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OATS AND BARLEY ACREAGE SUPPLY FUNCTION

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The research reported in this paper completes a series of estimates of supply relationships for the four major feed grains--corn, sorghum, oats and barley--in the post World War II period.1/ These four commodities account for about 95 percent of the grain fed to U.S. livestock and, in each of the past two years, they have earned more than $1 billion for U.S. farmers from export sales. This strong demand has been accompanied by remarkable advances in feed grain technology that have more than doubled per-acre yields since World War II. The resulting surge in supply has exceeded buoyant growth in demand, leading to downward pressure on feed grain prices and on incomes of producers in many recent years. To partially counteract these forces, the government instituted supply restricting programs to limit output when burdensome surpluses threatened.

Because of the influence of government policies during the past two decades, special emphasis in this research is on empirical measurement and analysis of the effects of government policies and programs on feed

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* We wish to acknowledge helpful comments received from James Vermeer and W. Herbert Brown of the Economic Research Service of the U.S. Department of Agriculture and from several staff members of the Department of Agricultural and Applied Economics of the University of Minnesota.

1/ Previous work has been reported in J. P. Houck and M. E. Ryan, "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," Am. J. Agr. Econ. 54: 184-191, May 1972; M. E. Ryan and M. E. Abel, "Corn Acreage Response and the Set-Aside Program," Agri. Econ. Res., 24: October 1972; and M. E. Ryan and M. E. Abel, "Supply Response of U.S. Sorghum Acreage to Government Programs," Agri. Econ. Res., 25: April 1973 grain acreage. A theoretical model was developed for the analyses of corn and sorghums, and it is here applied to estimate acreage supply functions for oats and barley.[2/]

The Setting

Acreage, Yield, and Production

Figure 1 illustrates changes in acreage planted to oats and barley in the United States and for the crops with which they mainly compete for production resources. The most marked trends are the contraction in oat acreage beginning in 1956 and the steady expansion in acreage planted to soybeans. Although plantings of corn and wheat declined during the fifties no trends seem apparent since then. Acreage planted to barley is now at about the same level as at the beginning of the study period, however from 1954 until the early 1960's, considerably more acreage was devoted to barley. During many of these years planting restrictions were imposed on wheat and corn but not on barley. Acreage began to be withdrawn from barley when government land-rental programs were established in the early 1960's.

National average yields of oats, barley, corn, wheat, and soybeans are given in Figure 2. Though yields have increased for all crops since 1949, the advances for corn are most prominent. (The sharp dip in 1970

2/ The model may be expressed as

$$A = f(PF, DP, Z)$$

where A is acreage planted; PF is the support price weighted by planting restriction, if any; DP represents payment for land withheld from production of the crop; and Z includes other supply determinants and random factors. See earlier work referred to in footnote 1 for a complete discussion of the model and for a description of how the policy variables, PF and DP, are constructed.

resulted from widespread occurrence of corn blight.) Yield increases for oats and barley lag far behind corn and also behind wheat. Relative changes are more clearly revealed by the following yield ratios:

Yield ratio (bu/acre)	1949-51	1969-72*
oats to corn	.92	.62
oats to barley	1.33	1.20
oats to wheat	2.21	1.65
barley to wheat	1.66	1.37

*Data for 1970, the year of the corn blight, were omitted.

Notice that barley yields have risen slightly faster than those for oats.

The tabulation below indicates the relative importance of oats and barley as feed grains. These data show that oats has decreased in importance while barley has retained its share of acreage and production.

Percentage of feed grain	Oats		Barley	
	1949-53	1969-72	1949-53	1969-72
	percent			
Production	18	8	6	6
Acreage	29	19	7	8

Factors related to production and use

Plantings of both crops are widely scattered throughout the United States, although barley acreage is somewhat more concentrated than oats. About three-fourths of the nation's barley is grown in the northwestern tier of states, from Western Minnesota to the Pacific. Montana and North Dakota are the two top producing states. Another major barley area is in

Figure 1. U.S. Acreage Planted to Oats, Barley, Corn, Wheat and Soybeans, 1949-1972

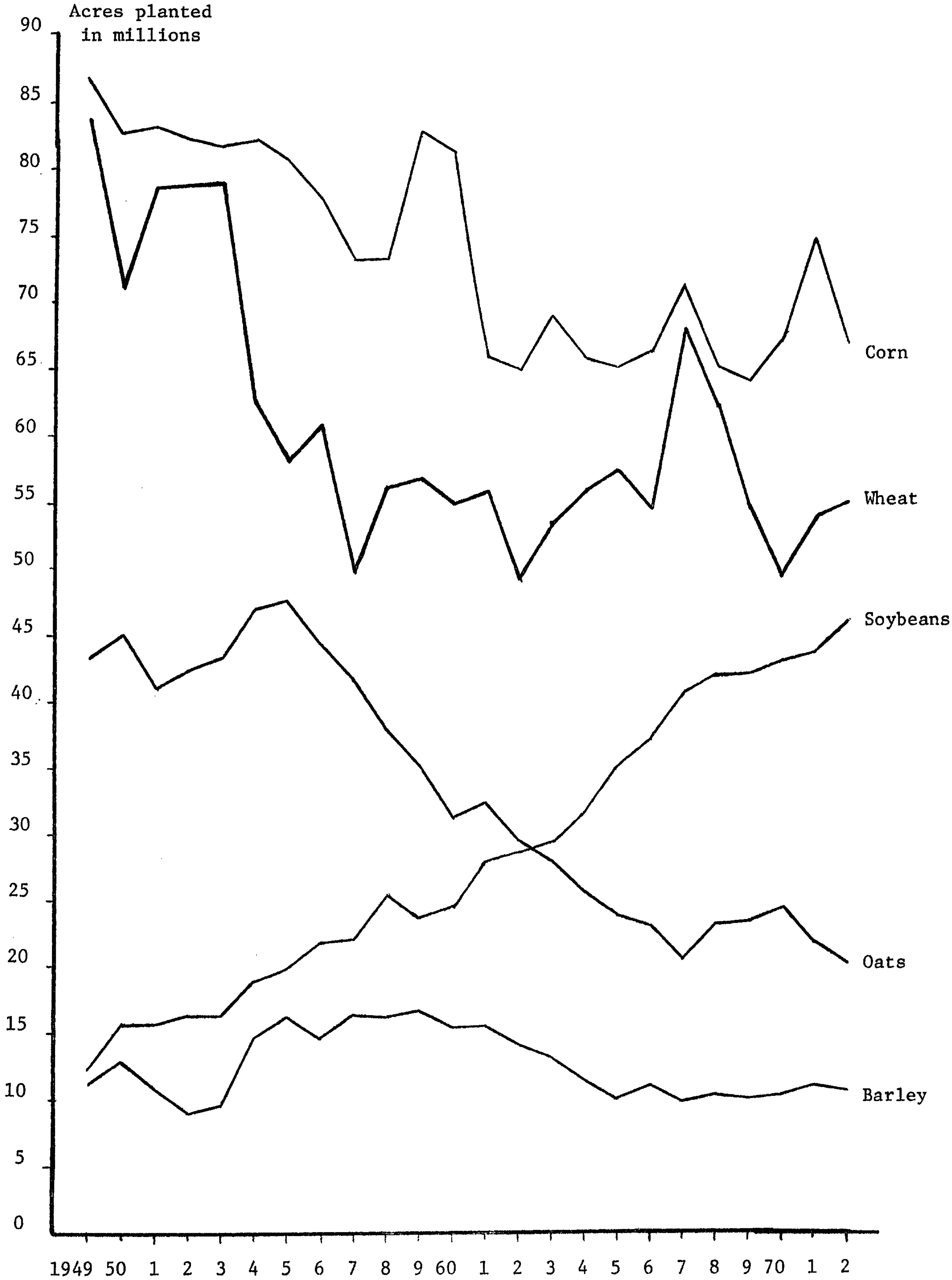
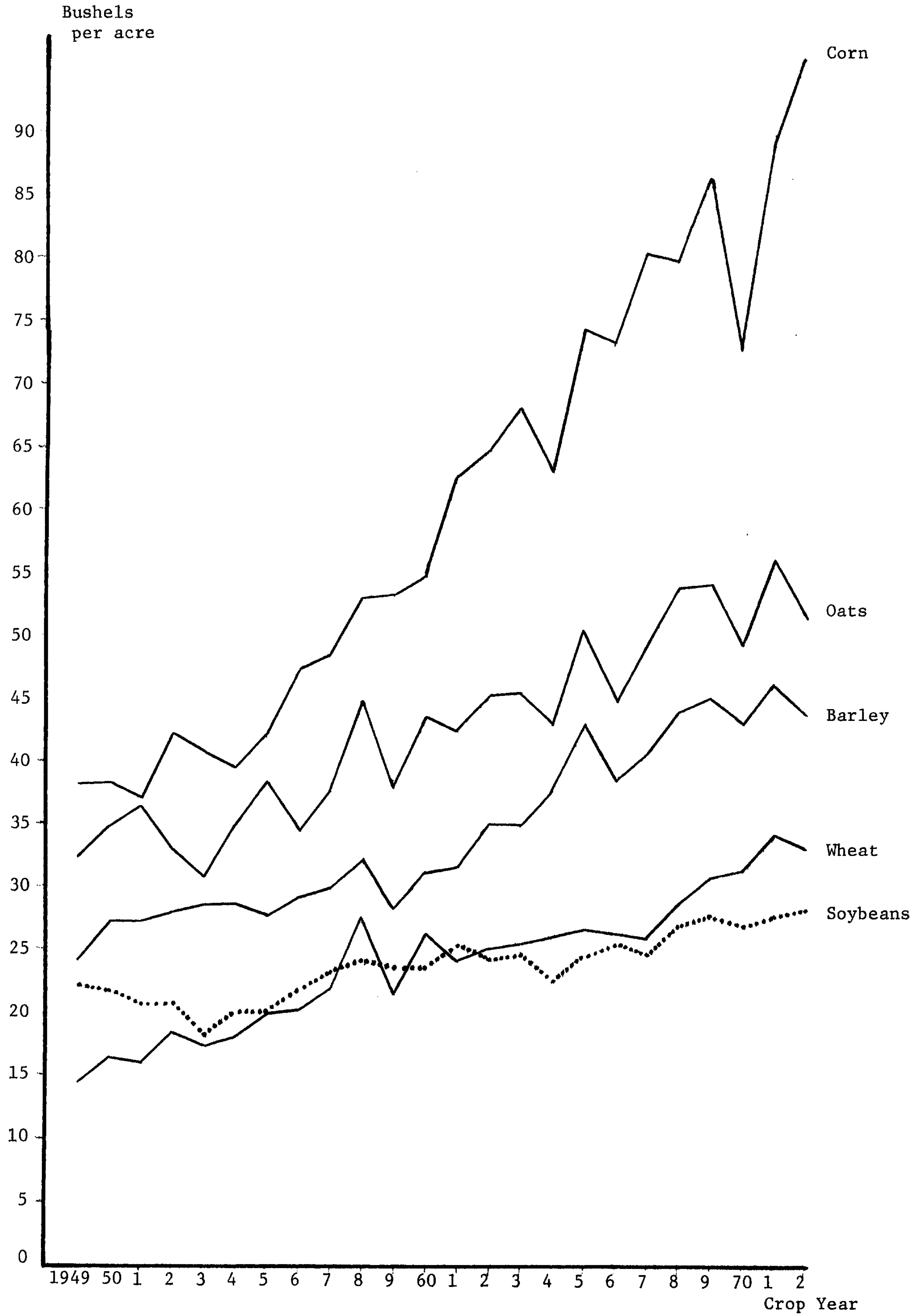


Figure 2. U.S. Average Yields for Oats, Barley, Corn, Wheat and Soybeans, 1949-1972



California where 11 percent of U.S. output was grown in 1972. Barley and oats areas overlap in the Upper Midwest while the remaining principal oats acreage lies to the South and East. Minnesota and Iowa contain the largest acreages of oats while the leading producers of oats for the market are North Dakota and Minnesota.

Besides its contribution to grain and forage supplies, oats is often planted as a nurse crop for grass and legume seedings, as a cover crop on idled acreage, and in crop rotations to help control weeds. Moreover, oats provides straw needed by livestock farmers.

Nearly two-thirds of oats production is utilized on farms where it is grown, compared with about one-fourth for barley. The heavy utilization of oats by producers is one reason for the wide dispersal of oats acreage in the nation.

The need for oats in crop rotations began to taper off when herbicides became generally available for controlling weeds in corn and soybeans.[3/] The contraction of oats acreage after 1955 coincides with the adoption of chemical weed control and the resulting expansion in soybean acreage, particularly in the Corn Belt. Much of the national acreage decrease of oats between 1955 and 1967 occurred in this region. Technically, corn could also be grown on land previously planted to oats; however, supply-control programs for corn limited its spread.

3/ Based on W. Herbert Brown, Soybeans: Acreage Response to Price and Farm Program Changes, ERS-473, Economic Research Service, U.S. Department of Agriculture, July 1971, and private discussions with Mr. Brown.

The expansion of oats acreage in the early 1950's can be traced to the introduction of new oats varieties in the South Central States. These varieties did not prove very successful and producers shifted to other crops so that reductions in oats acreage and increases in soybean acreage in the South Central States contributed to national trends since 1955. A reversal in the downward trend from 1967 to 1970 reflects a slowdown in substitution of corn and soybeans for oats in the Corn Belt and of soybeans for oats in the South Central States, along with sharp cutbacks in wheat and soybean acreage in the Northern Plains, freeing land for oats.

This examination of factors related to oats production suggests that corn, soybeans and wheat are the chief competitors with oats for land and other resources.

In most barley areas, wheat is the major production alternative. The main variation in barley acreage during the study period occurred when wheat planting was curtailed by government programs beginning in 1954. From 1953 to 1954, wheat planting dropped over 16 million acres while barley acreage climbed about 5 million, see Figure 1. Besides its use as a feed grain, about one-fourth of barley production is now utilized in the alcoholic beverage industry. This is approximately the same share as at the beginning of the study period. Although this nonfeed grain demand for barley exerts a distinct influence on the barley market, the effect on acreage planted was assumed to be reasonably constant in this study.

Government programs for oats and barley

Government policies to restrict acreage of feed grains have never applied to oats and were first imposed on barley in 1962. Since then barley planting restrictions applied in all years except 1967, 1968 and 1971. Payments for idling land were made to barley producers whenever planting was curtailed. Acreage diversion programs for feed grains and wheat permitted seeding of oats on idled land to conserve the soil. This provision probably caused the slight increase in acreage planted to oats in 1961, the first year of this type of program, see Figure 1. (Harvesting of oats from diverted acres was not permitted and statistics for acres harvested show a decrease of 2.7 million acres from 1960 to 1961.)

Prices of oats and barley have been supported by loans throughout the study period. The levels of the loan rates are tied to the corn loan rate by law to reflect the feeding values of each, relative to corn. For 1972 the national average loan rates per bushel were 54 cents, 86 cents and $1.05, respectively, for oats, barley and corn. Moreover, the loan rate for wheat has been set close to its feed value since 1964, making wheat more competitive with the coarse grains for feeding purposes. Similarly market prices for grains are closely linked.

Estimated Acreage Supply Functions

Acreage supply functions for oats and barley, estimated by ordinary least squares, are presented in Tables 1 and 2. Table 3 contains descriptions of the variables. The study periods were 1956-1971 for oats and 1949-1971 for barley. Given the structural and technological developments which affected oats production since the mid 1950's it was felt that the 1956-71 period was most relevant for analysis.

Policy variables are included in most of the equations reported. The policy variables PFO and PFB are the support price variables for oats and barley, respectively. Because no acreage restrictions applied to oats, PFO is the loan rate. For barley, the loan rate has been adjusted downward to obtain PFB for those years in which planting was curtailed. The variable DPB is the diversion payment variable for barley. Since there were no diversion programs for oats, there is not a corresponding variable for oats. These policy variables are constructed in exactly the same manner as the policy variables employed in the previously reported corn and sorghum studies. The data for these and the other variables used in the analysis are in the appendix.

Oats Results

Equation 1-1 in Table 1 is a good estimator of acreage planted to oats, AO; the signs of the estimated coefficients are consistent with prior expectations, the t-values of the regression coefficients are relatively large, and the overall fit of the equation, indicated by R^2, is exceptionally good. It contains the policy variable, PFO, two variables to measure the effect of substitution between oats and wheat (AW and AWD), and three variables (T, T^2 and DV68) to capture various trend influences in the study period. Actual and estimated values of AO based on equation 1-1 are shown in Figure 3.

The policy variable, PFO, has a strong, positive relationship with acreage planted to oats. A ten-cent per bushel increase in the loan rate for oats, ceterus paribus, is associated with an increase in AO of about 1.4 million acres. Possible effect of the lagged market price of oats, POT-1, is also investigated (equation 1-2) but the coefficient of POT-1 is not significant. In a preliminary estimation, POT-1 was added to equation 1-1. The result was a negative coefficient for POT-1, similar in size and significance to that of equation 1-2; the other variables in the equation were not appreciably affected by the addition of POT-1. The superiority of the price support variable to lagged market price was consistent with previous results obtained for corn and sorghum.

Acreage planted to wheat (AW) and acreage idled under the wheat programs (AWD) are important variables in all specifications. Changes in AW are associated with changes in the opposite direction of AO of about 25 percent -- a 100 acre increase in wheat decreases oats acreage by about 25 acres. The effect on oats plantings of acreage idled under wheat programs is about half the size of the effect of wheat acreage planted. This result is consistent with the "slippage" phenomenon observed in acreage diversion programs in which changes in acres diverted are roughly one-half as great as opposite changes in acres planted to a given crop.

It is postulated that soybeans and corn, as well as wheat, compete with oats for production resources. In equations 1-3 and 1-4 acreage planted to soybeans, ASB, and acreage planted to corn, AC, are entered as possible means of capturing such substitution. Neither of these specifications results in significant relationships between oats and these competing crops. It is quite likely that substitution between acreages of oats and corn or soybeans is being picked up by the trend variables. Nevertheless, replacement of the trend variables by ASB and/or AC does not result in as statistically significant an equation as 1-1. Regressions were also estimated that included variables representing price supports for corn and soybeans, acreage diversion payments for corn, and total acreage diverted under feed grain programs. These alternative formulations did not improve upon the explanatory power of the reported equations.

The rationale underlying the trend variables is as follows: The factors influencing the rapid shift away from oats beginning in the mid fifties (the adoption of chemical weed control in corn and soybean production and the limited success of southern varieties of oats) were likely to lessen in their effect through time; that is, in the first few years, large amounts of acreage would be withdrawn from oats then the process would slow as a saturation point was approached. These movements would result in a trend, declining at a decreasing rate, or expressed algebraically, $AO = a - bT + cT^2$. It was presumed that this process took about a decade, ending in 1967, based on the observation that both oats and soybean acreage leveled off somewhat in the late sixties (see Figure 1). To measure this complex relationship, two trend variables, T and T^2, are included in each regression, where T is a linear trend, assigned the values of 1 in 1956, 2 in 1957, ... 12 in 1967 and T^2 is the square of T, equal to 1 in 1956, 4 in 1957, ... 144 in 1967. A dummy variable, DV68, which takes values of zero in 1956-1967 and 1 in 1968-1971, is added to shift the intercept to correspond with the termination of the trend influences measured by T and T^2.[4/] The trend variables are highly significant and have the expected signs.

Barley Results

Equation 2-1 is, perhaps, the best equation in Table 2 for estimating acreage planted to barley, AB. The signs of the estimated coefficients conform with economic theory, the significance of the coefficients, indicated by t-values, are fairly high, and the R^2 signifies that 95 percent of the variation in AB is accounted for by the six selected independent variables. The performance of this equation is illustrated in Figure 4.

Equation 2-1 bears several similarities to equation 1-1 for oats. It contains a barley policy variable, PFB, wheat variables AW and AWD, and a trend variable, in this case a simple linear trend. In addition to these five variables, a significant relationship was found between the policy variable for oats, PFO, and acreage planted to barley, AB.

Barley acreage is less responsive than oat acreage to changes in the price support variable, in absolute and in relative terms. A ten-cent per bushel increase in PFB is associated with slightly less than a one-half million acre increase in barley plantings. This acreage change is 34 percent of the mean of AB for the study period, whereas the corresponding percentage for oats is 47 percent, based on equation 1-1. Like the findings for the other feed grains, the lagged market price, PBT-1 is inferior to the price policy variable for estimating acreage

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4/ Separate analyses of trend behavior confirm the absence of trend in the 1968-71 period.

planted (compare equations 2-3 and 2-4).

Government policies for barley included diversion payments in seven of the 23 years of the study. These payments are incorporated into the variable, DPB. In models containing this variable, a strong, negative relationship between DPB and AB obtains, as expected, but the inclusion of DPB impairs the sign and significance of PFB. "This is probably caused by intercorrelation between DPB and the other policy variables." The simple correlation (r) between DPB and PFB is .83 and between DPB and the ratio PFB/PFO is .98. Since no models containing both PFB and DPB are entirely consistent from an economic standpoint, equations containing PFB instead of DPB are recommended because price support loans were in force in all years of the study, and government loans are more apt to be continued annually in the future than government payments for idling land.

The addition of PFO improves the estimating model by raising the significance of PFB without lessening the significance of the other variables, compare 2-1 with 2-3. In equation 2-1, a ten-cent per bushel change in PFO is estimated to change AB by 1.3 million acres in the opposite direction. Because of the interrelatedness of loan rates among the major grains, it is not unreasonable to assume that PFO might be picking up substitution relationships in addition to that of oats.

Acreage planted to wheat (AW) and acreage idled under wheat programs (AWD) are important explanatory variables in all equations, as was the case for oats. These statistical results are in conformance with the earlier examination of cropping patterns that suggested that wheat, barley

Table 1. Estimation of U.S. Oats Acreage Planted, 1956-1971
(Regression Coefficients and t-values)

Dependent variable = AO

Equation	Constant	PFO	POT-1	AW	AWD	AC	ASB	DV68	T	T^2	R^2	s
1-1	54,369.60	13,919.77 (4.4)		-.26 (2.4)	-.14 (1.7)			-23,989.83 (35.1)	-3,625,80 (10.5)	128.24 (4.3)	.9965	555.83
1-2	63,745.43		-5,239.45 (0.6)	-.22 (1.2)	-.09 (0.6)			-24,455.34 (20.5)	-3,771.31 (6.3)	141.41 (2.8)	.9894	968.40
1-3	53,702.24	13,896.03 (4.2)		-.28 (2.3)	-.16 (1.7)		-.09 (0.5)	-25,961.38 (6.1)	-3,684.76 (9.6)	121.57 (3.6)	.9966	581.57
1-4	60,604.34	9,283.40 (1.5)		-.24 (2.2)	-.13 (1.6)	-.05 (.09)		-24,728.86 (22.4)	-3,767.43 (9.7)	134.94 (4.3)	.9968	563.87

Table 2. Estimation of U.S. Barley Acreage Planted, 1949-1971
(Regression Coefficients and t-values)

Dependent variable = AB

Equation	Constant	PFB	PBT-1	DPB	PFO	AW	AWD	DV	YEAR	R^2	s
2-1	56,195.40	4,335.81 (3.2)			-13,005.52 (4.5)	-.31 (10.0)	-.13 (3.0)	397.75 (0.6)	-330.58 (5.4)	.95	670.74
2-2	59,697.62	-4,078.11 (0.9)		-19,551.26 (1.9)	- 1,871.94 (0.3)	-.30 (10.6)	-.10 (2.6)	477.26 (0.8)	-378.83 (6.1)	.96	621.25
2-3	53,710.15	2,733.37 (1.4)				-.37 (9.5)	-.20 (3.5)	669.05 (0.7)	-335.84 (3.8)	.89	973.63
2-4	55,427.00		-3,169.90 (1.1)			-.29 (6.7)	-.18 (3.2)		-345.20 (7.4)	.88	996.06

Table 3. Variable Descriptions

AB	=	U. S. acreage of barley planted, in thousands
AC	=	U. S. acreage of corn planted, in thousands
AO	=	U. S. acreage of oats planted, in thousands
ASB	=	U. S. acreage of soybeans planted, in thousands
AW	=	U. S. acreage of wheat planted, in thousands
AWD	=	U. S. acreage diverted under wheat programs, in thousands
DPB	=	barley acreage division payment rate, weighted by eligible diversion acreage, dollars per bushel
DV	=	0 in 1957-65 and 1 in 1966-71, to account for a change beginning in 1966 when support payments were shifted from PF to DP
DV68	=	0 in 1956-67 and 1 in 1968-71
PBT-1	=	lagged barley market price received by farmers, dollars per bushel
PFB	=	U. S. average barley loan rate (plus direct support payments, 1963-65) weighted by acreage restriction requirements, dollars per bushel
PFO	=	U. S. average oats loan rate (plus direct support payments, 1963-65) weighted by acreage restriction requirements, dollars per bushel
POT-1	=	lagged oats market price received by farmers, dollars per bushel
T	=	linear trend; 1956 = 1, 1957 = 2, etc.
T^2	=	T squared; 1956 = 1, 1957 = 4, etc.
Year	=	linear trend; 1949 = 49, 1950 = 50, etc.
s	=	standard error of the estimate

Figure 3. U.S. Oats Acreage Planted, Actual and Estimated, 1956-1971

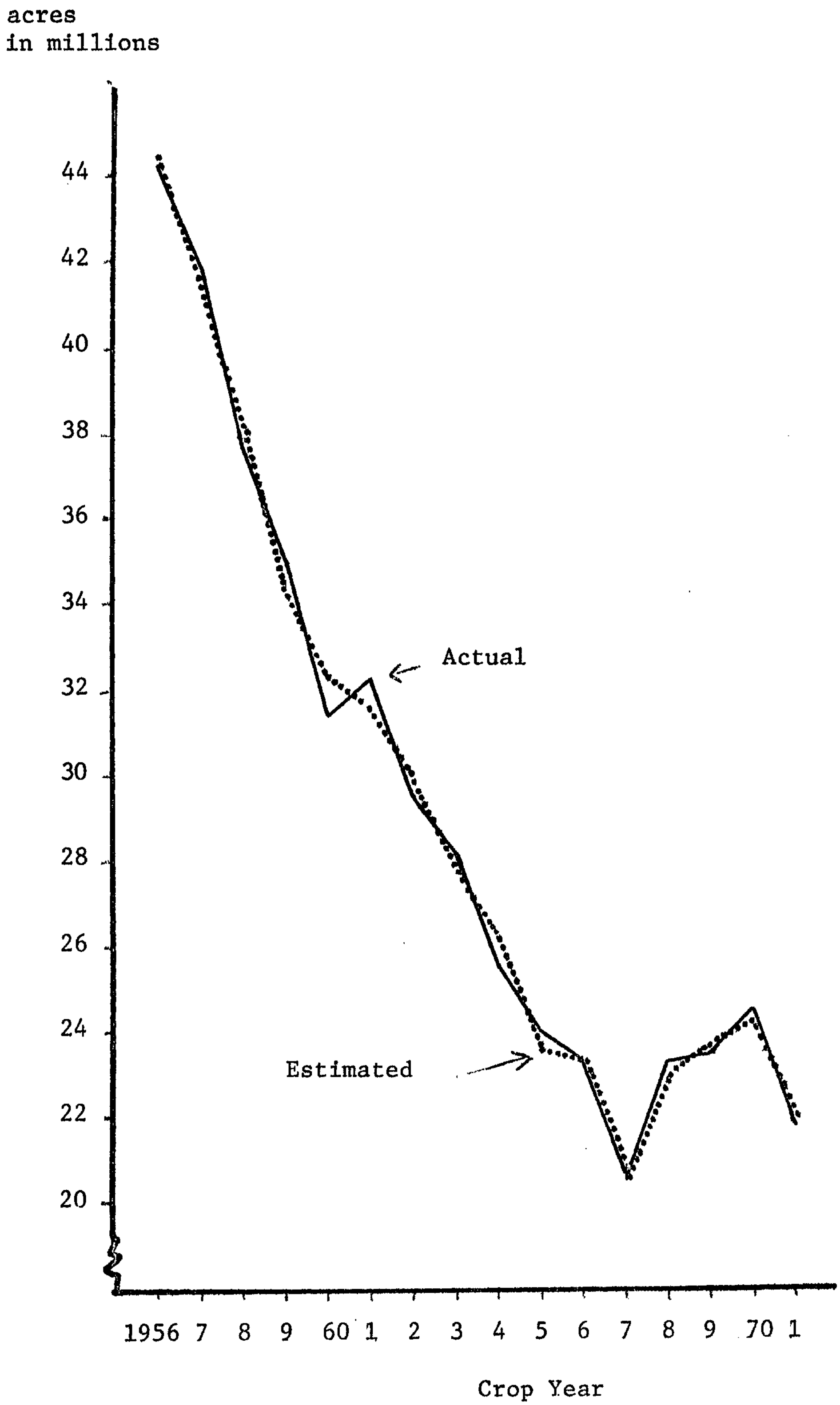
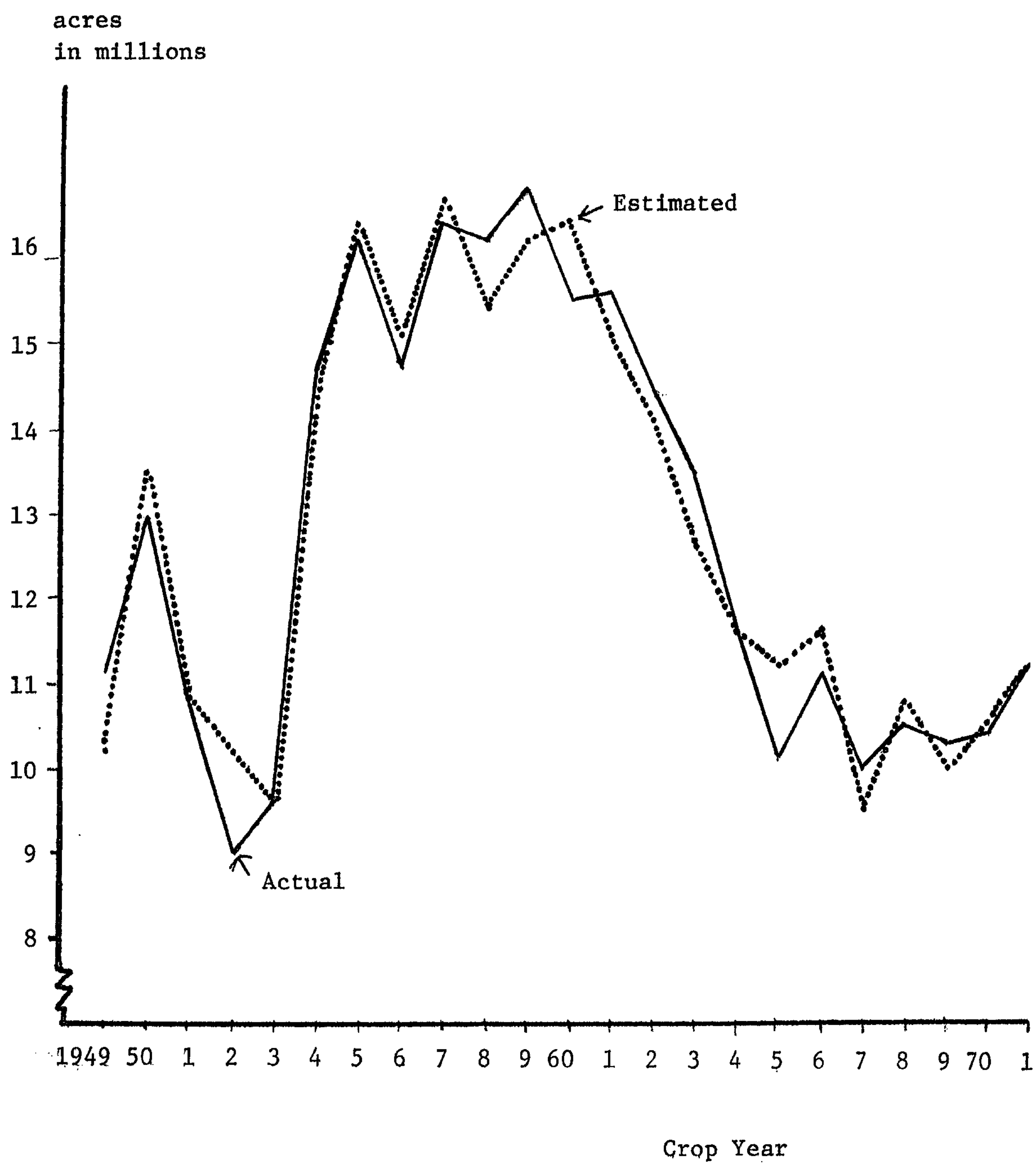


Figure 4. U.S. Barley Acreage Planted, Actual and Estimated, 1949-1971



and oats compete for production resources in the major oats and barley areas. The degree of wheat substitution measured is not greatly different than that for oats; a one hundred acre increase in wheat is associated with about a 30 acre decrease in barley compared with a 25 acre decrease in oats. Changes in wheat acreage diversion have about the same estimated effect on acreages planted of barley and oats -- a ten acre increase in AWD is associated with one acre decreases each in AO and AB.

According to these estimates, barley plantings are declining about 0.3 million acres annually owing to factors captured by a linear trend.

Conclusions

The equations for estimating acreages planted to oats and barley seem to explain historical variations in plantings very well. As with previous analyses for corn and sorghum, the policy variables employed for oats and barley are significantly related to acreage planted. It would appear that the acreage estimating equations for oats and barley should prove useful in evaluating the acreage planted implications of alternative values of the policy variables.

To further test the usefulness of the models, they were used to predict acreage planted in 1972. The results are as follows:

	1972	
	Actual acreage planted	Predicted acreage planted
	1000 acres	
Oats (equation 1-1)	20,495	20,614
Barley (equation 2-1)	10,548	10,000

The close correspondence between actual and predicted acreages in 1972 lend further support to the accuracy and usefulness of the analytical framework and estimating equations for oats and barley presented in this paper.

APPENDIX TABLE

The Data Series

Crop Year	AO	AB	PFO	POt-1	PFB	PBt-1	DPB
1949	43,132	11,132	0.69	0.717	1.09	1.16	0.0
1950	45,044	13,010	0.71	0.655	1.10	1.06	0.0
1951	41,015	10,790	0.72	0.788	1.11	1.19	0.0
1952	42,341	9,190	0.78	0.820	1.22	1.26	0.0
1953	43,220	9,616	0.80	0.789	1.24	1.37	0.0
1954	46,898	14,740	0.75	0.742	1.15	1.17	0.0
1955	47,494	16,293	0.61	0.714	0.95	1.09	0.0
1956	44,205	14,732	0.65	0.600	1.02	0.92	0.0
1957	41,840	16,398	0.61	0.686	0.94	0.99	0.0
1958	37,699	16,150	0.61	0.605	0.93	0.89	0.0
1959	35,064	16,766	0.50	0.578	0.77	0.90	0.0
1960	31,419	15,527	0.50	0.646	0.77	0.86	0.0
1961	32,314	15,623	0.62	0.599	0.93	0.84	0.0
1962	29,500	14,380	0.62	0.642	0.65	0.98	0.149
1963	28,054	13,452	0.65	0.624	0.67	0.92	0.086
1964	25,634	11,652	0.65	0.622	0.62	0.90	0.139
1965	24,010	10,099	0.60	0.631	0.62	0.95	0.139
1966	23,301	11,134	0.60	0.622	0.52	1.02	0.175
1967	20,646	10,002	0.63	0.655	0.90	1.05	0.0
1968	23,166	10,477	0.63	0.659	0.90	1.00	0.0
1969	23,532	10,311	0.63	0.599	0.54	0.91	0.170
1970	24,492	10,435	0.63	0.586	0.54	0.87	0.162
1971	21,926	11,182	0.54	0.626	0.81	0.96	0.0

AO = oats acreage planted, in thousands

AB = barley acreage planted, in thousands

PFO = support price for oats, dollars per bushel

POT-1 = lagged market price for oats, dollars per bushel

PFB = weighted support price for barley, dollars per bushel

PBT-1 = lagged market price for barley, dollars per bushel

DPB = weighted diversion payment rate for barley, dollars per bushel

The Data Series continued

Crop Year	AW	AWD	AC	ASB	DV66	DV68	T	T^2	Year
1949	83,905	0	86,738	12,456	0	0			49
1950	71,287	0	82,859	15,640	0	0			50
1951	78,524	0	83,275	15,655	0	0			51
1952	78,645	0	82,230	16,374	0	0			52
1953	78,931	0	81,574	16,719	0	0			53
1954	62,539	0	82,185	18,872	0	0			54
1955	58,246	0	80,932	19,981	0	0			55
1956	60,655	0	77,828	21,998	0	0	1	1	56
1957	49,843	12,800	73,180	22,186	0	0	2	4	57
1958	56,017	5,300	73,351	25,350	0	0	3	9	58
1959	56,706	0	82,742	23,579	0	0	4	16	59
1960	54,906	0	81,425	24,649	0	0	5	25	60
1961	55,707	0	65,919	27,981	0	0	6	36	61
1962	49,274	10,700	65,017	28,593	0	0	7	49	62
1963	53,364	7,200	68,771	29,598	0	0	8	64	63
1964	55,672	5,100	65,823	31,794	0	0	9	81	64
1965	57,361	7,200	65,119	35,227	0	0	10	100	65
1966	54,395	8,300	66,306	37,294	1	0	11	121	66
1967	67,796	0	71,093	40,776	1	0	12	144	67
1968	62,486	0	65,126	42,037	1	1	0	0	68
1969	54,279	11,100	64,476	42,198	1	1	0	0	69
1970	49,488	15,700	67,352	43,332	1	1	0	0	70
1971	54,643	13,700	74,651	43,637	1	1	0	0	71

AW = wheat acreage planted, in thousands

AWD = wheat acreage diverted, in thousands

AFGD = feed grain acreage diverted, in thousands

ACT = cotton acreage planted, in thousands

AC = corn acreage planted, in thousands

ASB = soybean acreage planted, in thousands