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SUPPLY RESPONSE OF U.S. SORGHUM ACREAGE TO GOVERNMENT PROGRAMS

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The value of sorghum grain production approached $1 billion in 1971. Nearly 900 million bushels were produced, placing sorghum second to corn in the volume of feed grain production. The increasing importance of sorghum as a feed grain has paralleled the growth of the livestock industry in the central and southern plains states. More than half of the total number of cattle on feed on January 1, 1972 were located in the eight leading sorghum producing states, compared with about one-third for the period 1949-1957. Sorghum is also an important export crop. During the past decade exports have exceeded 100 million bushels annually.

Sorghum competes with other grains for production resources throughout the central and southern plains and additionally with cotton in the southern states of the area. Most of these crops have been enmeshed in government programs to control production and to support prices for many years. Thus government policies play key roles in determining the supply of sorghum.

This paper presents and discusses estimated acreage supply functions for sorghum in the United States for the period 1957-71. The work reported

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is part of an ongoing research project to investigate supply relationships for feed grains, sponsored jointly by the U.S. Department of Agriculture and the Department of Agricultural and Applied Economics at the University of Minnesota. A focal point of this research is to examine the effect of government programs on acres planted to the various feed grains. Work on corn has been completed and reported.[1/]

Theoretical and Analytical Models

The theoretical and analytical models developed for the corn studies are employed in this analysis. Figure 1 illustrates the theoretical model. Assume that S_1 is a static acreage supply function for a crop at various price support levels. Acreage is measured along the horizontal axis and support price along the vertical axis. At the announced price support of PA, producers would plant A_1 if there were no restrictions or conditions attached to the price support. But if policy makers wish to reduce acreage to, say A_2, they could (1) drop the support rate to PF, (2) attach acreage-restricting conditions to obtaining the higher PA so that, on balance, acreage planted falls to A_2, (3) make diversion payments sufficient to shift the supply function to S_2, or (4) employ some combination of these three options.

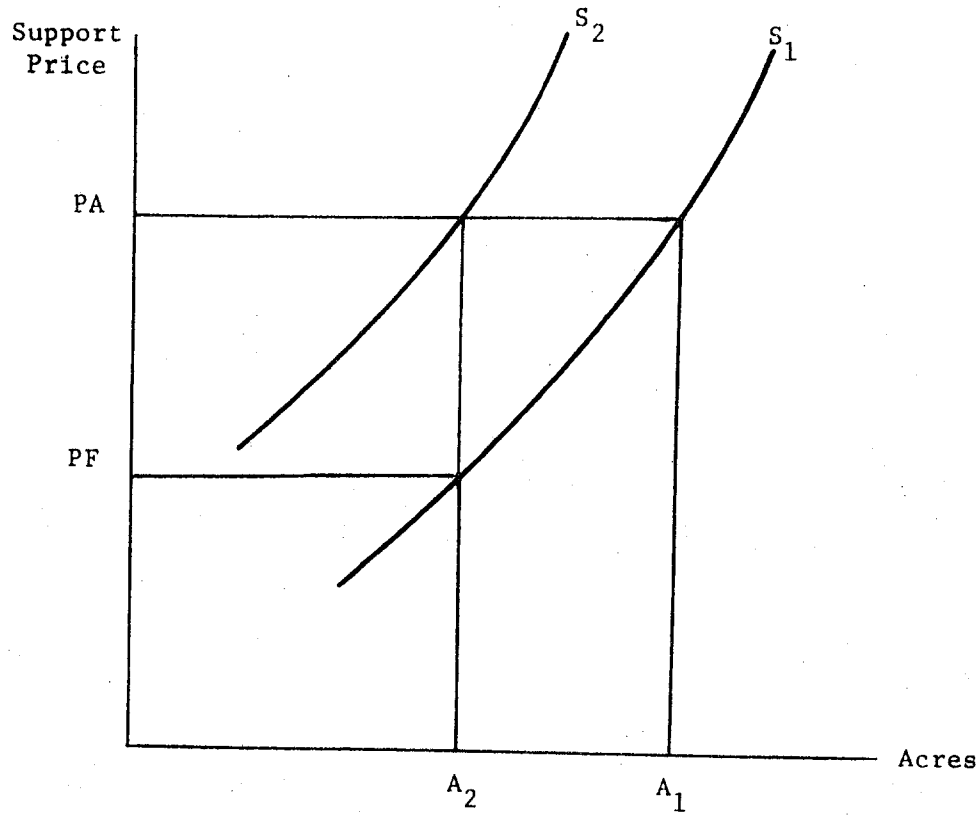
This model may be expressed as

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

[1/] J. P. Houck and M. E. Ryan, "Supply Analysis for Corn in the United States: The Impact of Changing Government Programs," American Journal of Agricultural Economics, 54:2, May 1972, pp. 184-91.

Mary E. Ryan and Martin E. Abel, "Corn Acreage Response to Government Policy Variables with a Special Analysis of the Set-Aside Program," Agricultural Economics Research, October 1972.

Figure 1.



where A is sorghum acreage planted in the United States, PF is the support price weighted by planting restrictions, DP (a shifter of PF) represents payments for diverting land from sorghum production, and Z includes other supply determinants and random factors. The analytical and empirical problems are to determine how to calculate PF and DP for any given set of program provisions.

Assume that

$$(2) \quad PF = rPA,$$

and that

$$(3) \quad DP = wPR$$

where PA is the announced support rate and r is the adjustment factor reflecting planting restrictions, and PR is the payment rate for diversion and w is the proportion of acreage eligible for diversion payments.

Generally, the ranges of r and w are between 0 and 1.0. If no planting restrictions are imposed for obtaining PA, r equals 1.0. Similarly, if all land may be diverted for payment, w equals 1.0. The tighter the planting restrictions, the closer r will be to zero; and, the smaller the permitted diversion acreage, the closer w will be to zero. The values of PF and DP are seen to depend both upon payment levels (PA and PR) and upon the amount of acreage eligible for payment (r and w). Changes in any of these four variables, holding the others constant, will affect acreage planted. Increases in r or PA will raise PF and increase acreage; increases in w or PR will increase DP and decrease acreage planted.

Calculated values of PF and DP for sorghum are presented below, after

a brief discussion of other supply determinants and of factors affecting the analytical procedure.

Preliminary Analyses

Sorghum acreage in the United States climbed from 11 million in 1949 to nearly 27 million in 1957. During these years, sorghum was allowed on land diverted under corn, wheat and cotton programs. Acreage dropped to almost 14 million in 1961 when sorghum acreage was restricted under the feed grain program. Since then, plantings have trended irregularly upward, reaching 21 million in 1971. (See Figure 2.) Annual changes in harvested acres follow the same general pattern as planted acres but the difference between planted and harvested acres appears to be much more stable since 1957 than in earlier years.

A dramatic change in yield and production of sorghum grain occurred in the mid-1950's as a result of the introduction of hybrid varieties (Figure 3).[2/] While sorghum yields fluctuated narrowly around an average of 20 bushels per acre between 1949-1956, the introduction of hybrid varieties led to a fairly steady increase in yields for the next decade so that yields have exceeded 50 bushels per acre since 1965.

As a consequence of sharp increases in both yield and area planted, sorghum production jumped from 205 to 570 million bushels between 1956 and 1957. By 1971 production was at a level of 890 million bushels. Because of this significant development, the characteristics of sorghum grain production since about 1957 differ to some extent from earlier years. For

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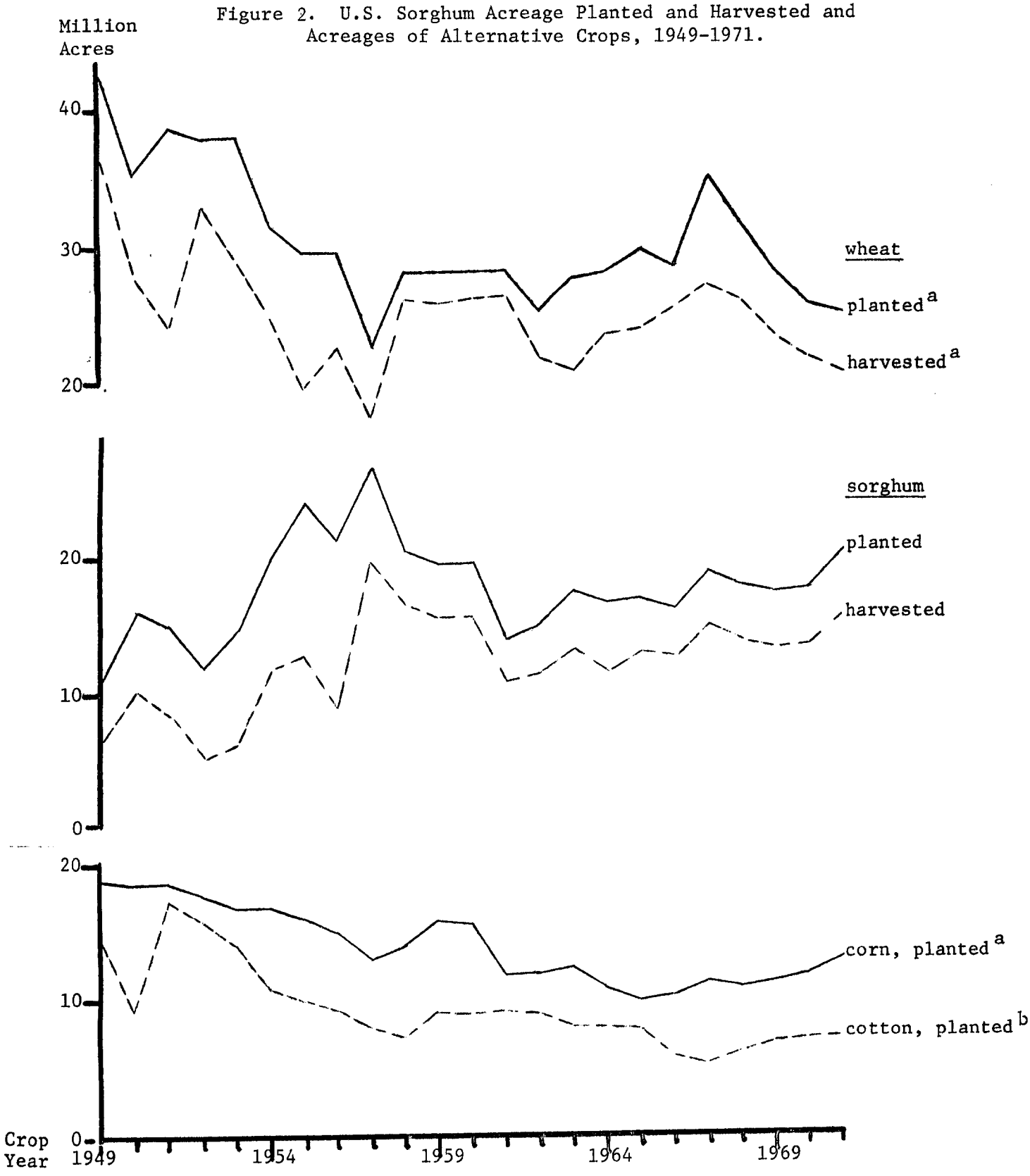
[2/] Jack S. Ross, "Grain Sorghum Trends in the 1960's," Feed Situation, ERS, U.S. Department of Agriculture, May 1970, pp. 28-32.

Figure 2. U.S. Sorghum Acreage Planted and Harvested and Acreages of Alternative Crops, 1949-1971.



[a]Acreage in Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, Missouri and California.

[b]Acreage in Texas, New Mexico, Oklahoma, Missouri and California.

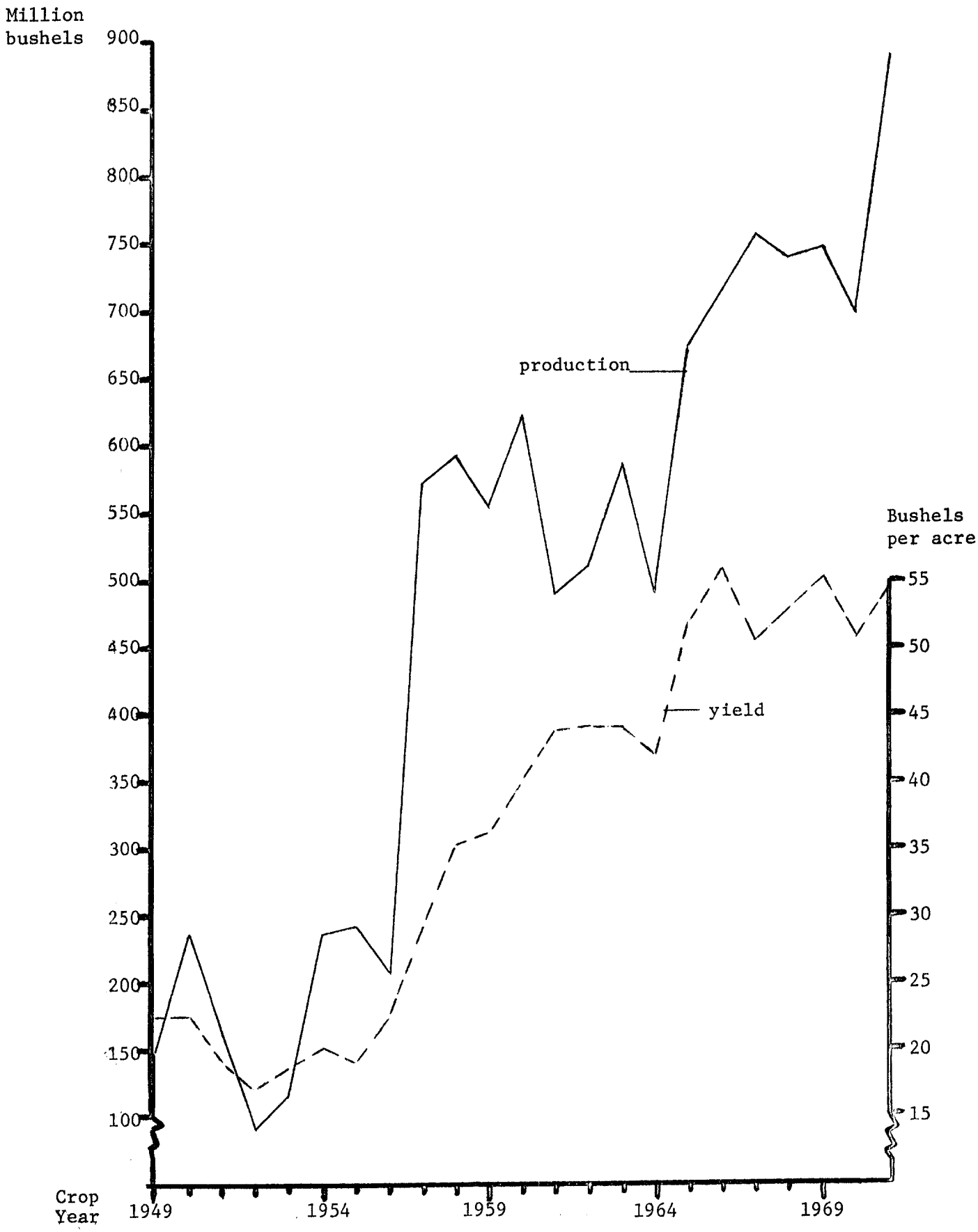


Figure 3. U.S. Sorghum Production and Yield, 1949-1971.

this reason the statistical estimations presented in this paper are based on a time period beginning in 1957, the period when the hybrid varieties have been used in significant amounts.

Texas is the leading sorghum producing state. In 1969 Texas accounted for 42% of U.S. sorghum production for grain. In the same year 95% of the nation's production of sorghum grains was obtained from eight states -- Texas, New Mexico, Kansas, Oklahoma, Colorado, Nebraska, Missouri, and California. For the 23-year period 1949-71, mean acreage in these eight states was 93.5% of all acreage planted to sorghum in the United States. Aggregate annual changes in sorghum plantings in these eight states are almost perfectly correlated with changes in U.S. plantings. The simple correlation coefficient (r) between the two is .997 for 1949-1971.

Because of the importance of these eight states in sorghum output, competitive production relationships in these states were examined in detail. Graphic and statistical analysis revealed that winter wheat and cotton were important competitors with sorghum in Texas. Substitution with cotton also appeared likely in California and Oklahoma. Winter wheat and sorghum plantings moved in opposite directions for many years in all eight states.[3/] Corn and sorghum substitution before 1961 had been revealed and measured in the study of corn.[4/] This substitution is of particular importance in parts of Kansas, Nebraska and Missouri.

On the basis of these preliminary investigations it was postulated

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[3/] In years when inclement weather for wheat prevails, sorghums are often planted on land sown to winter wheat the previous autumn. When this occurs, sorghum acreage is more closely associated with harvested than with planted wheat acreage.

[4/] Houck and Ryan, op. cit. and Ryan and Abel, op. cit.

that the main competition with sorghum for production resources would be captured by the following variables: acreages of wheat, cotton, and corn in the eight leading sorghum states. These variables are shown in Figure 2. Less certain was possible substitution with soybeans. Soybean acreage in Kansas, Nebraska, Missouri, Oklahoma and Texas trended irregularly upward throughout the study period and some substitution with sorghum was possible. Throughout the study period plantings of soybeans were not restricted in contrast to allotments or restrictions on wheat, corn and cotton in most years and on sorghum during the 1960's. This meant that producers were more free to plant soybeans wherever technically feasible than to plant the other three crops.

Acreage restrictions on sorghum became a requirement for obtaining sorghum price supports in 1961. Before then a farmer could plant any amount he wished and still obtain a sorghum price support loan. Also, prior to 1961, farmers who reduced corn and wheat acreage as required for corn and wheat support loans could plant sorghum without restriction on these freed acres. During the years when these liberal provisions applied, sorghum acreage increased sharply in some principal corn and wheat areas, especially in the southwestern portion of the Corn Belt and southern plains states. Although government programs have allowed corn and sorghum substitution since 1961 and substitution between wheat and feed grains since 1965, total acreage of all three commodities has been curtailed in some degree.

The program change in 1961 suggested that substitution among commodities might be altered at that point in the study period. To determine the effects of the program change for the analysis of sorghum acreage, preliminary

analyses were done separately for the time periods 1949-60 and 1961-71. For 1949-60 substitution emerged between sorghum acreage and acreages of winter wheat, corn, and cotton in the eight major sorghum states. No substitution was found to exist between sorghum and wheat acreage for 1961-71 but substitution between cotton and sorghum did appear. The effect of changes in cotton acreage on sorghum plantings was greater during the later than in the earlier period. Results were inconclusive for sorghum-corn competition since 1961. Possible competition with soybeans was measured by means of a price support variable for soybeans in both periods. The price support of soybeans emerged as a significant variable in some specifications for both time periods.

Another competitor with sorghum planting since 1961 has been acreage diverted under annual feed grain programs. Sorghum acreage diverted for 1961-71 is shown in Figure 4, along with acres planted to sorghum. The substitution between plantings and diversion since 1961 is pronounced.

Also graphed in Figure 4 are the two policy variables, PF and DP, computed for sorghums. These policy variables are the weighted or effective price support rate, PF, and the weighted diversion payment rate, DP, calculated from program provisions as announced each year, according to equations (2) and (3), respectively.[5/] From 1957 to 1960, PF equals the loan rate. Beginning with 1961 the loan rate has been weighted to reflect acreage restrictions. A positive relationship between PF and acres planted to sorghums is apparent in Figure 4, as expected. Values of PF, DP, and the loan rate appear in Table 1.

[5/] Detailed descriptions of the calculations for each year are contained in Appendix B (page 24) for PF and in Appendix C (page 28) for DP.

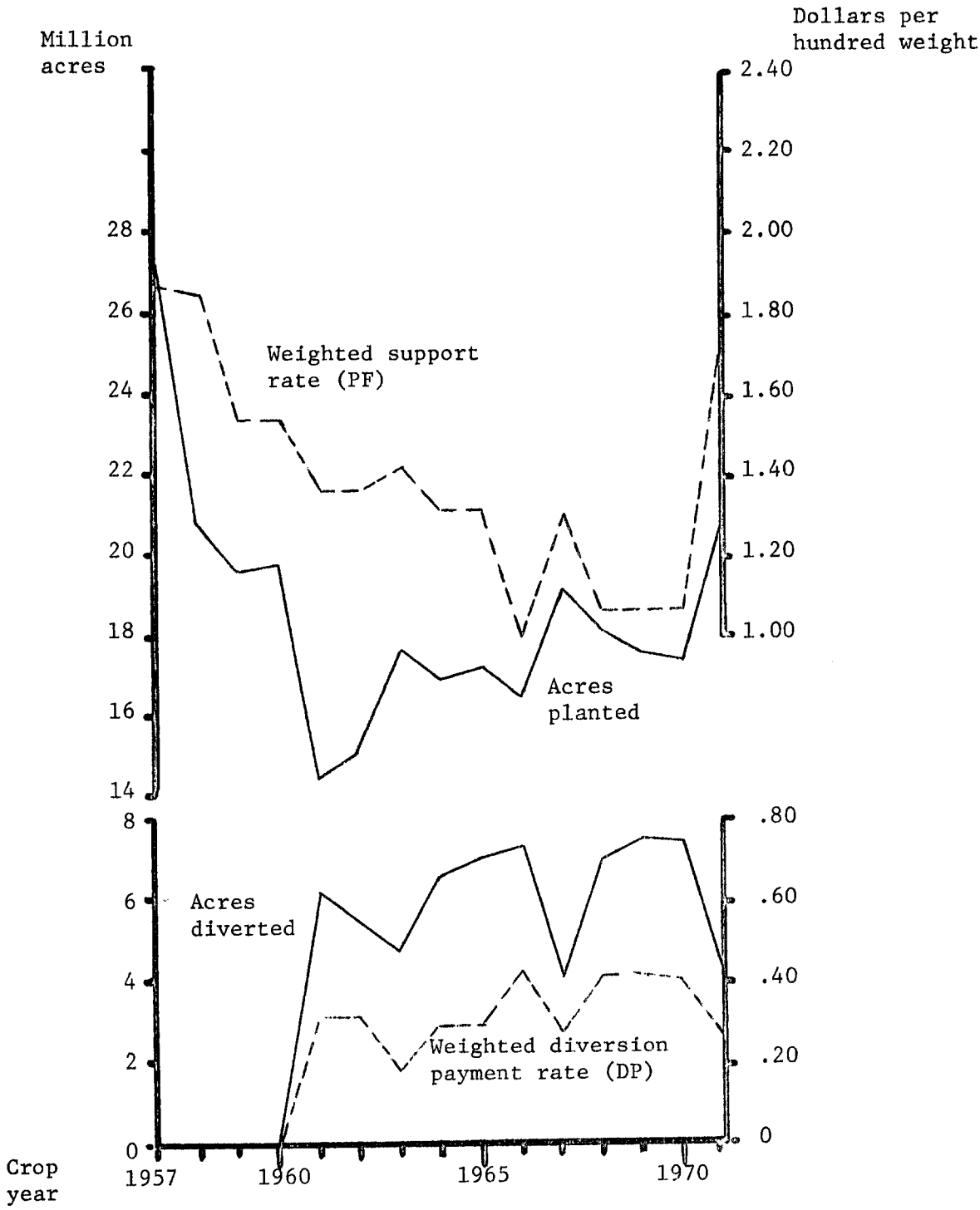


Figure 4. U.S. Sorghum Acres Planted and Diverted Under Government Programs, Weighted Support Rate and Diversion Payment Rate, 1957-1971.

Table 1. Announced support prices, calculated weighted support rates and diversion payment rates, dollars per hundred weight, 1957-1972.

	Announced Support Price	Weighted Support Rate (PF)	Weighted Diversion Payment Rate (DP)
1957	1.86	1.86	0
1958	1.83	1.83	0
1959	1.52	1.52	0
1960	1.52	1.52	0
1961	1.93	1.35	.309
1962	1.93	1.35	.309
1963	2.00[a]	1.40	.180
1964	2.00[a]	1.30	.290
1965	2.00[a]	1.30	.290
1966	1.52[b]	.99	.418
1967	1.61[b]	1.29	.265
1968	1.62[b]	1.05	.410
1969	1.61[b]	1.05	.409
1970	1.61[b]	1.05	.393
1971	1.73[b]	1.73	.259
1972	1.79[b]	1.52	.442

[a]Direct support payments are included. They are 29¢ for 1963, 23¢ for 1964, 35¢ for 1965.

[b]Direct support payments beginning with 1966 are included with diversion payments because they have functioned as a payment for minimum diversion since then.

The policy variable, DP, is a measure of substitution between planted and diverted acreage. Figure 4 reveals that movements in DP parallel changes in acres diverted and that both of these variables move in opposite directions from PF and acres planted. A statistical test was also made of the relationship between DP and acreage diverted from sorghums under the feed grain program, AD, for 1961-1971.

$$\triangle AD = 136.59 + \underset{(11.5)}{18{,}878.99}\triangle DP - \underset{(2.9)}{224.71}\triangle DV$$

$$s = 706.37 \qquad R^2 = .9430$$

where DV is a dummy variable to account for adding support payments to DP beginning in 1966, $\triangle$ indicates the first difference of the variable, s is the standard error of the estimate, and the numbers in parentheses are t-values. Annual changes in sorghum acreage diversion are closely related to the policy variable, DP, and thus it is reasonable to use the latter to measure the effect of substitution between sorghum acreage planted and diverted in estimating planted acreage.

Estimated Acreage Supply Functions

Sorghum acreage supply functions for the United States were estimated by ordinary least squares. For all equations the dependent variable was acreage of sorghum planted in the United States. The results for several of the estimations are contained in Table 2 and zero-order correlation coefficients for pairs of variables are given in Table 3.

All equations contain the policy variables PF and DP as well as DV, the dummy variable, added to account for shifting support payments from PF to DP beginning in 1966. The price support rate for soybeans, PSS, and

Table 2: Estimation of U. S. Sorghum Acreage Planted, 1957-71
(regression coefficients and t-values)

Equation	Constant	PF	DP	PT-1	PSS	AWWM	ACM	ACT	DV	T	R^2	s
1.	76,616.9	3,001.9 (2.6)	-7,346.7 (2.1)		-7,909.2 (3.4)	-1.2 (9.7)		-1.4 (3.5)	1,016.6 (1.2)		.98	566.6
2.	75,559.5	2,645.0 (1.9)	-9,063.2 (1.8)		-7,327.5 (2.7)	-1.3 (9.0)		-1.3 (3.1)	825.6 (0.9)	54.2 (0.5)	.98	594.9
3.	62,275.5	756.4 (0.4)	-16,292.1 (4.2)		-2,472.4 (1.0)	-1.0 (3.7)	-0.7 (1.0)		3,723.5 (5.1)		.95	854.7
4.	65,708.0	-795.7 (0.4)	-21,726.6 (4.1)		-1,724.3 (0.7)	-1.0 (3.9)	-1.0 (1.5)		2,636.9 (2.7)	207.9 (1.4)	.96	807.2
5.	75,143.5	3,530.9 (2.2)	-6,293.0 (1.5)		-8,110.4 (3.3)	-1.3 (6.1)	0.3 (0.5)	-1.5 (3.1)	700.2 (0.7)		.98	594.0
6.	74,998.5	3,142.5 (1.3)	-7,668.0 (1.0)		-7,695.9 (2.4)	-1.3 (5.4)	0.2 (0.3)	-1.4 (2.3)	690.6 (0.6)	32.4 (0.2)	.98	638.7
7.	74,818.4	2,825.2 (1.9)	-7,757.2 (1.8)	365.7 (0.2)	-7,649.9 (2.8)	-1.2 (7.4)		-1.3 (2.9)	1,054.2 (1.2)		.98	603.7
8.	75,788.6	2,659.9 (1.6)	-9,055.4 (1.7)	-53.1 (0.0)	-7,347.6 (2.4)	-1.3 (6.2)		-1.3 (2.7)	814.4 (0.7)	55.8 (0.4)	.98	642.6

(continued)

Table 2. - (continued)

Variable Descriptions

A = U. S. acreage of sorghums planted, in thousands.

PF = U. S. average sorghum loan rate (plus direct support payments, 1963-65), weighted by acreage restriction requirements, dollars per hundred weight.

DP = sorghum acreage division payment rate, weighted by eligible diversion acreage, dollars per hundred weight.

PT-1 = lagged market price received by farmers, dollars per hundred weight.

PSS = U. S. average soybean price support loan rate, dollars per bushel.

AWWM = acreage of winter wheat planted in 8 states (Texas, New Mexico, Oklahoma, Colorado, Kansas, Nebraska, Missouri, California), in thousands. Actual values of plantings for 1957-60 and the mean of 1957-60 acreage for 1961-71.

ACM = acreage of corn planted in 8 states (see AWWM), 1957-60 and the mean of 1957-60 acreage for 1961-71, in thousands.

ACT = acreage of cotton planted in 5 states (Texas, New Mexico, Oklahoma, Missouri, California), in thousands.

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.

T = linear trend; 1957=9, 1958=10, etc.

s = standard error of the estimate.

Table 3: Simple Correlation Coefficients, 1957-71.

	PF	DP	PT-1	PSS	AWWM	ACM	ACT	DV	T
A	.70	-.66	.55	-.40	-.54	-.46	-.05	-.08	-.34
PF		-.84	.28	-.60	-.20	-.31	.43	-.54	-.62
DP			-.02	.81	.00	.00	-.51	.65	.80
PT-1				.13	-.54	-.47	-.32	.25	.26
PSS					-.18	-.31	-.72	.62	.62
AWWM						.76	.06	.00	.10
ACM							.23	.00	.12
ACT								-.85	-.66
DV									.85

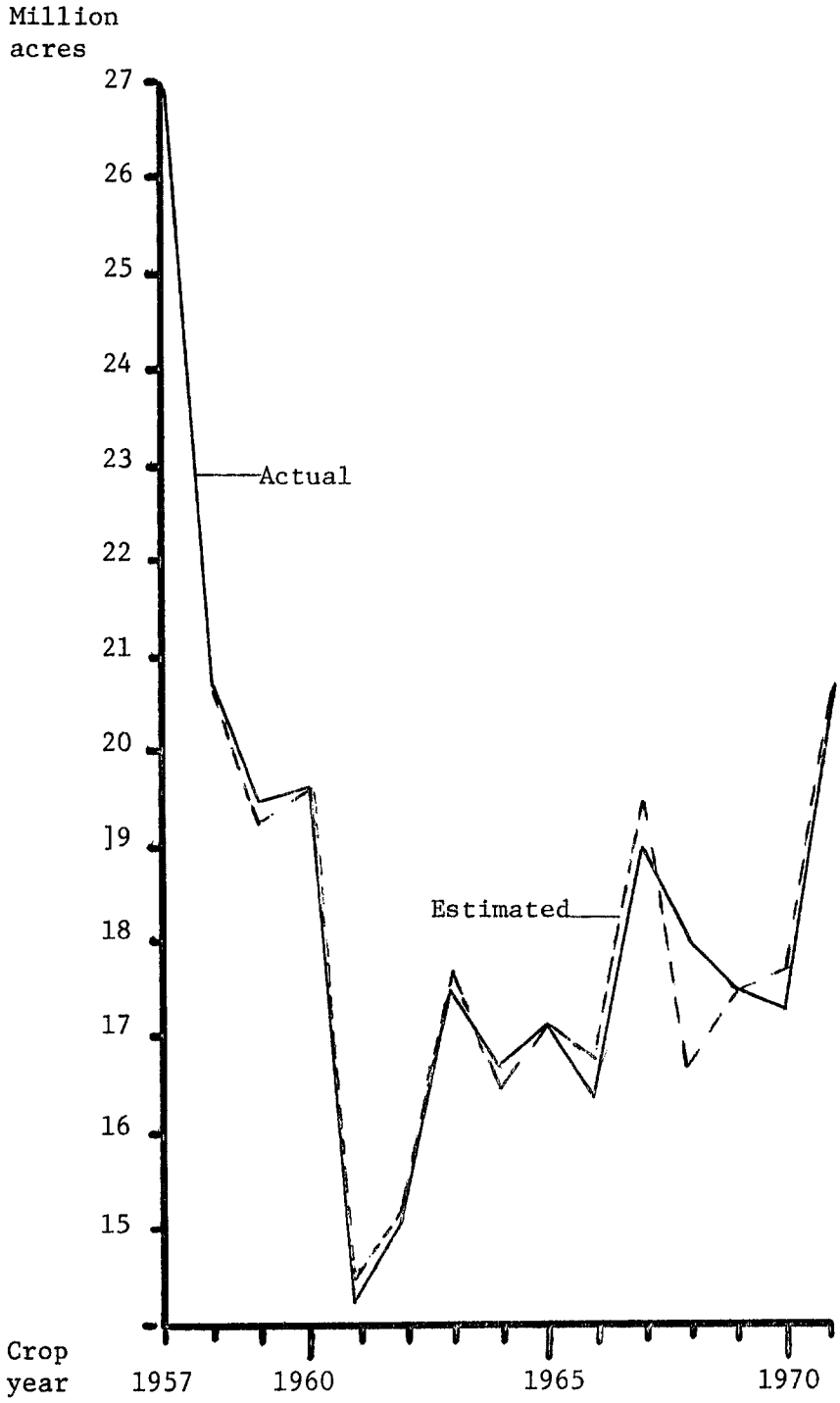
acreage of winter wheat planted, AWWM, were also included in all the equations.

The variable AWWM consists of actual values of winter wheat plantings only for 1957 to 1960; it is held constant for 1961 to 1971 at the mean value of plantings in the 1957-1960 period. Similarly, ACM consists of actual values of corn acreage for 1957 to 1960 and is held constant at the mean of 1957-1960 for 1961 to 1971. Holding corn and winter wheat plantings constant since 1961 is the method used to account for the change in the sorghum program which curtailed sorghum planting on acreage withdrawn from wheat and corn production under government programs. These variables assume a different competitive relationship after 1961 than existed in earlier years. Such a difference was supported by preliminary analyses based on two separate time periods -- 1949-60 and 1961-71.

Equations 1 and 2 contain ACT, acreage of cotton planted, and differ only by the inclusion of trend in equation 2. All the variables have the expected signs, and these equations explain 98 percent of the variation in sorghum acreage planted. The coefficient of the trend variable is not significant, possibly because of intercorrelation between DV and T (simple correlation, r, is .85). The inclusion of trend does affect the values of the coefficients of other variables; namely, it decreases slightly the coefficients of PF, PSS, ACT, and DV while it increases the coefficients of DP and AWWM. Figure 5 illustrates the performance of equation 2.

Equations 3 and 4 are similar to equations 1 and 2 except that acreage of corn planted, ACM, has been included instead of acreage of cotton planted, ACT. ACM is a decidedly weaker variable than ACT. Furthermore, its inclusion, together with the exclusion of ACT, destroys the statistical

Figure 5. U. S. Sorghum Acreage Planted, Actual and Estimated, 1957-1971.



significance of PF, greatly raises the size and significance of the coefficient of DP, and lowers the size and significance of PSS. The effect of including trend in equation 4 is similar to that in equation 2.

Equations 5 and 6 contain both ACM and ACT, with trend included in equation 6. Here again the importance of ACT and the insignificance of ACM are noticeable. The coefficients of the corn variable in these two equations are not significantly different from zero.

In equations 7 and 8 the lagged market price of sorghum, PT-1, is added and ACM is excluded. Lagged market price is not a significant variable.

Summary and Conclusions

The statistical results and their graphic representations indicate that the selected variables and the manner in which they are employed provide good estimates of U.S. sorghum acreage for 1957-71. The results are generally similar to the earlier ones obtained for corn.

The policy variables, PF and DP, contribute importantly to the explanation of changes in U.S. sorghum acreage planted. Increasing loan rates and/or loosening of planting restrictions, as measured by PF, are positively associated with changes in acreage planted while increases in diversion payment rates and/or in allowable acreage to be diverted for payment are associated with decreases in acreage planted.

Among the crops which compete for acreage with sorghum grains, changes in cotton acreage have the largest impact on acreage planted to sorghums. According to these estimates, a one-acre increase in acreage of cotton planted in the eight states was associated with a reduction in U.S. sorghum plantings of between 1.3 and 1.5 acres.

Wheat is the second major competitor of sorghums for production

resources in our model. Acreage planted to winter wheat varies only during the 1957-60 period; it is held constant between 1961-71. According to these estimates, a one-acre increase in area planted to winter wheat from 1957 to 1960 reduced planted sorghum acreage by about 1.0 to 1.3 acres.

Substitution between sorghums and soybeans was measured by PSS. As estimated, a ten-cent increase in the price support for soybeans decreases sorghum planting by about 750,000 acres.

Although competition between corn and sorghums from 1957 to 1960 had been postulated, no significant measure of this substitution was obtained to correspond with the significant negative relationship obtained in the corn studies covering 1949-1970. It is possible that the shorter time period employed for the sorghum analysis caused this apparent discrepancy. Prior to 1961, when there were no restrictions on sorghum acreage, corn allotments were imposed in 1950, 1954, 1955, 1956, 1957 and 1958. Only the last two of these years were included in the sorghum study whereas the corn study period encompassed all six allotment years. It was only when restrictions applied to corn but not to sorghum that large amounts of sorghum were planted on land formerly planted to corn.[6/]

To provide a partial test of the forecasting properties of our models, acreage planted to sorghums is estimated for 1972 for all the equations in Table 2. These estimates are presented in Table 4. To obtain these values,

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[6/] This argument is supported by the fact that in preliminary analyses for sorghum, based on the 1949-71 period, the coefficient of ACM was negative and significantly different from zero.

Table 4. Actual and Estimated Acreage Planted to Sorghum in the United States, 1972.

	Acreage planted (million acres)
March intentions report	18.4
Actual plantings	17.4
Equations:	
1.	18.8
2.	18.0
3.	17.7
4.	17.6
5.	18.8
6.	18.5
7.	18.6
8.	17.1

PF and DP for 1972 were calculated to be 1.52 and 0.442, respectively, and appropriate data were entered for the other variables.

There appears to be considerable variation in the predicted values of planted sorghum acreage among the equations. As a set, equations 2, 3, 4 and 8 would appear to be most accurate. However, because of the undesirable features of equations 3 and 4 discussed earlier, one may not want to place great reliance on these equations, even though the forecasts for 1972 appear to be quite reasonable. More experience with using these equations to forecast planted sorghum acreage will be required to test their respective validity as forecasting tools. As of now, they appear promising.

The model presented should prove useful to those concerned with obtaining preliminary estimates of the relative impact on sorghum acreage of different levels of the policy variables as well as different assumptions about either the price support level or acreage of competing crops. Since there appears to have been a rather stable relationship between planted and harvested acres of sorghum during the 1957-71 period (Figure 2), the model could also be employed to estimate harvested acreage.

APPENDIX A

The Data Series

Crop Year	A	PF	DP	AD	PT-1	PSS	AWWM	ACM	ACT	DV	T
1957	26,886	1.86	0.0	0	2.05	2.09	22,291	12,962	8,136	0	9
1958	20,675	1.83	0.0	0	1.74	2.09	27,942	13,734	7,346	0	10
1959	19,508	1.52	0.0	0	1.78	1.85	28,161	15,762	8,945	0	11
1960	19,598	1.52	0.0	0	1.53	1.85	27,840	15,557	9,059	0	12
1961	14,294	1.35	0.309	6,101	1.49	2.30	26,559	14,504	9,225	0	13
1962	15,060	1.35	0.309	5,509	1.80	2.25	26,559	14,504	9,025	0	14
1963	17,516	1.40	0.180	4,651	1.82	2.25	26,559	14,504	8,150	0	15
1964	16,770	1.30	0.290	6,552	1.74	2.25	26,559	14,504	8,145	0	16
1965	17,079	1.30	0.290	6,994	1.88	2.25	26,559	14,504	7,702	0	17
1966	16,372	0.99	0.418	7,300	1.76	2.50	26,559	14,504	5,741	1	18
1967	19,007	1.29	0.265	4,131	1.82	2.50	26,559	14,504	5,357	1	19
1968	18,014	1.05	0.410	6,982	1.77	2.50	26,559	14,504	6,046	1	20
1969	17,457	1.05	0.409	7,522	1.70	2.25	26,559	14,504	6,857	1	21
1970	17,292	1.05	0.393	7,442	1.91	2.25	26,559	14,504	6,907	1	22
1971	20,714	1.73	0.259	4,145	2.05	2.25	26,559	14,504	6,978	1	23

A = sorghum acreage, planted, in thousands

PF = weighted support rate for sorghum, dollars per hundred weight

DP = weighted diversion payment rate for sorghum, dollars per hundred weight

AD = sorghum acreage diverted, in thousands

PT-1 = lagged market price for sorghum, dollars per hundred weight

PSS = soybean price support rate, dollars per bushel

AWWM = acreage of winter wheat planted, in thousands

ACM = acreage of corn planted, in thousands

ACT = acreage of cotton planted, in thousands

APPENDIX B

Calculations of the Policy Variable PF for Sorghums, 1957-1972

Formula: PF = r PA

where PA is the announced support rate for sorghums produced (the loan rate in most years) and r is a weighting or adjustment factor reflecting planting restrictions. If no planting restrictions are imposed, r equals 1.0; the tighter the restrictions the closer r will be to zero. Values for PA are announced each year. The values for r must be estimated from program provisions as announced. The procedure followed for this research is detailed below.[1]

Year	Loan rate[2]	PA[2]	Estimation of r	PF[2]
1957	1.86	1.86	Price support = loan only. No planting restriction, so r = 1.0 and PF =	1.86
1958	1.83	1.83	Price support = loan only. No planting restriction, so r = 1.0 and PF =	1.83
1959	1.52	1.52	Price support = loan only. No planting restriction, so r = 1.0 and PF =	1.52
1960	1.52	1.52	Price support = loan only. No planting restriction, so r = 1.0 and PF =	1.52
1961	1.93	1.93	Price support = loan only, if planting restricted. The restriction was based on an average of 1959-60 plantings and provided	

[1]Descriptions of program features are in Feed Situation, Economic Research Service, U.S. Department of Agriculture, various issues 1957-1972.

[2]Monetary values are in dollars per hundred weight.

Year	Loan rate	PA	Estimation of r	PF
			each participant a choice of the amount of land he wished to divert from sorghum production. The minimum he could divert was 20% of his base acreage, leaving 80% for sorghum planting. The maximum he could divert was 40% of his base, leaving 60% for sorghum planting. To account for the range from 60% to 80%, a simple average was taken to reflect the overall restrictiveness of the program.[3] So r = 1/2(0.6 + 0.8) = 0.7, hence,	
			(1.93)(0.7) =	1.35
1962	1.20	1.20	Same as 1961	1.35
1963	1.71	2.00	Total price support consisted of a loan rate of $1.71 and a direct payment of 29¢ for all sorghum grown in compliance with planting restrictions. Maximum and minimum diversion requirements were 40% and 20%, respectively, leaving 60% to 80% of base acreage for sorghum planting. So, r = 1/2(0.6 + 0.8) = 0.7, hence,	
			(1.71)(0.7) + (.29)(0.7), or (2.00)(0.7) =	1.40
1964	1.77	2.00	Total price support consisted of a loan rate of $1.77 and a direct payment of 23¢ for all sorghum grown in compliance with planting restrictions. Maximum and minimum diversion requirements were 50% and 20%, respectively, leaving 50% to 80% of base acreage for sorghum planting. So, r = 1/2(0.5 + 0.8) = 0.65, hence,	
			(1.77)(0.65) + (.23)(0.65) or (2.00)(0.65) =	1.30
1965	1.65	2.00	Total price support consisted of a loan rate of $1.65 and a direct payment of 35¢ for all sorghum grown in compliance with planting restrictions. Remaining provisions were the same as 1964, giving an r of 0.65, hence,	
			(1.65)(0.65) + (.35)(0.65) or (2.00)(0.65) =	1.30

[3]Special diversion provisions for small producers are not accounted for in these calculations for 1961-1970. The program also provided payments for land diversions; these are contained in the calculation of DP.

Year	Loan rate	PA	Estimation of r	PF
1966	1.52	1.52	Price support = loan only.[4] Remaining provisions were the same as 1964, giving an r of 0.65, hence	
			(1.52)(0.65) =	.99
1967	1.61	1.61	Price support = loan only. Only one level of diversion was specified -- 20% of base acreage, leaving 80% available for sorghum, so r = 0.8, hence,	
			(1.61)(0.8) =	1.29
1968	1.62	1.62	Price support = loan only, if planting restricted. The same range of diversion was allowed as for 1964, so r = 0.65, hence,	
			(1.62)(0.65) =	1.05
1969	1.61	1.61	Same as 1968	1.05
1970	1.61	1.61	Same as 1968	1.05
1971	1.73	1.73	Price support = loan only. No planting restriction, so r = 1.0 and PF =	1.73
1972	1.79	1.79	Price support = loan only. No planting restriction applied at the minimum level of participation, so r = 1.0. Two options were offered for the maximum level of participation. Under one option, called Plan A, still no restriction applied to sorghum planting. Under the second option, Plan B, higher payments were offered if sorghum acreage was reduced below 1971 plantings. At the maximum level of diversion, 1972 sorghum acreage must cut back 30% from 1971, so the estimate of r from Plan B is 0.7. Following the practice adopted for previous years of averaging the most restrictive and the	

[4] A change in program provisions limiting the support payment to a maximum of 50 percent of base acreage, and discontinuing a separate payment for minimum diversion, made the support payment function as a payment for minimum diversion. Therefore, beginning with 1966, support payments are included with diversion payments in the calculations of DP.

Year	Loan rate	PA	Estimation of r	PF
			least restrictive program provisions, r = 1/2(1.0 + 0.7) = 0.85 where 1.0 reflects participation at minimum level diversion and 0.7 reflects maximum diversion under Plan B, the more restrictive of the two plans. Hence, PF is	
			(1.79)(0.85) =	1.52

APPENDIX C

Calculations of the Policy Variable DP for Sorghums, 1957-1972

Formula: $DP = wPR$

where PR is the payment rate for diversion or set aside, essentially a land rental payment made by the government for withdrawal of land from sorghum production, and w is the proportion of acreage eligible for diversion or set aside payments. If all land is eligible for payment, w equals 1.0; the smaller the permitted diversion acreage, the closer w is to zero.

Year	PR[5]	Estimation of w	DP[5]
1957-1960	0	No government payment, so w = 0 and DP =	0
1961	.965 (1.158)	Two different payment rates applied. For the first 20% of base acreage diverted, the minimum requirement, the payment was \$0.965 per cwt on estimated production from that land. Thus, for minimum diversion, PR is .965 and w is assumed to be .2, the proportion of base acreage eligible for diversion. If these were the only program provisions, DP would be $(.965)(.2)$. But diversion of an additional 20% of base acreage was optional. For this additional diversion, the payment rate was \$1.158 per cwt on estimated production from the idled land. To calculate DP for maximum diversion of 40% of base acreage, the equation $DP = wPR$ must be disaggregated to account for the two different payment rates, i.e., $DP = w_1PR_1 + w_2PR_2$ where $w_1 = .2$ and $PR_1 = .965$, the appropriate values for the first 20% diverted, and	

[5]Monetary values are expressed in dollars per hundred weight (cwt).

Year	PR	Estimation of w	DP
		w_2 = .2 and PR_2 = 1.158, the values for the second 20% diverted. Thus, DP for maximum diversion is (.2)(.965) + (.2)(1.158). To account for both minimum and maximum diversion provisions, a simple average was taken to reflect the overall diversion payment provisions, thus 1/2[(.2 x .965) + (.2 x .965 + .2 x 1.158)] = .309 where (.2 x .965) represents minimum diversion provisions and (.2 x .965 + .2 x 1.158) represents maximum diversion provisions.	
1962	.965 (1.158)	Same as 1961	.309
1963	.40 (1.00)	Two different payment rates applied, as in 1961 and 1962, but the rates were changed. For the first 20% of base acreage diverted, the minimum requirement, the rate was 40¢ per cwt. The rate for an additional optional diversion of 20% was $1.00 per cwt. These values enter into the calculation of DP as follows: 1/2[(.2 x .40) + (.2 x .40 + .2 x 1.00)] =	.180
1964	.40 (1.00)	Although two payment rates were offered for 1964 diversion as in 1961, 1962, and 1963, a new payment scheme was adopted. In addition, the allowable maximum diversion was increased from 40% to 50% of base acreage. The lower rate, 40¢, was paid for minimum diversion of 20% of the base, so w = .2 and PR = .40. But if an additional 30% of the base was idled, $1.00 per cwt was paid for estimated production on all acreage diverted. Thus, for maximum diversion, w = .5 and PR = 1.00. Averaging minimum and maximum rates gives 1/2[(.2)(.40) + (.5)(1.00)] =	.290
1965	.40 (1.00)	Same as 1964	.290

Year	PR	Estimation of w	DP
1966	1.325 (1.025)	The payment for minimum diversion was \$1.325 per cwt on estimated production for 20% of base acreage. This was called the support payment in program language but it functions as a payment for minimum diversion. Hence DP for minimum diversion is (.2)(1.325). Payment for an additional 30 percent diversion was \$1.025. Using these values, DP for maximum diversion is (.2)(1.325) + (.3)(1.025), and averaging minimum and maximum values gives 1/2[(.2 x 1.325) + (.2 x 1.325 + .3 x 1.025)] =	.418
1967	1.325	Payments were offered only for minimum diversion, \$1.325 per cwt on 20 percent of base acreage. Hence, (.2)(1.325) =	.265
1968	1.325 (.968)	The payment for minimum diversion was \$1.325 on 20% of the base, yielding (.2)(1.325). An additional 30% of diversion was allowed, at a rate of 96.8¢. Hence DP for maximum diversion is (.2)(1.325) + (.3)(.968). And averaging the two, 1/2[(.2 x 1.325) + (.2 x 1.325 + .3 x .968)] =	.410
1969	1.325 (.963)	Same as 1968, except lower payment rate for additional diversion. So DP is 1/2[(.2 x 1.325) + (.2 x 1.325 + .3 x .963)] =	.409
1970	1.325 (.856)	Same as 1968, except lower payment rate for additional diversion. So, DP is 1/2[(.2 x 1.325) + (.2 x 1.325 + .3 x .856)] =	.393
1971	1.295	Payments were offered only for minimum diversion, \$1.295 per cwt on 20% of base acreage. Hence, (.2)(1.295) =	.259
1972	1.358 (.876)(1.36)	For minimum diversion of 25% of base acreage, the rate was \$1.358 per cwt. Yielding a DP of (.25)(1.358) = .339	

Year	PR	Estimation of w	DP
		Under Plan A, diversion of an additional 20% of base acreage was allowed at a rate of 87.6¢. Thus, DP for maximum diversion under Plan A is	
		(.25)(1.358) + (.20)(.876) = .514	
		Under Plan B, diversion of an additional 15% of base acreage was allowed at a rate of $1.358, the same rate as for the first 25% diversion. Thus, DP for maximum diversion under Plan B is	
		(.25)(1.358) + (.15)(1.358) or (.40)(1.358) = .543	
		And following the practice adopted for earlier years of averaging minimum and maximum diversion provisions, DP for the entire program is	
		1/2[(.25)(1.358) + (.40)(1.358)] =	.442
		where (.25)(1.358) reflects minimum diversion provisions and (.40)(1.358) reflects maximum diversion provisions under Plan B. Plan B maximum provisions are employed instead of Plan A provisions because the calculated value of DP is greater under Plan B (.543) than under Plan A (.514), indicating more incentive to divert land.	