shortages have caused a virtual reversal in U.S. agricultural policies and in the operation of Government programs. In the mid-seventies, the goal is to expand output. Even so, the ideas and estimates presented here, with appropriate adjustment, can be relevant in an expansionist era. Furthermore, there is no guarantee that the standby commodity control programs authorized in current agricultural legislation will not be needed again, especially if export demand suddenly weakens.

This report discusses supply estimates for seven crops in U.S. agriculture that were heavily influenced, either directly or indirectly, by postwar Government programs. These crops are corn, grain sorghum, oats, barley, wheat, soybeans, and cotton. For each commodity, a rather uncomplicated economic model was used which relied on annual time series observations and introduced market and Government impacts on alternative crops.

The standard USDA series of crop acreages and prices form the data base for these analyses. They are published in the annual Agricultural Statistics by USDA's Statistical Reporting Service, and various ERS situation reports.

The seven commodities made up 55 percent of the U.S. gross farm value of crops (net of Government payments) in 1969 and 1970 and 26 percent of all cash receipts from farm marketings (table 1). They were planted on 73 percent of total U.S. crop acreage in those years. In addition to their dominance of the acreage and crop income picture, these seven commodities--especially corn, grain sorghum, wheat, and cotton--formed the backbone of the price-supporting, income-supplementing, acreage-controlling policies operated by the U.S. Government since World War II.

These commodities include most of the major "problem" crops to which farm policy attention has been directed. Wide swings in prices and the general problem of surplus production or its potential have provided the incentive for every administration since the thirties to intervene in their pricing, production, and marketing. Also, each of these commodities can be stored relatively inexpensively for long periods, making possible flexible programs of surplus storage and disposal.

2/ Underscored numbers in parentheses refer to items in Literature Cited at the end of this report.

Table 1--Average acreage and farm value of seven major field crops, 1969/70-1970/71 crop years

Item	Acreage planted	Farm value of crop production
	1,000 acres	Million dollars
Corn	65,740	5,365
Grain sorghum	1/13,628	794
Oats	23,983	573
Barley	10,365	379
Soybeans	41,519	2,926
Wheat	51,884	1,821
Cotton	11,914	1,088
Total	219,033	12,946
	---Percent---	
Seven-crop total as percentage of U.S. total	2/72.7	3/55.2

1/ Acres harvested for grain.
2/ Based on acreage of 59 principal U.S. crops.
3/ Based on value of 78 U.S. crops.

After World War II, Government programs for crops were altered--usually annually--to reflect changing shortrun views of economic conditions. In addition, program philosophy was altered somewhat from administration to administration and from Congress to Congress to reflect changing political views of farm problems and their solutions. Since the mid-seventies, nearly all controls contained in the Agriculture and Consumer Protection Act of 1973 have been abandoned, and maximum production has been sought. However, the supply-restricting provisions of the Act can be reactivated if economic circumstances change.

Figure 1 illustrates the importance of cropland diversion relative to total cropland in the United States, beginning with the Soil Bank of 1956 and continuing through the voluntary annual programs of the sixties and seventies. Most of the diverted acreage shown was from the crops studied here. Figure 2 shows the level of direct Government payments under the commodity diversion programs.

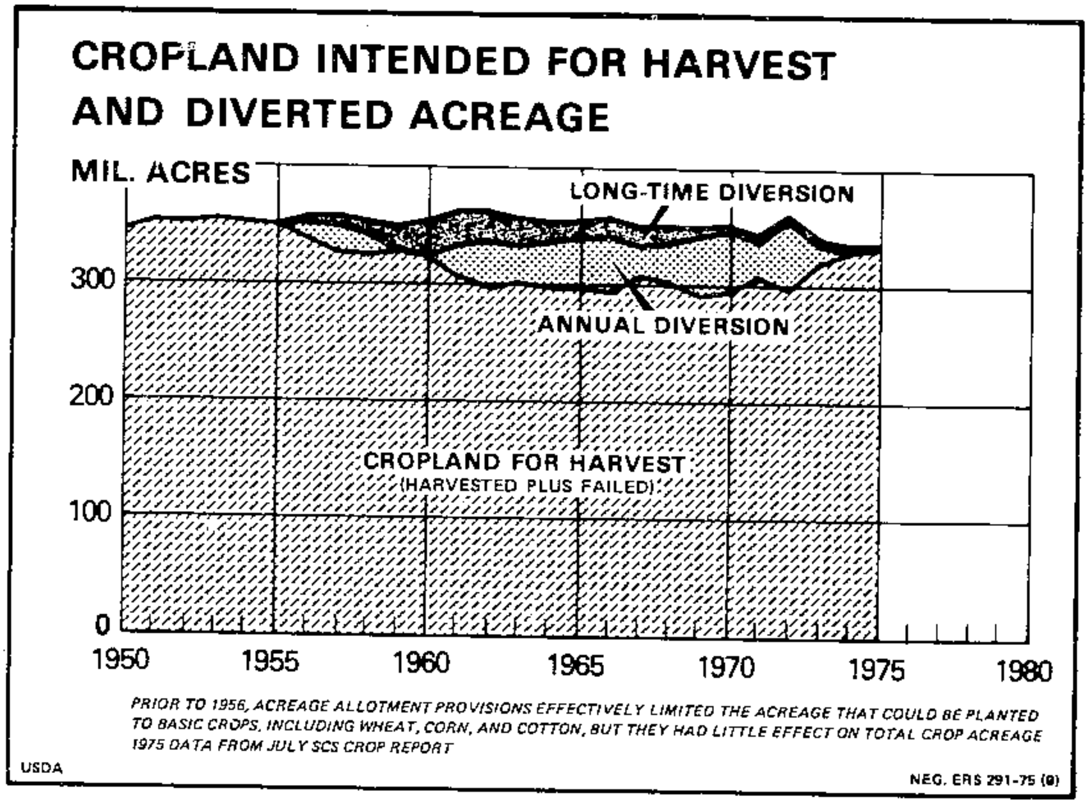
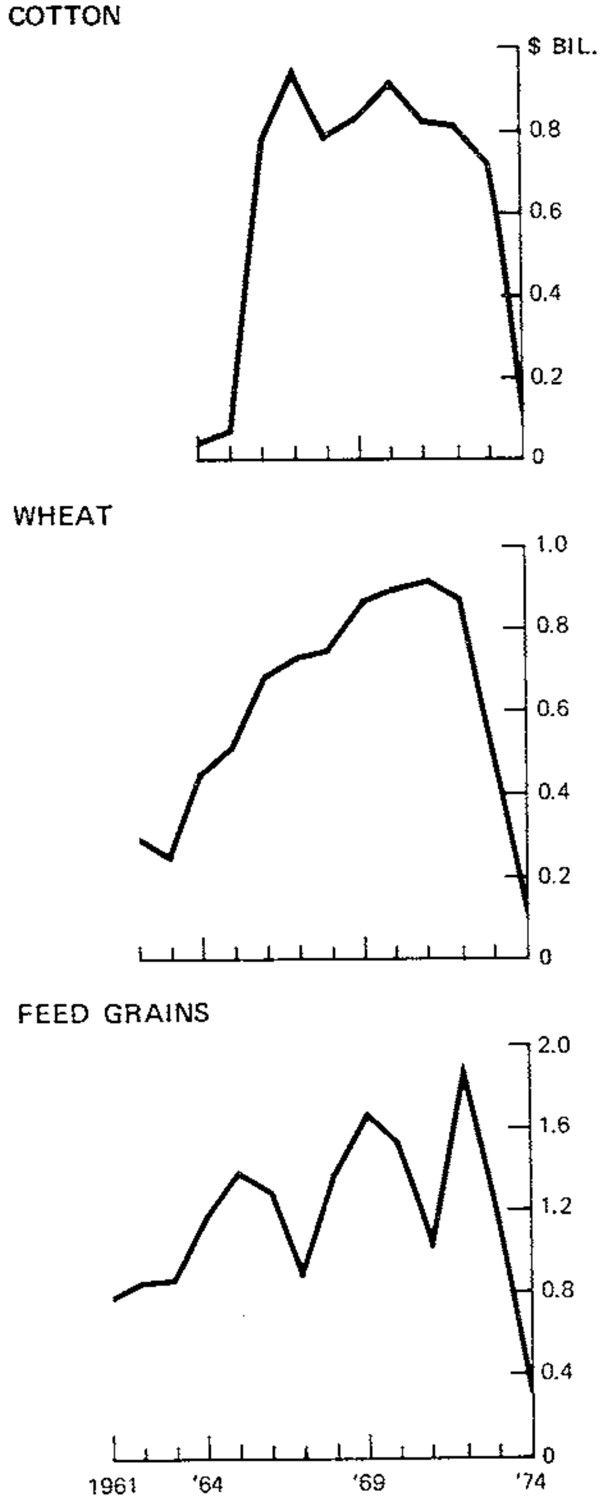

CROPLAND INTENDED FOR HARVEST
AND DIVERTED ACREAGE
MIL. ACRES
LONG-TIME DIVERSION
ANNUAL DIVERSION
CROPLAND FOR HARVEST
(HARVESTED PLUS FAILED)
300
200
100
0
1950
1955
1960
1965
1970
1975
1980
PRIOR TO 1956, ACREAGE ALLOTMENT PROVISIONS EFFECTIVELY LIMITED THE ACREAGE THAT COULD BE PLANTED TO BASIC CROPS, INCLUDING WHEAT, CORN, AND COTTON, BUT THEY HAD LITTLE EFFECT ON TOTAL CROP ACREAGE
1975 DATA FROM JULY SCS CROP REPORT
USDA
NEG. ERS 291-75 (9)

Figure 1

GOVERNMENT PAYMENTS TO PROGRAM PARTICIPANTS*



* EXCLUDING DISASTER PAYMENTS UNDER 1973 ACT.

Figure 2

It is not within the scope of this report to provide a detailed description of the production, marketing, and use of these commodities, although some relevant material of this kind will appear in the separate sections dealing with individual crops. Furthermore, the vast complexities of the commodity programs will not be probed in depth here, but pertinent features of the various programs will be discussed as necessary in the commodity sections.

THE ANALYTICAL FRAMEWORK

The Basic Economic Model

Since the models discussed in this report are supply models for field crops, the dependent or decision variable in each case is acreage planted. No explicit analysis of yield response to market phenomena or to Government policy variables was conducted, although this important issue is the subject of some ongoing research under this general project. In addition, the relationship between acreage planted and acreage harvested of the crops studied is presumed to be very close, with no systematic economic relationships coming into play. In most instances, deviations between the two are assumed to be caused by random environmental factors.

A very general functional statement of the economic model underlying this investigation is equation 1:

(1) $A = f(M, G, Z)$,

if A is the annual acreage planted of the particular crop under consideration; M represents the composite of all open-market economic forces which influence the aggregate of decisions to plant; G represents all relevant Government policy provisions which affect planting decisions; and Z includes all other supply-determining factors, including noneconomic and random effects.

The major items indicated by M include some collection of recent and past market prices for the crop in question and for relevant alternative crop and livestock enterprises. Similarly, M could include prices for productive inputs such as machinery, fertilizer, and seed. Interest rates, availability of production credit, and wage rates available to the farm operator for nonfarm employment also might be included in M. Although many of these variables might not appear in any given empirical analysis, they can still be identified as basic supply-inducing factors suggested by economic theory.

The major elements encompassed by Z include the net effects of past and current weather patterns, presence of plant pests such as insects and disease, and future expectations not based on measurable past prices and price relationships. In addition, Z might reflect planting decisions made to accommodate longrun crop rotation or environmental protection plans, the level of crop-production technology, and a host of other nonmarket and non-Government phenomena, many of which are not measurable.

The remaining variables--those reflected in G of equation 1--form the central focus of this study. For the commodities studied, G includes several kinds of supply-influencing policy variables which were important in the postwar period. Among them were price support loan rates, direct support payments to growers, payments for idling acreage, planting restrictions, allotments, acreage idling and set-aside requirements, long-range land retirement payments, and special payments for conservation and recreational uses for cropland. As with M and Z, some of the potential variables indicated by G might not appear in a given empirical study, especially one dealing with aggregated regional or national supply. But several of the variables mentioned here, especially those connected closely with programs to support prices and incomes and to control acreage during the fifties, sixties, and early seventies, were measured and used in the supply analyses.

Equation 1 can be viewed as a generalized acreage supply response function. By assuming an appropriate algebraic form for the equation and some fairly general properties of the random elements in Z, the relationship can be estimated empirically if sufficient information is available on the important variables specified for M, G, and the balance of Z. Economists have been rather successful over the years in measuring the effects of supply-inducing elements in M and Z for farm products when G has not been important. This includes both crop and livestock production supply relationships. Economic theory, statistical techniques, and actual data are abundant for applications of supply analysis where only M and Z enter. It is to the theory and the measurement of elements in G that we now turn.

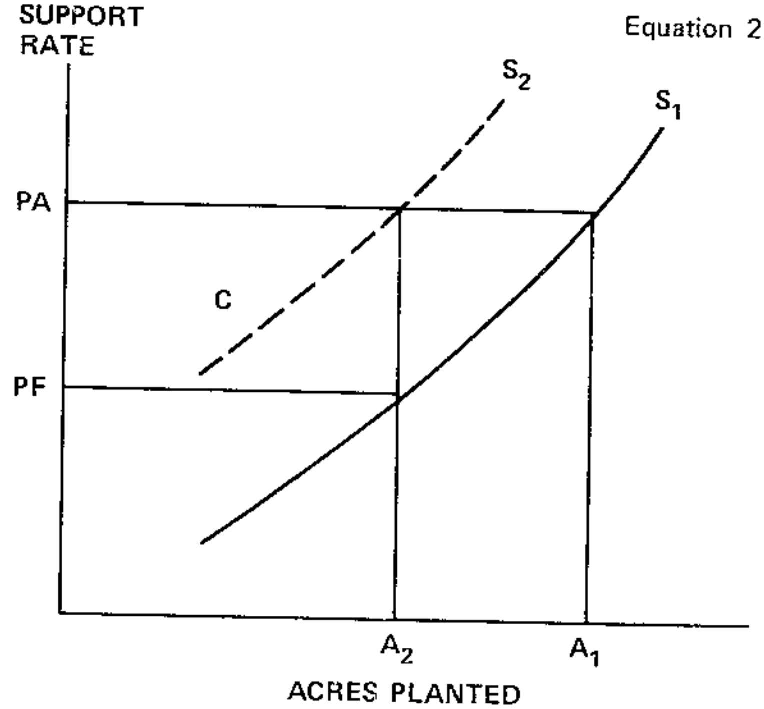
Government Policy Variables

The main goal of this section is to illustrate the fundamental ideas behind the policy variables developed for use in the statistical analyses to follow. For each commodity, the problem was to combine into a few quantitative variables the price- and income-supporting features of annual commodity programs and their acreage-controlling aspects. To focus attention on the influence of policy decisions on acreage of a particular crop, assume that the current year's production is a function of previous market prices, of current policy or program details for that crop, and of other supply shifters, the last being held constant for the moment.

With a given set of previous prices and a constant set of other supply shifters (including policy provisions for alternative crops) the curves in figure 3 reflect some possible policy relationships. First consider the simplest case: The Government announces a support price and attaches no mandatory or voluntary acreage or other production controls. In this case, producers will view the announced support rate as a price guarantee. At higher announced support rates, they will plant more acreage; at lower rates, less acreage. Curve S_1 illustrates such a relationship. The position and slope of S_1 in any year are influenced by previous market prices and other supply shifters, but the underlying presumption is that S_1 is positively sloped. At support rate PA in figure 3, the planted acreage will be A_1 when no acreage restrictions apply.

RELATIONSHIP OF GOVERNMENT COMMODITY PROGRAMS TO ACREAGE PLANTED OR DIVERTED

(Based on equations shown in text)



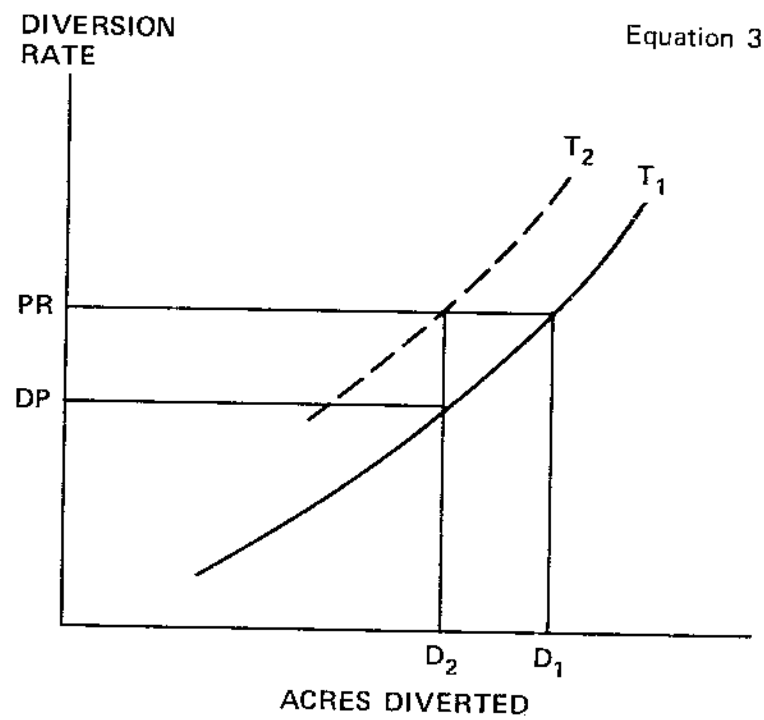


Figure 3

Now consider a somewhat more complex case. For policy purposes, the desired acreage of the crop in question is A_2. An unrestricted lower support rate of PF would result in the planting of A_2. But assume that political, social, and other considerations linked to farm income levels make it impossible or undesirable for policymakers to sanction such a reduction in support. A support rate of PA could be announced, but in order to obtain PA, producers might be required or induced to reduce acreage sufficiently so that $A_1 - A_2$ is taken out of production. In this case, PF could be called the "effective support" rate in equation 2:

$$(2) \qquad PF = r\ PA$$

if r is some adjustment factor which embodies the planting constraint attached to the availability of PA. When no restrictions apply, as in the first case, r = 1.0 and PF = PA. As planting restrictions become tighter, r will move closer to zero. Generally, r will lie between 0 and 1.0. As r departs from 1.0, income protection (equal to area C in figure 3) will become available to those producers who participate in the program. If more acreage is required in another year to meet consumption, export, and inventory requirements, measures to relax restrictions and increase r can be adopted. Then, A_2 will move toward A_1, and C ultimately will vanish.

The voluntary acreage programs of the recent past included another feature which can be visualized within this general theoretical framework. In some years and for some program crops, direct payments were offered to program participants for withdrawing land from production and leaving it idle. Imagine that policymakers wished to reduce planted acreage from A_1 to A_2 in figure 3 solely by means of payments for idled land. They could announce an unrestricted support price of PA and then offer payments attractive enough so that producers would, on balance, divert sufficient acreage from production so that S_1 shifted to S_2 and $A_1 - A_2$ land was idled for payment. Parallel with equation 2, we can write equation 3:

$$(3) \qquad DP = w\ PR$$

if PR is the payment rate for diversion, w is the part of base acreage eligible for diversion, and DP is the effective diversion payment rate. At a fixed level of PR (which can be and often is linked to PA), w can vary between 0 and 1.0. If there is no limit on acreage eligible for diversions, w is equal to 1.0. The smaller the permitted diversion, the closer w is to zero.

With the offer of diversion payment rate PR and no restrictions on the amount of acreage diverted, acreage D_1 will be diverted from production, other things remaining the same. Increases or decreases in PR will generate increases and decreases in diversion along T_1. The imposition of a constraint on the maximum amount eligible for diversion will open a gap between PR and DP as in equation 3. The effect will be to shrink the diverted acreage to D_2. The argument behind this relationship is similar to that governing the relation between PA, PF, and acreage planted. In a sense, PR is a Government-sponsored "rental" rate for land for nonproduction, and w is a quantitative restriction on the amount of land eligible for "rental" to the Government in the annual programs.

Still looking at figure 3, it is possible to view an increase in PA or PF as a shifter which moves T_1 to the left. If D_2 is the desired diversion and PR the diversion payment rate, then D_2 could be achieved along T_1 by adjusting w to yield DP in figure 3 or by increasing PA or PF sufficiently to move the supply of divertable acreage to T_2. Of course, it is possible to employ a combination of both approaches to achieve target levels of production and farm income. In fact, numerous combinations of PA, PF, PR, and DP were used in various modifications of commodity programs during the postwar period.

Unfortunately, actual program provisions were not specified so that support and diversion rate variables, especially PF and DP, are unambiguous for quantification and inclusion in supply analyses. Consequently, the estimation of values for PF and DP is crucial in empirical work with this conceptual framework. 3/ These two variables, if reasonably well estimated, can capture the essence of the various control programs in the crop sector. So, for each of the separate supply studies, an important part of the work was to develop reasonable, internally consistent estimates of PF and DP. For purposes of analysis, it was not absolutely necessary to estimate the actual level of PF and DP with precision, but it was important to capture year-to-year change in a consistent way. This is especially critical in years when the operating rules or underlying philosophy of the programs were changed substantially. Such changes usually occurred when major new farm legislation was adopted such as in 1962, 1965, and 1970, or when administrations changed, which followed the national elections of 1952, 1960, and 1968.

The quantitative estimates of program provisions presented in this report for the crops under study are creatures of the individual researchers' judgments. They are not fixed or self-evident. In all cases, other calculations made by different individuals using somewhat different criteria might be just as valid. All that can be said for the computations and estimates to follow is that they seem realistic, given the complexities of the real programs and the limitations of this analytical apparatus, and are reasonably successful.

A Typical Supply Estimation Function

Consider an acreage supply function for a typical crop, X, which is affected by Government programs for itself and also by programs for an alternative crop, Y. Suppose that the relevant values of PF and DP were calculated for X and Y over several years. Equation 4 below is an estimating equation representative of the relationships used in following empirical analyses:

$$(4) \qquad AX_t = a_o + a_1PX_{t-1} + a_2PFX_t + a_3DPX_t + a_4PFY_t + a_5DPY_t + a_6K_t + U_t$$

if

AX_t = Acreage planted of X in year t

3/ For some discussion of both theoretical and empirical issues in these kinds of calculations see (6), including appendix B.

PX_{t-1} = Previous year's market price of X

PFX_t = The value of PF for crop X in year t (reflecting both support rates and acreage constraints)

DPX_t = The value of DP for crop X in year t (reflecting both payment rates and the proportion of base acreage eligible for diversion)

PFY_t = The value of PF for crop Y in year t

DPY_t = The value of DP for crop Y in year t

K_t = All other relevant supply shifters in year t

U_t = A mean-zero, serially independent random variable with finite variance

The supply response parameters of interest are the various a's in equation 4.

This typical equation is linear in actual numbers and includes a random variable (U) to capture the net effects of all other unspecified variables affecting acreage. Along with the calculation of PF and DP variables, the specification, estimation, and evaluation of such equations as this one comprise much of the analyses presented in the rest of this report.

FEED GRAINS

Introduction

Since the early fifties, yields have increased substantially for all four major feed grains: Corn and sorghum yields have more than doubled; barley yields have nearly doubled; and oat yields have increased by about 50 percent. But the supply growth resulting from these technological advances was not matched by a corresponding boost in demand during the fifties and sixties. The result was downward pressure on feed grain prices and income. So, it is not surprising that these crops were subject to the complete array of Government acreage control programs, as policymakers attempted to maintain price levels without accumulating unmanageable surpluses.

Government policy has affected acreage planted to feed grains mainly through programs applied to specific commodities. These have included price supports, payments for diverting land to specified purposes, restrictions on planted and diverted acreage, and harvesting restrictions. But changes in these provisions have not only affected acreages of the target crops, but also indirectly those of alternative crops. For purposes of the feed grain supply analysis, these indirect effects were reflected (1) through the effective levels of support and diversion payments for alternative crops and (2) through the application of planting restrictions on some, but not all, crop alternatives.

Among the factors with a direct impact on acreage planted are minimum price guarantees which have been offered to producers of all feed grains. These guarantees, by means of nonrecourse loans, have existed since the beginning of the study period. Moreover, the loan rates for the various feed grains have been legally linked because of the close substitutability of the grains in livestock feeds.

The application of other feed grain program features, however, has been less uniform, both in timing and means of implementing. Corn, sorghum, and barley have been subject to the same set of programs, but their imposition was staggered over a longer period. As early as 1949, corn planting within announced acreage restrictions was a prerequisite for obtaining price supports. Payments for voluntary diversion from corn planting, along with restrictions regarding eligible diversion acreage, were first instituted by the Soil Bank Program in 1956. The tie between eligibility for price supports and maximum acreage allotments and the initiation of diversion schemes (payments and acreage restrictions) were first established for sorghum in 1961 and barley in 1962. On the other hand, oats never have been subjected to acreage restriction or diversion schemes. In fact, oats planted for soil conservation was allowed on land diverted from the production of other feed grains and wheat throughout the study period. (Harvesting of oats from diverted acres, however, was not generally permitted.)

The adaptation of the early feed grain programs to the estimation model was fairly straightforward. However, incorporating more recent program features requires some elaboration. First, beginning in 1961, farm prices and incomes were supported by loans, voluntary acreage reductions, and direct payments, with the payments to farmers computed in two parts. One part was based on the land withdrawn from production (called the acreage diversion or set aside payment). The other part was based on land planted to the crop in compliance with the program (called the price support payment). Only acreage diversion payments were made in 1961 and 1962. Price support and acreage diversion payments were made during 1963-65. Thereafter, price support payment levels ceased to be related to planted acreage; payment was instead based on the farmer meeting the required minimum acreage diversion. Beginning in 1966, therefore, support payments can be interpreted either as supplemental payments for production or as payment for diverted acreage. Another complicating factor, present in most years, was an option offered participants to divert more acreage than the required amount for payment from the Government. Except for small farms, a maximum was placed on the amount of acreage eligible for diversion for payment.

Second, with the advent of the 1971 set aside program, acreage diversion requirements were stated without direct reference to particular crops. However, diversion requirements for specific crops still can be approximated since payment rates depended on the type of crop acreage diverted. With this information, it was possible to approximate the commodity-by-commodity diversion.

The price impact of each of the above programs was summarized by means of "effective price support" and "effective diversion payment" variables. For each feed grain, the effective price support in any given crop year was measured in equation 5 as:

$$(5)\qquad PF^i = r\,PA^i = \left[1/2 \left(\frac{A^i_{min}}{A^i_o} + \frac{A^i_{max}}{A^i_o} \right) \right] PA^i$$

if

PA^i = Announced support price for feed grain i

A^i_o = Base acreage of feed grain i

A^i_{min} = Minimum acreage of i allowable under price program

A^i_{max} = Maximum acreage of i allowable under price program

PF^i = Effective price support

The average proportion of base acreage eligible for planting was used as the measure of r. This allowed adjustment of the effective price support variable whenever minimum or maximum provisions are altered--so that r fluctuated between zero and unity for corn, sorghum, and barley. Since no acreage restrictions were imposed on oats, r equaled 1.0 throughout the historical period. The announced price support variable (PA^i) consists of the loan rate and, where relevant, additional support payments. In line with previous comments, support payments after 1965 were considered in some specifications as payments for production and in others as diversion payments. Sorghum and barley effective support rates were constructed under the assumption that direct payments were part of the diversion incentive.

Diversion payment rates were constructed in a similar way, except that varying payment rates for different levels of diversion were considered. This idea is expressed in equation 6 for a given crop year:

$$(6)\qquad DP^i = 1/2 \left(\frac{D^i_{min}}{A^i_o} \right) PR^i_1 + 1/2 \left(\frac{D^i_{max}}{A^i_o} \right) PR^i_2$$

if

PR^i_1 = Diversion payment rate for levels of diversion near the minimum requirement

PR^i_2 = Diversion payment rate for levels of diversion near the maximum allowable

D^i_{min} = Minimum acreage diversion requirement

D^i_{max} = Maximum acreage diversion requirement

A^i_o = Base acreage

The effective diversion payment variable for corn first took on a nonzero value in 1956 with the beginning of the corn acreage diversion program under the Soil Bank. Similarly, positive effective diversion payment levels occurred for sorghum and barley producers after 1961 and 1962, respectively. No corresponding diversion variable was needed for oats. Beginning with 1965, DP^i was calculated both with and without the inclusion of direct support payments.

The constructed PF and DP data are shown in table 2 for 1948-71. An examination of corn, sorghum, and barley data reveals that positive fluctuations in PF corresponded with negative fluctuations in DP, as would be expected. This tendency is especially pronounced in corn and sorghum policy. For 1957-70 the correlation coefficients between effective price support and effective diversion payments are -0.93 for corn and -0.92 for sorghum. This tendency is less dramatic with barley policy, the analogous correlation coefficient being -0.32.

Unraveling the indirect policy effects required an examination of the historical patterns of crop substitution for each commodity. Although this is a regional matter in its initial stages, the goal here was to determine, wherever possible, which substitution effects are of national significance. However, analysis of this aspect of feed grain supply was complicated by two factors.

First, effective price support variables for some substitute commodities were highly correlated. In others, appropriate price support or diversion payment data were not available. Therefore, even though effective price support data for substitute commodities probably should have been used as independent variables, the corresponding quantities often were used as proxy variables. Second, plantings of sorghum and barley were not restricted prior to the early sixties. During 1948-61, many plantings of corn as well as cotton and wheat were subject to acreage restrictions. By extending acreage restrictions to sorghum and barley around 1961, structural changes were imposed on some substitution relationships. These structural shifts were used in the analysis of corn and sorghum.

For each of the feed grains, a variety of analyses covering 1949-71 are presented and discussed. This was the period during which the major price support and acreage-controlling policies were used. Then a series of updated and revised analyses are presented that deal with more recent experience. Since 1971 acreage restraints have been removed, and market prices have been considerably above support levels. The use of "spliced" variables and price ratios to capture the effects of the changed economic setting in crop production is emphasized in these revisions.

Corn 4/

Corn is by far the major U.S. feed grain, accounting for 68 percent of total feed grain production in 1970. Technological advances in production and

4/ The basic research from which this section is drawn is reported in (5,13).

Table 2--Effective price support (PF) and diversion payment (DP) variables for feed grains

Crop year	Corn				Sorghum		Barley		Oats
	PFC*1/	PFC**2/	DPC*1/	DPC**2/	PFS**2/	DPS**2/	PFB**2/	DPB**2/	PFO3/
	---Dollars per bushel---				---Dollars per cwt.---		---Dollars per bushel---		
1948	1.44	1.44	0	0			1.09	0	0.69
1949	1.40	1.40	0	0			1.10	0	.71
1950	1.15	1.15	0	0			1.11	0	.72
1951	1.57	1.57	0	0			1.22	0	.78
1952	1.60	1.60	0	0			1.24	0	.80
1953	1.60	1.60	0	0			1.15	0	.75
1954	1.30	1.30	0	0			.95	0	.61
1955	1.33	1.33	0	0			1.02	0	.65
1956	1.11	1.11	0	0			.94	0	.61
1957	.96	.96	.043	.043	1.86	0	.93	0	.61
1958	.86	.86	.052	.052	1.83	0	.77	0	.50
1959	1.12	1.12	0	0	1.52	0	.77	0	.50
1960	1.06	1.06	0	0	1.52	0	.93	0	.62
1961	.84	.84	.192	.192	1.35	.309	.65	0	.62
1962	.84	.84	.192	.192	1.35	.309	.67	.149	.65
1963	.88	.88	.112	.112	1.40	.180	.62	.086	.65
1964	.81	.81	.180	.180	1.30	.290	.62	.139	.60
1965	.81	.81	.180	.180	1.30	.290	.52	.139	.60
1966	.80	.65	.098	.248	.99	.418	.90	.175	.63
1967	.99	.84	0	.150	1.29	.265	.90	0	.63
1968	.83	.68	.091	.241	1.05	.410	.54	0	.63
1969	.83	.68	.091	.241	1.05	.409	.54	.170	.63
1970	.83	.68	.081	.231	1.05	.393	.81	.162	.54
1971		1.05		.160	1.73	.259		0	

1/ Support payments after 1965 are included in the calculation of PFC* and not in DPC*.
2/ Support payments after 1965 are not included in the calculation of PFC**, PFS** or PFB** but are included in DPC**, DPS**, and DPB**.
3/ Since no support payments were offered for oats production and since r = 1 throughout the historical period, PFO is equal to the oats loan rate.

large amounts of fertile land primarily in the Midwest have resulted in this dominance (1). In turn, corn's importance among feed grains led to earlier and more extensive use of acreage control programs in coping with excess feed grain production capacity.

The specification of a corn supply model not only required inclusion of direct policy provisions affecting corn, but also factors affecting major crop alternatives. For example, corn and soybeans compete for cropland acreage throughout the Midwest. These two crops provide the most important substitute relationships on a national basis. Corn is also grown in competition with sorghum in the Southwest and, to some extent, with oats throughout the Midwest.

In supply analyses for agricultural crops, lagged market prices frequently are assumed to be a relevant supply-inducing price since very limited supply response to current price is generally possible. Such a relationship between lagged market price and corn acreage was postulated in this report (equation 4), but the presence of Government price supports made it difficult to isolate (5).

Between 1948 and 1969, the market price exceeded the loan rate (or loan plus support payment) in only 2 years. Hence, as might be expected, the variations in the weighted support price variable, PF, were found to explain variations of corn acreage better than the lagged market price. Moreover, intercorrelation between these two independent variables reduced the significance of both when they were entered in the same equation. Because of this intercorrelation problem and since the analytical emphasis of this research is on policy variables, lagged market prices do not appear in the corn supply equations which deal with the fifties and sixties. Some revisions to incorporate experience in the seventies also are presented in which market prices did enter the calculations.

In the corn supply analyses conducted at the national level, effective support and diversion rates as well as variables reflecting soybean and sorghum supply factors displayed significant explanatory power in a wide range of specifications. The influence of sorghum acreage on corn production, however, was found to be significant only through 1960. The structural change in this substitution relationship is attributable to the 1961 extension of acreage restriction programs to cover sorghum production.

These features are shown in equation 7 which estimates by ordinary least squares for the period 1949-69:

$$(7) \quad ACP_t = \underset{}{100{,}256.34} + \underset{(3.8)}{10{,}266.48\ PFC_t^*} - \underset{(6.7)}{40{,}894.56\ DPC_t^*} - \underset{(6.4)}{11{,}313\ PSS_t}$$

$$- \underset{(3.1)}{.30\ AGM_t} - \underset{(3.4)}{319.61\ T}$$

$$R^2 = 0.983$$

if

ACP_t = Corn acreage planted in year t, in thousands

PFC_t^* = Effective corn price support in year t in dollars per bushel

DPC_t^* = Effective corn diversion payment in year t in dollars per bushel

PSS_t = Effective soybean price support in year t, in dollars per bushel

AG_t = Acreage of sorghum planted in year t, in thousands

T = Time; 1948 = 1, 1949 = 2, . . .

$$AGM_t \begin{cases} AG_t, \text{ for } t = 1948, \ldots, 1960 \\ \overline{AG} \text{ (the 1948–59 average value of AG) for } t = 1961, \ldots, 1969 \end{cases}$$

(t-values are in parentheses below the estimated coefficients)

The t-values confirm the significance of each of these explanatory variables, and the high R^2 indicates the capacity of this set of variables to explain historic variations in corn acreage. Inclusion of the trend variable (T) had the effect of increasing the t-values for the individual variables and improving the overall fit of the equation as compared with specifications not including T. In this specification, the direct support payments made after 1965 were included as part of PFC, rather than DPC. This is indicated by the variable designations of PFC^* and DPC^*. (See table 2.)

A similar equation was estimated using the other definitions of PFC and DPC. In equation 8 below, which estimates for 1949–70 by ordinary least squares, the post-1965 direct support payments were included as part of DPC. (This is indicated by the variable designations of PFC^{**} and DPC^{**}.) A dummy variable DV(6) was included to account for a change in the method of calculating direct support payments in 1966 and thereafter, for beginning in 1966, direct support payments were available to program participants for only a part of their historical base acreage. Therefore, equation 8 is as follows:

$$(8) \qquad ACP_t = 99{,}316.90 + \underset{(3.2)}{8{,}954.82}\, PFC_t^{**} - \underset{(5.3)}{48{,}061.40}\, DPC_t^{**} - \underset{(4.7)}{10{,}010.35}\, PSS_t$$

$$- \underset{(3.4)}{.34}\, AGM_t + \underset{(7.5)}{7{,}016.16}\, DV(6) - \underset{(2.2)}{243.68}\, T$$

$$R^2 = 0.986$$

if the variables are as indicated for equation (7) and if

$$DV(6) = \begin{cases} 0;\ 1949, \ldots, 1965 \\ 1;\ 1966, \ldots, 1970 \end{cases}$$

Direct comparison of these two equations is limited because of the different definitions of the direct policy variables. Removing one component from PFC and adding it to DPC had the effect of making PFC^* greater than PFC^{**} and DPC^* less than DPC^{**} after 1965. Notice that equation 7 has a smaller coeeficient for PFC and a larger coefficient for DPC. In determining planted acreage then, equation 8 makes diversion policy relatively more important than price support policy. On the other hand, equation 7 placed slightly more emphasis on early sorghum substitution, and slightly less on the soybean substitution, although soybean support policy was clearly very important. Yet the performance in approximating historical data of these two equations was virtually identical. Figure 4 depicts the performance of equation 8.

Table 3--Extended price series for four crops

Crop year 1/	Corn PIC	Sorghum PIS	Barley PIB	Oats PIO
	$/bu.	$/cwt.	$/bu.	$/bu.
1972	1.08	1.87	0.99	0.61
1973	1.57	2.45	1.21	.73
1974	2.38	3.80	2.13	1.16

1/ Related data for crop years 1950-71 are in table 2.

Some revisions and reestimates were made because of the rapid increases in market prices for corn since about 1971 and because of the voluntary acreage control programs which became dormant in 1974. A cornerstone of the previous acreage equations was that the appropriate supply-inducing price variable was the effective support rate for corn along with effective acreage diversion payment rates when applicable. Market prices received by farmers for corn were not critical because of the complexities of Government programs in the fifties and sixties. However, this specification of the supply-inducing price is not appropriate for the period since about 1971.

A new variable (PIC) was constructed as the appropriate supply-inducing price. From 1950 to 1971, this variable was the same as the effective support rate (PFC_t) used in equations 7 and 8. For 1972-74, it was the lagged market price of corn received by farmers (PMC_{t-1}). The 1971 "splicing" point for this variable was adopted since the two series take on approximately the same value in that year. Table 3 presents the actual data used for PIC_t for 1972-74. In addition to the splicing and extension of the corn price variable, corn/soybean price ratios were used to deal with the extremely large recent increases in absolute price levels.

U.S. CROP ACREAGE PLANTED
(Based on equations shown in text)

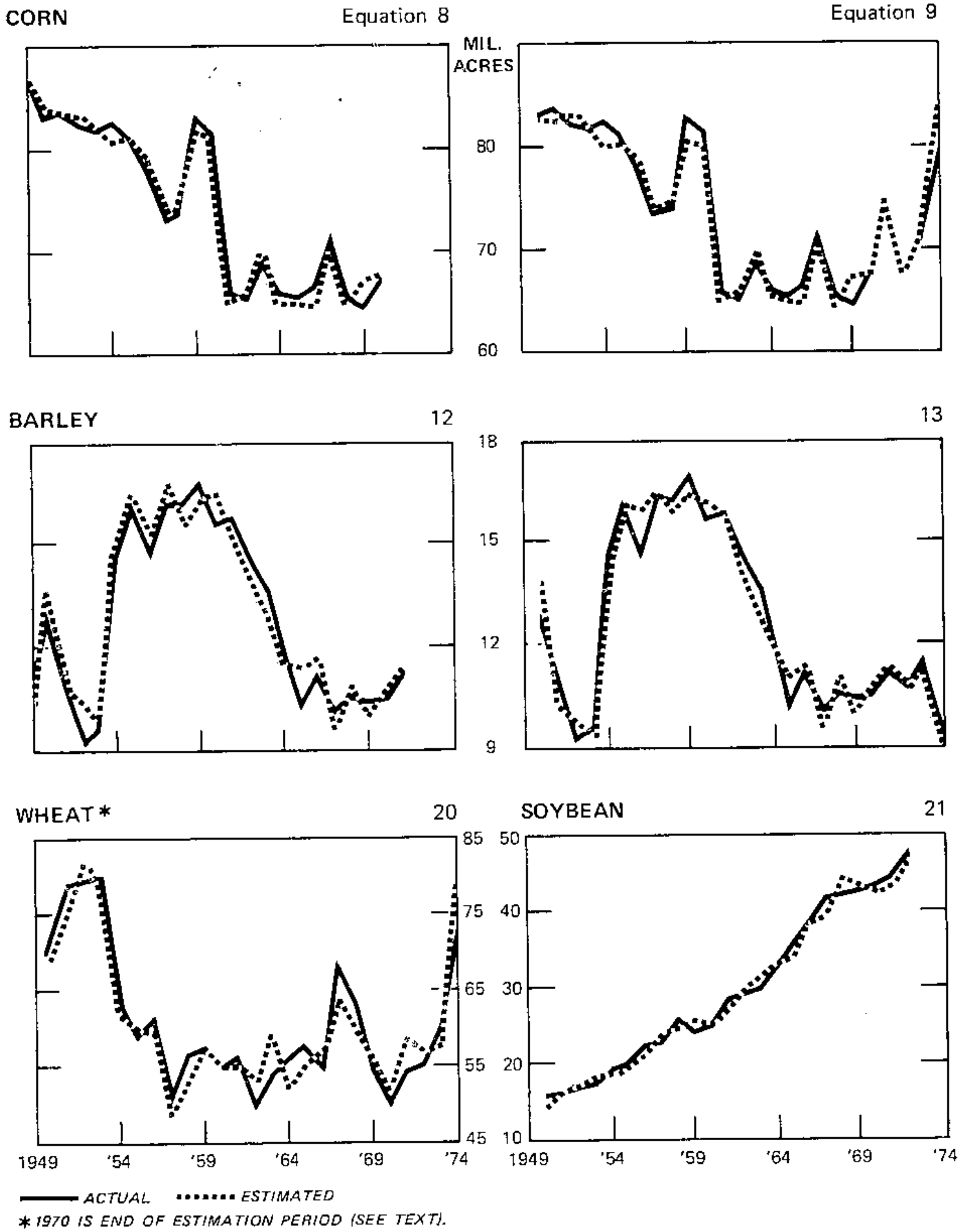


Figure 4

Equation 9 illustrates the results of these revisions and extensions, using 1950-74 data:

$$(9)\quad ACP_t = \underset{(9.5)}{87{,}044.1} + \underset{(3.3)}{23{,}035.6}\ PIC_t/PMS_{t-1} - \underset{(7.1)}{46{,}745.8}\ DPC^{**}_t$$

$$- \underset{(2.5)}{5{,}272.0}\ PSS_t - \underset{(2.0)}{0.287}\ AGM_t + \underset{(6.1)}{6{,}924.8}\ DV_t - \underset{(2.6)}{246.8}\ T$$

$$R^2 = 0.97$$

if the variables are defined as in equations 7 and 8 and

$$PIC = \begin{cases} PFC^{**}_t;\ 1950, \ldots, 1971 \\ PMC_{t-1};\ 1972, 1973, 1974 \end{cases}$$

PMC_{t-1} = Corn market price, lagged 1 year, in dollars per bushel

PMS_{t-1} = Soybean market price, lagged 1 year, in dollars per bushel

(t-values are in parentheses)

Equations 8 and 9 are reasonably similar in estimated coefficients and in their behavior over the data period. The R^2 remains high as does the statistical significance of individual coefficients. The inclusion of the corn/soybean price ratio as the supply-inducing price reduced the estimated coefficient on PSS. However, the direct price elasticities of supply with respect to PFC in equation 8 and PIC in equation 9 were almost identical at +0.125 and +0.130, respectively (evaluated at data means). The performance of equation 9 in approximating historical data is shown in figure 4. Notice especially the reasonable behavior of equation 9 in the 1971-74 period after the "splicing" point. The very high market prices of corn in 1973 generated the 1974 overestimate of acreage.

Sorghum 5/

Sorghum is a principal feed grain of the southern and southwestern United States. About 95 percent of 1970 sorghum production was centered in Texas, New Mexico, Kansas, Oklahoma, Colorado, Nebraska, Missouri, and California. Currently, sorghum ranks second to corn in national feed grain production. This national importance is fairly recent, generally corresponding with major yield increases in the fifties. Sorghum production has grown from around 200 million bushels before 1956 to over 500 million since. Both the rapid adoption of hybrid varieties and drought recovery in the mid-fifties were important in this expansion.

5/ The basic research from which this section is drawn is reported in (15).

Sorghum's recent rise in importance affected the length of the historical period chosen for statistical analysis. The smaller production levels in earlier years cast doubt on the usefulness of data from 1948 to about 1956. Because of the emphasis on capturing relevant relationships for policy analysis, 1957 was selected as the beginning year.

Given the predominance of the eight States in sorghum production, the crops which compete most with sorghum were specified rather easily. Sorghum acreages overlap with winter wheat in all of the States, with cotton in Texas, Oklahoma, and Missouri, and with corn and soybeans in Missouri, Kansas, and Nebraska.

Functions designed to analyze sorghum acreage response, therefore, could have included sorghum effective price supports and effective diversion payment rates as well as policy variables for wheat, cotton, corn, and soybeans. The extremely close relationship between corn and sorghum policy made it impossible to include price policy variables for both in a single useful equation. The regional nature and relatively modest size of sorghum acreage also made it necessary to include regional measures of wheat and cotton as production substitutes. Using crop year data for 1957-71, equation 10 best illustrates the sorghum analysis:

$$(10) \qquad ASP_t = 76{,}616.9 + \underset{(2.6)}{3{,}001.9}\ PFS_t^{**} - \underset{(2.1)}{7{,}364.7}\ DPS_t^{**}$$

$$- \underset{(3.4)}{7{,}909.2}\ PSS_t - \underset{(9.7)}{1.2}\ AWWM_t - \underset{(3.5)}{1.4}\ ACT_t + \underset{(1.2)}{1{,}016.6}\ DV(6)$$

$$R^2 = 0.98$$

if

ASP_t = U.S. acreage of sorghum planted in year t, in thousand acres

PFS_t^{**} = Sorghum effective price support in year t, in dollars per hundredweight

DPS_t^{**} = Sorghum effective diversion payment rate in year t, in dollars per hundredweight

PSS_t = Soybean effective price support in year t, in dollars per hundredweight

$AWWM_t$ = Acreage of winter wheat planted in 8 States (Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, Missouri, and California), in thousand acres. (Actual plantings for 1957-60 and the mean of 1957-60 acreage for 1961-71.)

ACT_t = Acreage of cotton planted in 5 States (Texas, New Mexico, Oklahoma, Missouri, and California), in thousand acres

$$DV(6) = \begin{cases} 0, & 1957\text{-}65 \\ 1, & 1966\text{-}71 \end{cases}$$

(t-statistics are shown in parentheses)

The direct policy provision for sorghum (PFS^{**} and DPS^{**}) were computed with post-1965 support payments included in DPS. As in the analogous corn equation, a dummy variable, DV(6), was included to capture the 1966 policy shift. This equation has good statistical properties indicated by the t-values and R^2. As shown in the top graph of figure 5, this equation performed well over the sample period.

Both of the direct policy variables (PFS^{**} and DPS^{**}) bore significantly on sorghum acreage and exerted a fairly symmetrical influence. For example, at 1968-70 mean values, a 10-percent increase in both PFS and DPS would account for an increase of 315,000 and a decrease of 297,000 acres, respectively, leaving a net increase of only 18,000. Consequently, nonproportional changes in PFS and DPS are needed to stimulate large net changes in sorghum acreage.

Sorghum acreage was related to cotton, soybean, and wheat programs as they affected the acreage and prices of these crops. Soybean price supports entered equation 10 directly, but cross effects with wheat and cotton were captured by acreage variables. Holding the winter wheat acreage variable constant since 1961 was the method used to account for the change in the sorghum program which curtailed sorghum planting on acreage withdrawn from wheat production under Government programs since that year.

Still, the acreage of cotton or its change would need to be specified to use this equation for predicting the level of or change in AGS. This problem not only affects the practical use of this equation but also raises questions about the simultaneous determination of crop acreages in response to price and program changes. However, in the following revision and reestimation of the sorghum equations using post-1971 data, this issue was sidestepped.

Since 1971, sorghum market prices increased greatly in absolute terms and in relation to support and target price levels. In addition, acreage control programs became dormant. So a new variable (PISG) was constructed to reflect this change. For 1957-71, this variable was the same as the effective support rate (PFS^{**}) described earlier. For 1972-74, this variable was the lagged market price of sorghum ($PMSG_{t-1}$) received by farmers. The 1971 "splicing" point for this variable is appropriate since the two series take on similar values in that year. Table 3 presents the actual data used for PISG during 1972-74. In addition to the splicing and extension of the sorghum price variable, some equation specifications involving sorghum/soybean and sorghum/wheat price ratios were tested to deal with the extremely large recent increases in absolute price levels. Equation 11 illustrates these analyses which employ 1957-74 data:

$$(11) \qquad ASP_t = 51{,}719 + \underset{(2.3)}{2{,}395}\,(PISG_t/PMW_{t-1}) - \underset{(4.2)}{10{,}652}\,DPS_t^{**} - \underset{(2.8)}{11{,}478}\,PFCT_t$$

U.S. CROP ACREAGE PLANTED*

(Based on equations shown in text)

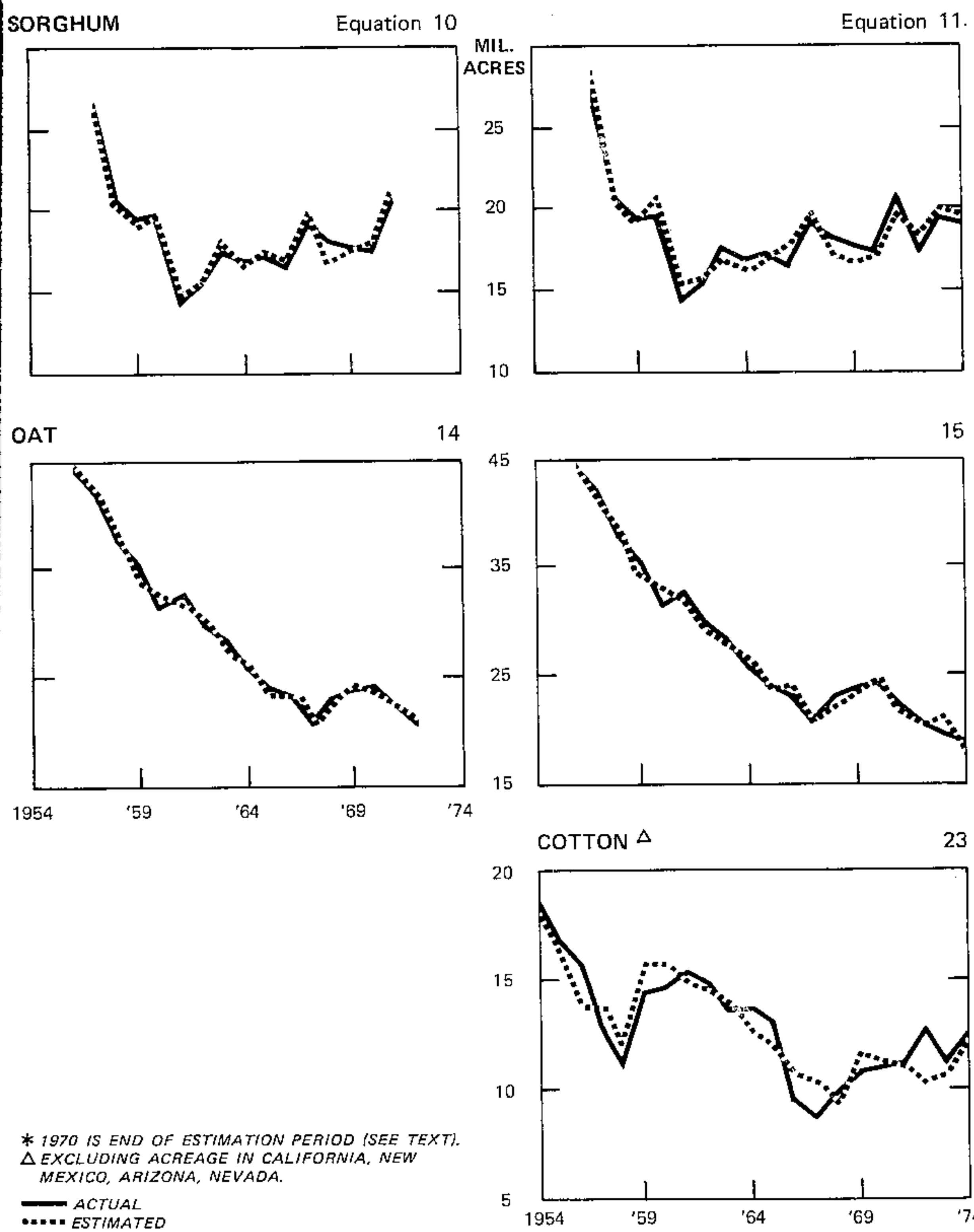


Figure 5

$$- 1.1099 \, AWP^{**} - 32{,}206 \, DV(1) + 1{,}981 \, DV(6)$$
$$\quad (6.8) \qquad\qquad (7.2) \qquad\qquad (3.7)$$

$R_2 = 0.91$

if

ASP_t = U.S. sorghum acreage planted in year t, in thousand acres

$PMSG_{t-1}$ = Sorghum market price received by farmers, lagged 1 year, in dollars per hundredweight

PFS_t^{**} = Sorghum effective price in year t, in dollars per hundredweight

$$PISG_t = \begin{cases} PFS_t; \ 1957, \ldots, 1971 \\ PMSG_{t-1}; \ 1972, 1973, 1974 \end{cases}$$

PMW_{t-1} = Wheat market price, lagged 1 year, in dollars per bushel

DPS_t^{**} = Sorghum effective diversion payment rate in year t, in dollars per hundredweight

$PFCT_t$ = Effective price support for cotton in year t, in dollars per hundredweight

AWP_t = Acreage of winter wheat planted in 8 States (Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, Missouri, and California), in thousand acres.

$$AWP_t^{**} = \begin{cases} AWP_t; \ 1957, 1958, \ldots, 1960 \\ 0; \ 1961, \ldots, 1974 \end{cases}$$

$$DV(1) = \begin{cases} 1; \ 1957, \ldots, 1960 \\ 0; \ 1961, \ldots, 1974 \end{cases}$$

$$DV(6) = \begin{cases} 0; \ 1957, \ldots, 1965 \\ 1; \ 1966, \ldots, 1974 \end{cases}$$

(t-values are in parentheses)

This equation features the ratio of the "spliced" sorghum price (PISG) and lagged market price of wheat. A substitution link with cotton is reflected in the use of PFCT. The variables AWP^* and DV(1) deal with the hypothesized relation between sorghum and wheat acreage in a similar manner as AWWM in equation 10. The dummy variable DV(6) reflects the 1966 change in the method of calculating direct support payments for voluntary sorghum program participants. Figure 5 illustrates the reasonably good historical performance of equation 11 as compared with the actual data through 1974.

The symmetry between the proportional effects of prices (PISG) and diversion payments (DPS^{**}) on sorghum acreage carried over into equation 11. The estimated elasticities at 1972-74 averages are +0.149 and -0.135, respectively.

Barley 6/

Barley, corn, and sorghum are the feed grains that were subjected to planting restrictions, support payments, and diversion schemes during the study period. This uniformity in policy approach, however, does not suggest that barley matches corn and sorghum in national importance. In 1970, for example, barley made up only 8 percent of national feed grain production. Also, in contrast to the geographic concentration of commercial corn and sorghum production, plantings of barley are scattered throughout the United States. But most of the barley acreage (about 75 percent) is the upper West--from western Minnesota to the Pacific Coast.

Because barley is partly a Great Plains crop, one would expect substitution to occur between wheat and barley. The importance of the upper Midwest also makes an oats-barley substitution relationship plausible. But the impact of oats and wheat policy on barley planting is likely to be complicated by the extension of acreage control programs to barley after 1961.

Ordinary least squares analyses based on national data for 1949-71 included measures for wheat and oats policy, effective support and diversion measures for barley, and barley market price. But not all of these variables had a statistically significant effect. The most consistent results are illustrated in equation 12, one of the stronger estimated relationships for barley:

$$(12)\qquad ABP_t = 56{,}243.40 + \underset{(3.2)}{4{,}335.81}\ PFB_t^{**} - \underset{(4.5)}{13{,}005.32}\ PFO_t - \underset{(10.0)}{.31}\ AW_t$$

$$- \underset{(3.0)}{.13}\ AWD_t + \underset{(0.6)}{397.75}\ DV(6) - \underset{(5.4)}{330.58}\ T$$

$$R^2 = .95$$

if

ABP_t = U.S. acreage of barley planted in year t, in thousand acres

PFB_t = Barley effective price support in year t in dollars per bushel

PFO_t = Oats effective price support in year t, in dollars per bushel

AW_t = U.S. acreage of wheat planted in year t, in thousand acres

AWD_t = U.S. acreage of wheat diverted under wheat programs in year t, in thousand acres

6/ The basic research from which this section is drawn is reported in (14).

$$DV(6) = \begin{cases} 0, & 1949\text{-}65 \\ 1, & 1966\text{-}71 \end{cases}$$

T = Trend (1949 = 1, 1950 = 2, <u>etc</u>.)

(The t-values are in parentheses)

Preliminary analyses suggested that neither barley acreage diversion policy nor lagged market price of barley exerted a statistically measurable effect on plantings over the data period. Hence, these variables do not appear in equation 12 even though the theory suggests otherwise. However, equation 12 has reasonable properties and, judging from R^2 and the graph in figure 4, most of the variation in barley acreage was explained by this set of variables. Moreover, the t-values were generally large for the individual variables. Both the t-values and the overall fit of this equation were much improved by the addition of a trend variable (T), which indicated a small but significant negative influence on barley acreage. As before, DV(6) was included to reflect the post-1965 change in the way effective supports were calculated. While the magnitude of this particular coefficient was small and the t-value not significant, its inclusion was justified because of increased significant levels which result for other explanatory variables.

This analysis confirms the importance of price support policy, although the influence of diversion payments was absent. Moreover, the indirect effect of a change in the oats loan rate apparently outweighed the influence of a corresponding change in barley price supports. Similarly, wheat substitution was important, as suggested by the coefficients on wheat plantings and diversion. As before, the inclusion of wheat acreage variables limits the predictive capacity of this equation. Estimates or assumptions about their level or change are required in making predictions of barley acreage levels or changes.

As with corn and sorghum, post-1971 price data for barley were used in "spliced" form to accommodate recent upheavals in grain markets. A new variable (PIB) was constructed. For the years before 1971, it was the barley effective support rate (PFB^{**}). From 1972 to 1974, it was the lagged market price of barley received by farmers. The 1971 data were appropriate for "splicing" since the variables take on similar values in that year. Table 3 presents the 1972-74 data for barley. In addition to the splicing and extension of the barley price variables, some equation specifications involving price ratios were tested to deal with the extremely large recent increases in absolute price levels. The barley/oats price ratio was retained in the barley analysis. Equation 13 below has the same specification as equation 12 except that the barley/oats price ratio was used as the supply-inducing price variable and 1950-74 data were employed:

$$(13) \qquad ABP_t = 51{,}935.3 + \underset{(6.6)}{3{,}316.9}\,(PIB_t/PMO_{t-1}) - \underset{(3.8)}{9{,}090.9}\,PFO_t$$

$$- \underset{(12.2)}{.31}\,AW_t - \underset{(4.9)}{.14}\,AWD_t + \underset{(0.2)}{111.7}\,DV(6) - \underset{(7.9)}{306.6}\,T$$

$R^2 = 0.97$

if the variables are the same as in equation 12 and if

PMB_{t-1} = Barley market price, lagged 1 year, in dollars per bushel

$$PIB_t = \begin{cases} PFB_t; \ 1950, \ldots, 1971 \\ PMB_{t-1}; \ 1972, 1973, 1974 \end{cases}$$

PMO_{t-1} = Oats market price received by farmers, lagged 1 year, in dollars per bushel

(t-values are in parentheses)

A comparison of equations 12 and 13 shows much similarity in the size and significance of the estimated coefficients. Also, the relative direct price effects were similar even though the specification of the variables differed between the two equations. The price elasticities with respect to PFB and PIB in the two equations. The price elasticities with respect to PFB and PIB in the two equations are +0.301 and +0.361, evaluated at the data means. Actual versus estimated values of planted barley acreage for equation 13 are pictured in the graph in figure 4. This equation performed well over the historical period and captured current changes with reasonable accuracy.

Oats 7/

Like barley, oats are a relatively minor feed grain in the United States. In 1970 oats made up only 9 percent of total feed grain production. In addition, oat production is as dispersed as barley's. Plantings are scattered throughout the United States, and the greatest concentrations are in North Dakota, South Dakota, Minnesota, Iowa, Wisconsin, and Indiana. However, oats differ from the other feed grains in two important respects relevant to supply analysis. First, oats have a variety of non-grain uses, such as a nurse crop for grass and legume seedlings, a cover crop on idled acreage, and a weed control in crop rotations. Second, increases in oat yields have not been large compared with those of other feed grains, especially corn.

With the introduction of new oat varieties in the early fifties, plantings began to increase notably in the South. Since 1956, however, acreages have been declining. This drop could be attributed to the lack of major yield increases as well as other factors, but whatever explanation is chosen, the equations should take it into account.

The downward trend in oat acreage began at about the time when chemical herbicides emerged as major weed controls. The use of oats as a weed-controlling crop in rotations, therefore, tended to diminish. The herbicides also increased the prospects for alternative crops, especially corn and soybeans. As a result, the fall in oat acreage coincided with a period of rapidly expanding soybean acreage which, although price supported, was not directly subject to Government acreage control programs.

7/ The basic research from which this section is drawn is reported in (14).

Preliminary analyses included acreages of soybeans, corn, and wheat, along with the oats price support loan rate. However, this approach was not successful, and other models were specified. The net effects of stable yields, decreasing use of oats for weed control purposes, and the shift of land into corn and soybean production were best measured by a trend variable, such as in equation 14, which used 1956-71 data:

$$(14) \qquad AOP_t = \underset{}{54{,}369.60} + \underset{(4.4)}{13{,}919.77\ PFO_t} - \underset{(2.4)}{.26\ AW_t} - \underset{(1.7)}{.14\ AWD_t}$$

$$- \underset{(10.5)}{3{,}625.80\ T} + \underset{(4.3)}{128.24\ T^2} - \underset{(35.1)}{23{,}989.83\ DV(8)}$$

$$R^2 = .996$$

if

AOP_t = Oat acreage planted in year t, in thousand acres

PFO_t = Oats price support loan rate in year t, in dollars per bushel

AW_t = U.S. wheat acreage planted in year t, in thousand acres

AND_t = U.S. wheat diverted under wheat program in year t, in thousand acres

T = Trend (1 in 1956, 2 in 1957, . . ., T = 12 in 1967; 0 in 1968, 1969 . . .)

$$DV(8) = \begin{cases} 0, & \text{for } T = 1, \ldots 12 \\ 1, & \text{otherwise} \end{cases}$$

(t-values are in parentheses)

The positive coefficient on the nonlinear quadratic trend term provided a softening influence on the negative linear trend until 1968, while the dummy variable, DV(8), allowed the estimated intercept to adjust to cessation of trend effects in that year. The t-values for the trend variables, the dummy variable, and the economic variables were acceptable. The very high R^2 statistic confirmed the ability of these variables to explain changes in oat acreage over the data period (figure 5).

These estimates confirmed the importance of oat price support policy, as well as wheat policy, through its effects on wheat plantings and diversion. On the other hand, the empirical estimates reported here and those obtained in preliminary analyses do not reflect a statistically significant substitute relationship between oats and the corn/soybean sector. However, the trend variable probably captured the net effect of these forces and other strong influences on oat acreage.

As with the other three feed grains, post-1971 price data for oats were used in a spliced form to account for the recent changes in the economic and policy environment. A new variable (PIO) was constructed for the years 1956 to 1974: For 1956-71, it was the oats effective support rate (PFO); for 1972-74, it was the lagged market price of oats received by farmers (table 3). As before, the "spliced" series was used in a price ratio to offset the large changes in absolute price levels. Equation 15 has the same basic specification as equation 14, except that an oats/barley price ratio was used as the supply-inducing price variable and 1956-74 data were employed. Equation 15 is as follows:

$$(15) \quad AOP_t = 63{,}198.4 + \underset{(2.8)}{10{,}706.2}\,(PIO_t/PMB_{t-1}) - \underset{(4.1)}{.367}\,AW_t - \underset{(2.7)}{197}\,AWD_t$$

$$-\underset{(10.6)}{4{,}213.3}\,T + \underset{(5.7)}{181.5}\,T^2 - \underset{(24.6)}{25{,}327.7}\,DV(8)$$

$$R^2 = 0.991$$

if the variables are the same as those in equations 13 and 14, except that

$$PIO_t = \begin{cases} PFO_t; & 1956, \ldots, 1971 \\ PMO_{t-1}; & 1972, 1973, 1974 \end{cases}$$

PMB_{t-1} = Market price of barley received by farmers, lagged 1 year, in dollars per bushel

The estimated coefficients in equations 14 and 15 were fairly similar. The direct price elasticities of acreage response relative to PFO and PIO in equations 14 and 15, respectively, were quite close at +0.298 and +0.243. The graph in figure 5 shows the actual versus estimated oat acreages using equation 15.

Feed Grain Summary

Overall, the direct aspects of feed grain policy that affect plantings seem to have been successfully measured by the effective price support and diversion payment variables. The estimated equations for acreage response suggest that an increase in the level of effective price support for any one feed grain tended to increase the acreage planted to that crop. Moreover, the diversion payments that were available to corn and sorghum growers had negative direct effects on acreages of those crops.

Acreage response to price change, including the unregulated era of the early and mid-seventies, was also captured successfully by means of "spliced" variables consisting of effective support prices in the fifties and sixties and open-market prices in the seventies.

Another objective was to measure important aggregate substitution effects among feed grains. The analyses suggested little measurable substitution on the supply side. Equations 7 and 8 suggested corn/sorghum substitution in earlier years. Otherwise, the only significant aggregate substitution between feed grains occurred between oats and barley, equations 12, 13, and 15.

In contrast, there is extensive competition between feed grains and other commodities on the supply side. Perhaps most important of these is with soybeans; changes in the soybean loan rate had a significant effect on planting of the two major feed grains, corn and sorghum. Also, there was a close relationship between wheat policy and plantings of oats, barley, and before 1961, sorghum. Although the cotton/sorghum substitution was not stated in national terms, the influence of cotton policy on aggregate sorghum acreage is clear.

Ideally, the specification and measurement of cross-commodity influences should involve administratively determined support prices and lagged market prices as independent variables. In some cases, this was not possible, and contemporaneous acreages planted of competing crops were used instead. This limits the predictive and analytical usefulness of such relationships, since the competing acreages must be known or assumed simultaneously for each period.

WHEAT

Most U.S. Government programs involving wheat production since World War II centered on supply adjustments and producer income protection. The main emphasis of this section is to identify the important annual policy provisions of the wheat programs since 1950 and to measure their impact on wheat acreage response.

In the United States, wheat acreages planted ranged between 50 million and 80 million acres since 1950. The variation in wheat acreage allotment levels and farmers' response to associated program provisions accounted for much of the change until recent years. However, wheat market prices also may have had some effect on shortrun adjustments.

The following analysis first considers a version of the basic theoretical framework underlying these acreage models, then develops quantified annual program specifications. Finally, the empirical results, employing both economic and noneconomic factors, are presented.

The Supply Model

Early studies of wheat supply response ignored the empirical and conceptual treatment of Government programs on supply adjustment (9). Recent studies on wheat acreage adjustments analyzed some of the possible effects of wheat program variables, including allotments and base loan rates (8).

In this chapter, the supply-inducing price variable was derived as an expected price and was based upon the adaptive expectations model (9). In this case, the expected price was considered to be a weighted combination of a simple lagged market price and a constructed price support variable. This constructed variable, referred to as the effective price support, contained the base loan rate and any direct payments associated with participation in the annual program. The price expectations relationship is expressed in equation 16:

(16) $P_t^* = (w_1 \ PMW_{t-1} + w_2 \ PFW_t)$

if

P_t^* = Producer price expectation for wheat in year t

PMW_{t-1} = Lagged average price received by farmers for wheat

PFW_t = Effective price support for wheat in year t

w_1 = Weight associated with PMW_{t-1}

w_2 = Weight associated with PFW_t

In the case of wheat, the participation rate is the proportion of wheat planted which was subject to or directly benefited from program provisions. This rate remained fairly constant over time. Therefore, it was assumed that weights derived from regression analysis, w_1 and w_2, indicate the market price influences, expressed by the lagged market price, and the program participation returns, measured by the effective support rate.

Measuring the Effective Price Support

Producers' price expectations as they relate to announced loan rates are influenced by restrictions on planting. In the simplest case, producers might expect a "guaranteed" market price floor if a loan rate were announced and no planting restrictions were required to obtain the loan rate. In a more complicated situation, producers might be required to meet acreage restrictions to obtain direct payments and be eligible for the wheat loan rate. Yet they could offset acreage restrictions by participating in other commodity programs.

The wheat acreage adjustment programs represent a wide range of acreage restriction complexities, from no allotment to rather restrictive acreage provisions. The programs were grouped into three broad historical periods: 1950-63, 1964-73, and the 1974 crop year. The effective support rate for each of these periods is shown in table 4.

The 1950-63 Period

Wheat marketing quotas based on producers' historical acreage allotments and projected yields were approved by annual referenda during 1950-63. But allotments and quotas were suspended during the Korean War in 1951-53, and loan rates were maintained at relatively high levels. When the war ended,

Table 4--Effective support rates and voluntary diversion payment rates computed for wheat

Crop year	Effective support rate	Effective voluntary diversion payment rate
	Dollars per bushel	
1950	1.75	--
1951	2.02	--
1952	2.20	--
1953	2.21	--
1954	1.76	--
1955	1.45	--
1956	1.40	0.84
1957	1.40	.84
1958	1.27	.76
1959	1.26	--
1960	1.24	--
1961	1.25	--
1962	1.18	.25
1963	1.28	.19
1964	1.09	.04
1965	1.53	.09
1966	1.63	.16
1967	1.66	--
1968	1.67	--
1969	1.67	.20
1970	1.48	.18
1971	1.66	--
1972	1.59	1/.04
1973	1.42	2/.16
1974	1.85	--

1/ Payment announced after winter wheat was seeded.
2/ Payment removed after winter wheat was seeded.

sizable carryover stocks accumulated, and acreage allotments again were instituted.

In this period of fairly rigid planting restrictions, participating producers had to divert wheat acreage from their historic bases and stay within their allotments in order to qualify for price support loans. The effective price support computation was relatively straightforward. Each year's announced loan rate was multiplied by the ratio of annual allotment acres to the defined historic base.

Despite restirctive quotas and related penalties for noncompliance, wheat could be grown in response to market price expectations. Nonparticipating producers generally could plant up to 15 acres of wheat and not be subject to penalties during this period. But production from this acreage was not eligible for loan. Such acreage--referred to as in excess of allotment not subject to penalty--ranged from 8 million to 13 million acres annually, accounting for about 12 to 20 percent of total acreage planted.

The 1964-73 Period

In the fall of 1963, the marketing quota referendum failed. The wheat program then reverted to earlier legislation which specified sharply reduced loan rates (about 50 percent of parity at that time, or $1.25 per bushel) with no penalties or quotas. With penalties eliminated, producers were free to plant unrestricted acreages if they did not participate in the loan program.

The lower loan rate and market prices stimulated a policy decision to maintain gross income for participating wheat producers through direct payments via a voluntary acreage-controlling program. The direct payments were based primarily on the domestic part of the total allotment--that is, the acreage needed to meet domestic wheat requirements. This totaled about 18-19 million acres, or about one-third of the national base allotment of 55 million acres. (For the 1964 and 1965 crops, the domestic allotment was accompanied by an export allotment for payment purposes. In later years, direct payments were based on only the domestic allotment.) The basic loan rate of $1.25 per bushel, plus direct payments to participating producers, raised the support level on the domestic part of the allotment to 100 percent of parity. The rest was supported only by nonrecourse loans at the base loan rate.

During several years of this period, total wheat acreage allotments were adjusted at the national level before they were allocated to individual producers. The major adjustments were: (1) An initial mandatory diversion ranging from 10 to 23 percent of the national allotment and (2) a net addition of 4-5 million acres for "small farm adjustments." These adjustments resulted in an "allocated" allotment which then served as the starting point for computing effective support rates for 1964-73.

Another major program provision for much of the period was "cross-planting" substitution. Under this provision, producers participating in both the feed grain and wheat programs could substitute feed grain and wheat acres for one another after mandatory diversions were met in each program. This provision permitted a producer to offset any required wheat diversion by planting wheat on the permitted acreage of a feed grain. As a result, wheat acreage increased, on the average, by about 3.5 million acres annually.

Appropriate adjustments also were made in the effective support rate computations to reflect the more flexible acreage set-aside provisions in the 1971-73 crop years under the 1970 Agricultural Act. These provisions made it much easier to substitute among crops planted on permitted acreage after diversion requirements were met under both wheat and feed grain programs.

The general form used to compute annual effective support rates for 1964-73 is summarized in equation 17:

$$(17) \qquad PFW = \frac{A_a' - RD + CP}{A_o} (PSW) + \frac{A_d}{A_o} (PDW)$$

if

PFW = Effective support for wheat, dollars per bushel

A_a' = Acreage allotment (total) adjusted for diversion and small farm adjustment; acres

A_d = Acreage allotment (domestic), acres

A_o = Base acres

RD = Required annual diversion from adjusted allotment, acres

CP = Feed grain base available for cross-planting substitution, acres

PSW = Loan rate for wheat, dollars per bushel

PDW = Direct payment rate, dollars per bushel

With the advent of direct payments, gross receipts to wheat producers were maintained at about $2.5 billion annually through the early seventies.

The 1974 Crop Year

The Agricultural and Consumer Protection Act of 1973 simplified the provisions of previous programs and allowed farmers greater decisionmaking flexibility. Under the Act, which extends until 1977, a 1974 target price of $2.05 per bushel was set on a total allotment of 55 million acres. Also, a basic loan rate of $1.37 per bushel was established. If market prices would have dropped below the target price in 1974, direct payments would have been used to make up the difference on individual allotments. Production beyond the allotment was supported at the base loan rate. The general form of computation for 1974 and beyond is equation 18:

(18) $$PFW = PSW + \frac{A_a}{A_o} (PDW)$$

if

PFW = Effective support for wheat, dollars per bushel

A_a = Acreage allotment (total), acres

A_o = Base acres

PSW = Loan rate, dollars per bushel

PDW = Direct payment rate, dollars per bushel

Measuring the Effective Voluntary Diversion Payment

The annual voluntary diversion payment for idling wheat acreage played an important role in acreage and output adjustment. Voluntary diversion has generally been defined as the part of a participating producer's allotment that may be left idle in addition to the required diversion. Cash payments were made for voluntary acreage diversion. The computation of the effective voluntary wheat diversion rate for this study was similar to that for the effective support rate. However, it was treated as a separate variable because producers usually qualified for these payments only after meeting the required diversion commitment.

The voluntary diversion provision was included in annual programs off and on since the mid-fifties. It first appeared in 1956 as part of the Soil Bank's acreage reserve program. Table 5 shows the wheat acreage diversions during 1950-75, and table 4 contains the effective voluntary diversion payment rates.

The effective voluntary diversion payment for wheat was constructed annually from equation 19:

(19) $$DPW = \left[\frac{A_a (PAD)}{A_o}\right] (DPR) (PNY)$$

if

DPW = Effective voluntary diversion payment rate for wheat, dollars per bushel

A_a = Acreage allotment, acres

A_o = Base acres

PAD = Permitted additional diversion, proportion of allotment

DPR = Payment rate for diversion, dollars per bushel

PNY = Proportion of normal yield on which DPR is paid

Table 5--Summary of acres diverted under annual wheat programs

Crop year	Required diversion to conserving use for-- Payment	No payment	Additional voluntary diversion to conserving use	Total diversion
	1,000 acres			
1950	--	--	--	--
1951	--	--	--	--
1952	--	--	--	--
1953	--	--	--	--
1954	--	--	--	--
1955	--	--	--	--
1956	--	--	1/ 5,700	5,700
1957	--	--	1/12,800	12,800
1958	--	--	1/ 5,300	5,300
1959	--	--	--	--
1960	--	--	--	--
1961	--	--	--	--
1962	4,259	--	6,436	10,695
1963	5,005	--	2,153	7,185
1964	4,346	--	777	5,123
1965	--	4,829	2,356	7,185
1966	--	6,318	1,939	8,257
1967	--	--	--	--
1968	--	--	--	--
1969	--	6,786	4,303	11,089
1970	--	12,080	3,639	15,719
1971	--	13,500	--	13,500
1972	--	15,036	5,070	20,106
1973	--	3,500	3,900	7,400
1974	--	--	--	--
1975	--	--	--	--

1/ Estimated from total acres diverted under the Soil Bank Acreage Reserve program.

Weather

Another important noneconomic factor, used as an explanatory variable, was weather. Preliminary analysis indicated that the only area where weather significantly affects wheat planting decisions is in the Southern Plains region. A comprehensive factor measuring the impact of drought on acres planted to wheat is not available, but a reasonable proxy was used--the USDA range condition statistic for major Southern Plains States.

Statistical Results

The acreage response equation was estimated with ordinary least squares using 1950-70 crop year data and the various explanatory variables described in the previous section. Equation 20 is as follows:

$$AWP_t = -15.370 + \underset{(8.9)}{22.452}\, PFW_t - \underset{(2.1)}{8.211}\, DPW_t \tag{20}$$

$$+ \underset{(5.0)}{13.193}\, PMW_{t-1} + \underset{(2.6)}{0.2360}\, RNC_t$$

$$R^2 = 0.89$$

(the t-values are in parentheses)

if

AWP_t = Wheat acreage planted in year t, in million acres

PFW_t = Effective price support rate in year t, in dollars per bushel

DPW_t = Effective voluntary diversion payment rate in year t, in dollars per bushel

PMW_{t-1} = Lagged price of wheat received by farmers, in dollars per bushel

RNC_t = Southern Plains range condition in year t, index value

These results suggest that wheat program policy variables, represented by effective price support and voluntary diversion payment rates, were important factors explaining annual wheat acreage adjustments. However, the market price component of price expectations was also highly significant. The elasticity of response with respect to the lagged market price was +0.39--virtually the same as that reported earlier by Nerlove for 1910-32, before Government acreage programs were important (9).

The remaining program policy variable--the effective voluntary diversion payment--also played a significant though relatively small role in explaining wheat acreage adjustments. The negative sign on the DPW coefficient supports the hypothesis that increases in the effective diversion payment resulted in a net decline in total wheat acres planted.

Moisture conditions in the Southern Plains, indicated by the range condition variable, also exerted a significant positive influence on wheat acres planted. A 10-percent drop in range conditions (about 8 index points) was associated with a 2 million-acre decline in wheat plantings. Although this response appears relatively large, such changes in condition were infrequent. However, one large change did occur during the fall seeding of the 1957 crop when the range condition was at a record low index level of 53, compared with 72 the year before. That fall, wheat plantings in the Southern Plains dropped to 20 million acres from 27 million the previous fall, despite fairly stable price and program provisions.

Figure 4 illustrates the actual versus estimated values of wheat acreage planted using equation 20 for 1950-74. This equation was used as the basis for prediction during 1971-74, even though the estimation period ended in 1970. However, a simple application of the 1971-74 data to the estimated equation did not yield acceptable results because of the economic upheavals during this period.

Rather than respecify and reestimate as was done with the feed grains, a different approach was taken for wheat. First, the rapid increase in the agricultural price level was accounted for by deflating the price variables during 1971-74 by factors computed from the index of prices paid by farmers for production items. The deflation factors for each year were calculated allowing for an approximate 4- to 5-percent annual historic inflation in prices paid by producers during the data period. Annual input price increases beyond these rates were deflated out of PFW, DPW, and PMW. The deflation factor used for 1971 was 1.01; 1972, 1.02; 1973, 1.15; and 1974, 1.29. The predicted values in figure 8 shown for 1971 and 1972 are simply the values obtained from equation 20, using the indicated deflation factors.

But a different approach was used for 1973 and 1974. The acreage diversion and set-aside features of previous programs were nearly dormant in these years. No substantial adjustments were made in loan rates or target prices, although acreage allotments were changed. Hence, it was assumed that all adjustments in planted acreage during 1972-73 and 1973-74 occurred because of changes in the lagged price of wheat received by producers. The changes in deflated lagged market prices (PMW) and the estimated coefficient on that variable were used to obtain the 1973 and 1974 predictions.

The sizable overestimate in 1974 may be, at least in part, because the overall inflation rate (reflected in the index of prices paid by farmers for production items, interest, taxes, and wage rates) understated the 1974 cost increases because of very rapid price increases for fertilizers and fuels. In any case, except for the change between 1971 and 1972, the predictions are in the appropriate direction and of the appropriate orders of magnitude.

Government acreage programs played an important role in wheat supply adjustment policy in recent decades. Although the role of market prices was apparently obscured in the fifties and sixties, the results of this study suggest that the response of wheat acreage to changes in producers' overall price expectations remained relatively stable for a long period. As a result, analyses of wheat acreage adjustments should consider the impact of both policy variables and market prices. The rapid rise in input costs in recent years suggests that producer expectations are dampened below the actual level of wheat prices received. This is indicated by the results for recent years based on deflated wheat prices. In any event, this particular analysis provides insight into the wheat acreage adjustment process and describes these annual adjustments even in the recent turbulent period.

SOYBEANS

Unlike the other crops discussed in this report, soybeans have never been directly controlled by acreage allotments, marketing quotas, acreage diversion or set-aside programs. Since World War II, soybean prices have been supported at the farm level by means of nonrecourse loans by the Commodity Credit Corporation (CCC). Eligibility for these loans has been independent of the amount of soybean acreage planted and not contingent upon participation in acreage control programs for other crops. In fact, at least part of the huge increase in U.S. soybean acreage over the past 25 to 30 years probably was stimulated by controls on crops such as wheat, feed grains, and cotton.

The impact of Government policy on soybean acreage came primarily through the unrestricted availability of price support loans and the indirect effects of price support and acreage control programs for such production alternatives as wheat, corn, and cotton. Supply analyses for soybeans then should reflect the influence of these two classes of policy variables. On a regional level, soybean acreage changes can be related to changes in the policy variables for a variety of local alternative crops. 8/ These alternatives include corn in the Corn Belt and most other regions, cotton in the Delta States, and wheat in some States. In aggregate supply analyses for soybeans, the effects of the corn program remain strong in all statistical estimates. However, the measurable influence of several other commodity programs tends to disappear as regions are combined.

It is not surprising that corn and soybeans can be closely linked in supply analyses. Both are row crops, heavily produced in the Midwest, and employ about the same combinations of labor, machinery, and other productive inputs. Also, they require similar conditions of soil and climate for successful production and fit well in many crop rotation patterns. In addition, cropping decisions for corn and soybeans are made almost simultaneously by producers throughout the major production areas.

Soybean Acreage Supply Functions

The soybean acreage supply functions presented here emphasize the close relation between soybean and corn markets and between soybean and corn policy. These functions were selected from many equations and combinations of variables. Overall, they are perhaps the best aggregate equations although their inclusion here is mainly for illustrative purposes.

The market relationship between soybeans and corn is reflected in the ratio of the farm price received for soybeans to that for corn. This ratio in year t-1 was assumed to affect soybean acreage planted in year t. Since no acreage restraints have been used on soybeans, the value of PF for soybeans was equal to PA and r = 1.0 (see equation 2). Table 6 contains market prices and announced support rates for soybeans. Notice that average market prices were above support prices in most years.

The impact of the annual corn programs on soybean acreage was accounted for by including the PFC and DPC variables for corn. These variables, discussed in detail earlier, measure the price support and diversion payment features of the various annual corn programs. In particular, they include adjustments for the acreage restraints imposed on voluntary program participants.

8/ Two regional studies of soybean acreage response used the general concept of "effective price support" (2, 4). Although not specifically discussed here, the paper by Evans and Kenyon (2) quite closely parallels the methods of analysis emphasized in this report.

Table 6--Market prices and support prices for soybeans

Crop year	Market price received by farmers	Average support price
	Dollars per bushel	
1950	2.47	2.06
1951	2.73	2.45
1952	2.72	2.56
1953	2.72	2.56
1954	2.46	2.22
1955	2.22	2.04
1956	2.18	2.15
1957	2.07	2.09
1958	2.00	2.09
1959	1.96	1.85
1960	2.13	1.85
1961	2.28	2.30
1962	2.34	2.25
1963	2.51	2.25
1964	2.62	2.25
1965	2.54	2.25
1966	2.75	2.50
1967	2.49	2.50
1968	2.43	2.50
1969	2.35	2.25
1970	2.85	2.25
1971	3.03	2.25
1972	4.37	2.25

The Estimates

Equation 21 illustrates ordinary least squares estimates of this aggregate soybean acreage supply for 1950-1972:

$$(21) \quad ASB_t = -6{,}381 + \underset{(3.0)}{5{,}639}\,(PS/PC)_{t-1} + \underset{(1.3)}{2{,}355}\,PSS_t - \underset{(2.0)}{3{,}904}\,PFC_t^{**}$$

$$- \underset{(1.1)}{9{,}728}\,DPC_t^{**} + \underset{(16.5)}{.87}\,ASB_{t-1}$$

$$R^2 = .99$$

if

ASB_t = Acreage of soybeans in year t, in thousand acres

$(PS/PC)_{t-1}$ = Ratio of soybean and corn market prices received by farmers, lagged 1 year

PSS_t = Effective price support for soybeans in year t, dollars per bushel

PFC_t^{**} = Effective price support rate for corn in year t, dollars per bushel

DPC_t^{**} = Effective diversion payment rate for corn in year t, dollars per bushel

(the t-values are in parentheses)

Unlike acreage for the directly controlled commodities, soybean acreage increased almost continuously during the observed period (fig. 4). Therefore, it was not difficult to devise equations which very closely fit the acreage data, especially if trend or trend-like variables such as lagged acreage were included. Equation 21 contains lagged acreage, which accounted for much of the variation in current acreage. But a substantial part of the remaining variations in acreage was picked up by the price and policy variables.

Equation 21 suggests that, next to the lagged acreage variable, the market price ratio exerted the most significant influence on planted soybean acreage. The historic lack of restrictions on soybean planting, together with the fact that market prices for soybeans generally have been above support rates for most years in the period, made this dominance of market phenomena in the analysis quite plausible. The price elasticity of acreage supply with respect to soybean prices (holding PC constant) at the data means was +0.39. This estimate is smaller than earlier results based on regional data (4), but it is similar to one estimate using national data (7) and to a national value of +0.46 generated from recent regional analyses (2).

The support price of soybeans had a net positive effect on acreage, even after market price effects were accounted for. The estimated coefficients indicate that, for an equal change in market and support prices (holding the corn price unchanged at its mean), the market price had somewhat more effect on acreage than the support rate. The low t-value on the support price coefficient, however, suggests that this conclusion must be tentative, although it is consistent with earlier regional work on soybean supply functions (4).

The estimated coefficients of the corn policy variables confirmed the competitive relationship between corn and soybeans on the production side. Higher support rates for corn were associated with a net downward pressure on soybean acreage. Similarly, an increase in the attractiveness of voluntary acreage diversion for corn was negatively associated with soybean acreage. The relative size of the estimated coefficients of PFC^{**} and DPC^{**} is consistent with the direct results for corn acreage response. In both cases, a change in DPC^{**} showed a stronger influence on acreage than a similar change in PFC^{**}. Of course, an increase in DPC^{**} was associated with a net decline in both corn and soybean acreage, but an increase in PFC^{**} was positively associated with corn acreage and negatively associated with competitive soybean acreage. Again, the t-values of these coefficients suggest caution in interpreting the results.

To examine the soybean market and policy variables apart from the strong uptrend in acreage, several first-difference equations were estimated using a set of variables similar to those employed and discussed above. Equation 22 is the first-difference version of equation 21, except that the lagged acreage variable was dropped:

$$(22) \quad \Delta ASB = 1{,}342 + \underset{(2.2)}{3{,}355}\ \Delta(PS/PC)_{t-1} + \underset{(2.2)}{3{,}735}\ \Delta PSS$$

$$- \underset{(3.1)}{5{,}506}\ \Delta PFC^{**} - \underset{(1.8)}{11{,}716}\ \Delta DPC^{**}$$

$$R^2 = .51$$

As is typical with first-difference equations of times series data, the R^2 statistic was greatly reduced compared with specifications in actual numbers. Most of the general conclusions remain the same as those with the aggregte analysis in actual numbers. But the size of the estimated coefficient on the soybean/corn price ratio dropped, relative to the coefficient on PSS. With this first-difference equation, it is difficult to argue that market price influences were stronger than support rate changes. The impact of the corn program was still in the expected direction and clearly underscores the dominance of diversion payments, relative to the corn support rate, as a factor influencing soybean acreage changes.

Conclusion

Market phenomena directly and strongly influence soybean acreage because of the historical buoyancy of the market and the consequent absence of acreage or marketing controls on this crop. Yet the level of soybean support prices also affected planting decisions in a significant way. An additional conclusion is that, in the aggregate, corn prices and programs substantially affected soybean acreage both in terms of competition for planted acreage and through the impact of acreage diversion when it was available.

COTTON

Over the past two decades, cotton production and marketing have changed markedly with such innovations as improved varieties, new production methods, mechanical harvesting, and advances in ginning and processing technology. Despite these advances, cotton acreage has exhibited a general downward trend since 1954, and sustained increases only in recent years. Another innovation--synthetic fibers--was responsible for much of the decline.

Cotton is grown across the entire southern part of the United States. Many crops are competitive, such as corn, soybeans, and grain sorghum. Cotton acreage has been directly influenced by Government cotton programs and indirectly by programs for competing crops.

The results reported here for cotton are from a broader study which examined commodity program effects for several commodities for the United States as a whole and for the major production regions (10, 11, 12). The overall study focused on developing acreage response equations for the four major crops which were estimated as an interdependent system. The statistical results presented here are for only the cotton equation taken from the broader system. Because of the intercommodity aspects of the original model, the dependent variable in this analysis was U.S. planted acreage of cotton, excluding that in California, New Mexico, Arizona, and Nevada (these States accounted for approximately 9 to 10 percent of the acreage in the data period).

General Provisions of Cotton Programs

Government programs relating to cotton production have been in effect since 1929. Although these programs have varied over the years, several general features remained constant. These are price support loans, marketing quotas, acreage allotments, and price support payments. The price support loans are designed to provide a floor under market prices; the marketing quota and acreage allotments to control production; and the support payments to protect farm income.

Other program features relating to cotton were introduced from time to time. These include direct payments to farmers, payments for idling allotment acreage, and more general land-retirement options. Other less general features also included limitations on program payments to individuals and special program compliance provisions for small farms and for acreage designated for export.

The method of calculation and the level of cotton price support loan rates and payments are determined annually by the Secretary of Agriculture before planting time. But the manner in which the base is set for price support loan rates and payments has changed over time. For instance, the base grade and staple length of cotton often was changed as was the method for evaluating bale weight. So, for this analysis, price support loan rates and payments for middling one-inch cotton were used as the basis for policy variable construction.

Calculated values for the weighted support rate variable (PF) and the weighted diversion payment variable (DP) are contained in table 7. However, only the values for the weighted support rate variable (PFCT) were used in the estimated model reported here. Exploratory analysis indicated that a masking effect occurs when both variables are included in estimated equations. This was probably because of the mandatory acreage allotments in contrast to voluntary participation in feed grain and wheat programs, which adds a quite different dimension to the effects of the two variables. Details on calculating these annual values are contained in (10).

Model Description and Results

Variables were included in the model to represent direct price and policy effects, competing uses for production resources, and factors hypothesized to uniquely affect the acreage of cotton. An examination of cotton data suggested the need for a variable to reflect the effect on planted acreage of the Acreage Reserve (ARP) and Conservation Reserve (CRP) parts of the Soil Bank program in the late fifties. Accordingly, a zero-one variable was used as a supply shifter.

Table 7--Effective price support and diversion payment variables for cotton

Crop year	Effective price support variable (PFCT)	Diversion payment variable (DPCT)
	Dollar per pound	
1954	0.259	0
1955	.247	0
1956	.225	.0450
1957	.224	.0300
1958	.243	.0300
1959	.253	0
1960	.241	0
1961	.241	0
1962	.232	0
1963	.208	0
1964	.158	.0228
1965	.153	.0283
1966	.111	.0817
1967	.107	.1005
1968	.107	.0939
1969	.225	0
1970	.238	0
1971	.225	.0300
1972	.225	.0300
1973	.225	0
1974	.378	0

A previous analysis of cotton supply response (10) suggested the importance of production cost variation as an explanatory variable. Inputs are committed on the basis of expected yields, but actual yields--realized at the season's end--may differ. Hence, per unit production costs and profits may vary from expected levels. It is assumed that such experience in the recent past influences current production decisions. An attempt to represent per unit cost changes was made by constructing a proxy variable. A trend value of per acre yield was calculated for each year. Then the percentage deviation of the actual from the trend value was computed, expressed as a position or negative value, and lagged 1 year.

Other variables in the equation were acreages of competing crops lagged one period. Acreages, rather than policy variables or prices of the competing crops, were used to avoid distortions likely to result from high intercorrelation among the price variables. This specification differed from that used with competing crop acreages in some of the other commodity analyses in this report. It has the advantage of being more amenable to predictive analysis, but it has the disadvantage of not representing the current allocation of productive resources among crop alternatives.

As mentioned previously, this cotton acreage analysis was part of a broader model of acreage response behavior across several commodities. The full model was estimated with joint generalized least squares to account for common influences in the disturbances of the various acreage response equations. Equation 23 uses data from 1954-72:

$$(23) \quad ACT_t = 12{,}980 + \underset{(2.3)}{18{,}420}\, PFCT_t - \underset{(0.9)}{0.1065}\, ASB_{t-1} - \underset{(1.4)}{0.2228}\, AGS_{t-1}$$

$$+ \underset{(1.0)}{0.2756}\, ACS_{t-1} - \underset{(1.4)}{1{,}792}\, DV + \underset{(0.7)}{26.65}\, PYDCT_{t-1}$$

if

ACT_t = Acres of cotton planted in year t, in thousands (excluding California, New Mexico, Arizona, and Nevada)

$PFCT_t$ = Effective price support rate for cotton in year t, dollars per pound

ASB_{t-1} = Acres of soybeans planted, lagged 1 year, in thousands

ASG_{t-1} = Acres of grain sorghum planted, lagged 1 year, in thousands

ACS_{t-1} = Acres of corn planted in 15 southern States, lagged 1 year, in thousands

DV = Dummy variable to reflect Soil Bank acreage diversion; 1.0 in 1956-58 and zero otherwise

$PYDCT_{t-1}$ = Percent deviation of cotton yield per acre from trend value of yield, lagged 1 year (above-trend values are positive; below-trend values are negative)

(t-values are in parentheses but do not have the strict statistical properties associated with ordinary least square procedures)

A least-squares estimation of this equation produced quite similar coefficients and yielded an R^2 of 0.83. The signs on all coefficients were as expected on a priori grounds, except for the corn acreage variable. Most of the results in equation 23 are plausible, although the estimated coefficients with the exception of that on PFCT were rather small relative to their estimated standard errors.

Cotton was a tightly regulated crop throughout the study period, hence, the cotton policy variable was the strongest explanatory variable in the equation. An acreage increase of 1.8 million acres results from a 10-cent increase in the weighted support rate per pound, other things constant.

Acreage of soybeans and grain sorghum showed weak competitiveness with cotton. Lagged acreage was viewed as a proxy for the relative profits of these crops. An increase in soybean plantings in a given period reduced cotton plantings in the following period by only one-tenth acre. On the othe hand, increased grain sorghum acreage was slightly more competitive, reducing cotton by almost a quarter of an acre. The relationship with corn was less definite, but the results suggest that cotton acreage was not influenced very much by corn acreage changes either.

Cotton acreage underwent a sharp reduction during 1956-58. It was hypothesized that the reduction was becuase of land retired under the Soil Bank program, which took many small farms out of production during those years. The coefficient for the zero-one variable (DV) indicated a net 1.8 million-acre shift from cotton acreage to general land retirment during this program.

Acreage was inversely related to production costs, all else held constant. The proxy variable for per unit production costs (PYDCT) indicated a 10-percent increase in yields in a given year (reflecting a decrease in unit production costs) to be associated with a 267,000-acre increase in the following year.

Since corn is produced in the South along with cotton, a competitive relationship was hypothesized. The statistical results, however, did not confirm the hypothesis. Corn acreage planted (lagged 1 year) in the 15 southern States was included to examine this relationship, but the sign of the estimated coefficient was positive. The acreage of both crops declined over time, and it is possible that the released acreage went to other crops or land diversion. Cotton and corn did not appear competitive in the aggregate. However, the coefficient was only slightly larger than its standard error, so the conclusion of noncompetitiveness must be tentative.

Actual versus estimated values of equation 23 are shown in figure 5 for 1954-74. Since the estimated equation was obtained with 1954-72 data, estimates of the last 2 years are from outside the data period. Generally speaking, the overall fit of the equation was good, except for a few years--expecially 1972. However, the independent estimates for 1973 and 1974 are quite good. Although this particular model differs in some ways from the others described in this report, it provides useful insight into the acreage response phenomena related to cotton within the effective price support context.

CONCLUSION

Though not developed in this report with full theoretical rigor, the rather simple economic rationale of the effective support rate and its relation to announced support prices is intuitively appealing. The statistical results across a broad spectrum of important U.S. field crops support the usefulness of these ideas, especially since several of these analyses span the program-heavy years of the fifties and sixties and the more free-market years of the seventies.

The primary focus of each commodity study was to measure and analyze the effects of Government policy and program provision changes on acreage response. Much less attention and elaboration was given to the mathematical form and other characteristics of the functions themselves, to the range of nonpolicy explanatory variables used, and to the estimation methods employed. Rather simple and widely known methods and techniques were used. Presumably some improvements in the statistical results could result from increased attention to these analytical issues.

In analyses of this kind, much of the potential success hinges on the construction, by the researcher, of internally consistent and reasonable variables to reflect both price support and policy changes. Obviously, this places an additional responsibility on the investigator as compared with more traditional econometric supply response studies. This is especially true if the models are to be continually modified and kept up-to-date for use in current policy and market analysis. Unfortunately, there was no single method of unambiguous approach that emerged from these studies for constructing effective support price levels and related variables. The general methodology seems appropriate, but the details depend upon the commodity and the times.

The abrupt change in the agricultural market environment during the early seventies made it prudent to reconsider the impact of supply-inducing prices faced by producers of previously controlled crops. Rapid inflation of input costs as well as major upward shifts in commodity price levels were captured reasonably well by the revision and reestimation of earlier equations, especially for the four feed grains. These adjustments involved the use of relevant price ratios and the redefinition of the effective price support series for each commodity. For the feed grains, open-market prices were spliced onto the effective price support series at the time when voluntary acreage controls and direct program payments became dormant. For wheat, some ad hoc adjustments were applied to an equation estimated with 1950-70 data to deal with economic and policy changes during 1971-74.

The results of these adjustments suggest that, in periods when agricultural price levels are changing slowly, absolute prices can capture the relevant economic incentives on the supply side. But if the study includes periods of rapid systematic inflation or sudden major changes in the level of commodity prices, then appropriate deflation and price ratio construction becomes necessary for successful analyses of time series data.

Models of this kind can be very helpful to policy decisionmakers and commodity analysts. But because of their inherent limitations, they should be viewed as only one part of the background investigation leading to predictions or policy judgments. They are simply systematic studies of past and current economic behavior. Their purpose is to identify and measure regularities which are consistent with economic theory and the prior judgments of the researcher. In this case, economic theory, well-accepted statistical techniques, and common sense proved rather successful in analyzing the effects of price and policy on acreage response for these seven crops.

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