ACREAGE DIVERSION RESPONSE UNDER THE 1961-70 FEED GRAIN PROGRAM

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INTRODUCTION

Following the depression of the early 1930's the federal government provided legislation and administrative initiative, along with treasury outlays, for various agricultural commodity programs. These programs retained the same general format through 1970. Virtually all of these programs were responses to the symptoms of problems faced by the agricultural industry.

Aside from war periods and years immediately following them, agricultural productivty in the United States grew more rapidly than domestic and export demands. Hence, in the absence of offsetting government policies, these conditions stood to depress farm commodity prices and reduce net farm income. As a means of maintaining farm prices and income, the public used a set of policy means including direct payments for idling land and restraining production, nonrecourse loans, and price supports at various levels, commodity storage to lessen market supplies, and publicly assisted exports.

Following crop shortfalls in Russia and other major world regions in 1972 and later years, export demand for U.S. grains increased greatly. Farm commodity prices and net farm income also increased sharply under these conditions. While farm prices and incomes have now receded somewhat, programs of the type used prior to 1973 have not generally been in effect since 1972. The 1973 Agricultural and Stabilization Act does, however, provide a framework for supply controls (acreage set asides), direct payments, and price supports (commodity loans) at various levels depending on price levels and other conditions.

Some agricultural leaders propose that export demand will remain so high in the future that the United States will never need to implement these programs. Others propose that while export demand will continue to grow with world population and income, U.S. agricultural supply capacity is so large that farm price and income may fluctuate greatly in the immediate years ahead. Because of large domestic supply capacity, U.S. farm prices and incomes may tend to be depressed during years of normal world grain production and carryovers but increase sharply under modest world shortfalls in grain production. While farm prices would be volatile under these conditions, the duration of depressed or premium incomes would depend on the sequence of high or low crop yields.

Whether farm programs of historic types might be acceptable or needed in U.S. agriculture will depend on future supply and demand conditions which cannot be predicted with great certainty at the present. However, in case production restraints might be needed by or be acceptable to farmers in the future, analysis of response of farmers to farm programs in the past is of interest. This study evaluates the set of programs initiated in 1961 and carried into the 1970's in terms of farmers' response to their provisions and the effectiveness of these programs in attaining their goals.[1]

This study uses statistical models for relating various programs, economic and other variables to acreage diversion under the 1961-70 Feed

[1]The several legislative acts for feed grains are referred to as "Feed Grain Program" or "programs" throughout this study.

Grain Program. Alternative levels of data aggregation and models were examined for their precision in predicting diverted acres under the Feed Grain Program. Time series and mixed data[2] for both the 48 states, Iowa and Iowa counties were analyzed for the 1961-60 period.

OBJECTIVES

The overall purpose of this study is to relate quantitatively farmer response in acreage diverted from crops, thus generating supply control participation, to various conditions and variables surrounding these programs. With this knowledge, future programs, if needed, could be organized with better prediction of their outcomes in terms of various program effects such as number of farmers expected to participate, extent of supply control attained, treasury costs and other related phenomena. However, to attain this overall goal, it was necessary to pursue several intermediate objectives or tasks. First, a theoretical framework needed to be established in order that relevant variables and influencing conditions could be related to those of the 1961-70 Feed Grain Program. From this theoretical analysis, it

[2]Mixed data are a cross section observed at uniformly spaced points in time (2, p. 107).

was demonstrated that various levels of strategic program variables cause farmers to participate in land retirement at various levels. These variables, along with other economic variables and farm and operator characteristics, logically influence acreage diversion.

The second task of the study was to assemble data for explaining acreages diverted for 1961-70 period. Time series, cross section and mixed data were assembled to reflect program policy variables, along with various other economic and classification or weighting variables and acreage diversion.

The third objective was to fit alternative multiple regression models to the data. Not only were alternative explanatory variables used in predicting diverted acres, but also models were fitted to alternative levels of data aggregation. This step was used to evaluate how well alternative variables explain annual acreage diversion.

A final intermediate objective or task was to compare the predictive ability of the alternative models examined. More specifically, we were interested not only in which variables explain a high percentage of acres diverted, but, also whether it is necessary to analyze county level data for obtaining efficient estimates of acreage diversion.

FEED GRAIN PROGRAM, 1930-60

Government programs for feed grain producers from the early 1930's through the 1960's had great similarity of provisions and administrative procedures. Other than terminology and emphasis on alternative means to achieve similar objectives, there were few fundamental differences in these

programs. Hence, it is likely that programs of the future also might have great similarities.

With passage of the Agricultural Adjustment Act of 1933, and the establishment of the Commodity Credit Corporation (CCC), the essential features of the Feed Grain Program were established over 40 years ago. These features included direct payments for voluntary annual acreage retirement and price supports based on nonrecourse loans and storage programs. A national corn allotment was determined and distributed proportionately to producers based primarily upon historical acreage and good conservation practices. A 1936 Supreme Court decision invalidated the production control scheme of the 1933 Act for corn and other commodities due to the illegality of a processing tax used to finance production control. In the same year, however, other legislation for farm income maintenance by production control, loans and storage was enacted. The Soil Conservation and Domestic Allotment Act of 1936 provided for voluntary shifting of acreage from soil depleting crops such as corn. Aside from drought in 1936, surpluses of basic commodities continued to grow because of insufficient acreage diversion and crop reduction.

Congress responded by passing the Agricultural Adjustment Act of 1938, providing for voluntary acreage allotments and direct parity payments for corn producers. The basic price support and acreage allotment provisions for corn under this Act continued for 20 years. Additional legislation during that period altered the percent of parity at which the price support levels were set. By the end of the 1955 marketing year, feed grain stocks were 1,060 million bushels. Price supports for corn were at 90 percent of parity from 1944 through 1954 and at 87 percent in 1955. High price supports and favorable yields encouraged production well beyond normal marketings and utilization despite the return to acreage allotments in 1954. Hence, the Acreage Reserve and Soil Bank legislation of 1956 provided for voluntary annual acreage retirement encouraged by direct payments. In addition, the Conservation Reserve of the Soil Bank Act provided for land retirement contracts of three to ten years for annual per acre payment. The Acreage Reserve expired after the 1958 season and likewise the Conservation Reserve in 1960 with very modest success. A relatively small amount of highly productive feed grain producing acreage was retired under the "Soil Bank" program (3, p. 50). Acreage allotments for corn were suspended by a corn farmers' referendum in November of 1958. However, price supports for corn were retained at a minimum of 65 percent of parity. By the end of the 1960 marketing year, feed grain stocks under loan or owned by the CCC reached the very high level of 2,696 million bushels.[3]

FEED GRAIN PROGRAM, 1961-70

In 1961, as in 1931 and in 1956, pressure arose for additional measures to halt the increase in feed grain stocks and treasury costs, while maintaining the incomes of feed grain and livestock producers. Beginning in March of 1961, a series of legislative acts established provisions to achieve a reduction in feed grain stocks. These provisions characterize the Feed Grain Program of the 1961-70 period. Although termed "emergency", the basic provisions of this program set the pattern for feed grain legislation for ten years. However, within these pro-

[3]This amount includes corn, grain sorghum, oats, barley and rye.

visions, changes were made in (a) loan rates, (b) direct payments per bushel, (c) acreage payments for land diverted from crops, (d) percentage of production eligible for loans and direct payments, (e) minimum and maximum acreage to be diverted for program eligibility, (f) yield used for making payments, (g) feed grains in the programs and (h) percentage of acreage eligible for direct payments. (See Table 1). The magnitude of the program variables in relation to market prices for grains and livestock generally determined the number and location of farmers and land where participation in land retirement and supply control were profitable.

Under the Emergency Program each farm was assigned a feed grain base by the county Agricultural Conservation and Stabilization Committee. The feed grain base consisted of the 1959-60 average acreage in feed grain production (corn and grain sorghum). Each farm was assigned a normal crop yield based on the 1959-60 average for the county and farm and the productivity index for the farm.[4] Normal yield, total county price support and diversion payment rate factors were multiplied together to determine a direct payment per acre.

To participate, a farmer had to divert a minimum proportion of the base to a conserving use (e.g., fallow or cover seeding). For 1961, a direct payment per acre was received for each acre diverted up to 40 percent of the base. Small farms (feed grain base equal to or less than 25 acres) and those who assumed a base of 25 acres were allowed to divert the entire base from production, with direct payments on all base acreage.

[4]Productivity ratings equaled the ratio of the farm's average yield to the county average yield and was multiplied times county average yield for the preceeding year to get the farm normal yield for the current year.

Table 1. Summary of Feed Grain Program provisions 1961-70[a]

Item	1961-62	1963	1964-65	1966	1967	1968-69	1970
1. Price support, corn ($/bu.)			1964 / 1965				
a. loan	1.20	1.07	1.10 / 1.05	1.00	1.05	1.05	1.05
b. payment	--	.18	.15 / .20	.30	.30	.30	.30
c. Total	1.20	1.25	1.25 / 1.25	1.30	1.35	1.35	1.35
2. Maximum production on base acreage eligible for:							
a. price support loan	Normal production	Total production	TP	TP	TP	TP	TP
b. price support payment	--	Normal production	NP	Proj. prod. (PP) of min. (planted ac., 50% of base)			
3. Base acreage to be diverted:							
a. minimum (to participate)	20%	20%	20%	20%	20%	20%	20%
b. maximum (for payment)	40%	40%	50%	50%	--	50%	50%
4. Payment per acre for percent of base acreage diverted:	Total price support rate (TPSR) times (x)	TPSR x	TPSR x	TPSR x	--	TPSR x	TPSR x
a. 20	50% of NP	20% of NP	20% of NP	None	None	None	None
b. 21-40	60% of NP	50% of NP	50% of NP	50% of PP	None	45% of PP	40% of PP
c. 41-50	--	--	50% of NP	50% of PP	None	45% of PP	40% of PP
5. Yield used for payment calculations (normal yield or projected yield)	1959-60 averages (ave.)	1959-60 averages (ave.)	1958-62 ave. for 1964: 1959-63 ave. for 1965	1960-64 ave. adj. for trend	1961-65 ave. adj. for trend	1962-66 for 1968: 1963-67 for 1969 ave. adj. for trend	1964-68 ave for trend:
6. Payment options for small producers for percent of base acreage diverted:	TPSR x	TPSR x	TPSR x	TPSR x	TPSR x	TPSR x	TPSR x
a. 20	50% of NP	50% of NP	50% of NP	20% of PP	20% of PP	20% of PP	20% of PP
b. 20-40	60% of NP	50% of NP	50% of NP	50% of PP	50% of PP	45% of PP	40% of PP
c. over 40	50% of NP	50% of NP	50% of NP	50% of PP	50% of PP	45% of PP	40% of PP
7. Feed grains in the Program	Corn, grain sorghum, 1961, & barley 1962	Corn, grain sorghum & barley	Corn, grain sorghum & barley	Corn, grain sorghum & barley	Corn, grain sorghum	Corn, grain sorghum & barley ('69 only)	Corn, grain sorghum & barley
8. Legislation in force	Emergency Feed Grain Program Act if Agr. Act of 1962	Food & Agr. Act of 1962	The Feed Grain Act of 1963	Feed Grain Act of 1965	Feed Grain Act of 1965	Feed Grain Act of 1965	Feed Grain Act of 1955 extended

[a]See appendix A for additional information on provisions.

Sources: (27, 28, 29, 50, 52).

Participants in the Feed Grain Program were permitted to plant an acreage of feed grains covered under the program equal to: feed grain base minus acres diverted for payment. However, as participants, the normal production (normal yield x permitted acres) or normal yield of acres actually planted to feed grains were eligible for a price support loan. Other feed production (barley, oats and rye) were eligible for price support loans if the farmer participated or even if he did not participate but had no corn or grain sorghum base. A further requirement for participation was maintenance of a normal conserving base acreage, in addition to the diverted acres, in a conserving use. The conserving base was determined from the 1959-60 average acreage of hay and rotation pasture.

Modifications to the 1961 Act

Legislation passed in 1961 for the 1962 crop year provided a program very similar to that of 1961. A Barley Program was added, with the barley base separate from the corn and grain sorghum base. A farmer could participate in the Barley Program and not the Feed Grain (corn and grain sorghum) Program. A special provision allowed the farmer to prove his actual 1959-60 yield was higher than the assigned normal yield. In 1963 a price support payment feature (nationally uniform) was defined as an amount above the basic loan rate. The price support payment was a payment per bushel on normal production of feed grain from the permitted base acres. Producers were entitled to the price support payment upon meeting the minimum diversion requirement for participation. Also, beginning in 1963, the price support loan was available for the total production of feed grain from the eligible acres, rather than just the normal production. In 1963 and subsequent years, barley base was added to the corn and grain sorghum base for a composite feed grain base.

The Feed Grain Act of 1965 extended the Feed Grain Program through the 1970 crop season with a few minor changes. Projected yield, a more explicit adjustment for trend, was substituted for normal yield. Further, price support payment was available for the minimum of planted acres or 50 percent of the feed grain base, as opposed to the normal production of feed grain from permitted acres for 1961 through 1965. Price support loan and payment as well as diversion payment rates were altered in various years at the discretion of the Secretary of Agriculture within the limitations of the legislation.

Program Performance, 1961-70

Experience with annual voluntary acreage retirement programs leading up to the 1960's provided evidence that more effective control measures were needed. Greater use of capital inputs in farm production were substituted for land. Hence, supply or output control could not be accomplished by a modest, part-farm land retirement program (3, p. 6). Although similar to the Acreage Reserve of the Soil Bank and previous acreage retirement programs, the Feed Grain Program of the 1960's was designed to encourage levels of participation and acreage diversion higher than had prevailed under previous programs. Tables 2 and 3 provide an aggregate summary of performance under the Feed Grain Program from 1961 through 1970. The 1961 diversion was 25.2 million acres, compared to 6.7 million acres

Table 2. Feed Grain Program participation and payments, 48 states: 1961–70[a]

Crop year	Participating farms (000)	Base on all farms	Base on participating farms	Diversion of participating farms	Direct payment: Diversion	Direct payment: Price support	Direct payment: Total
		(million acres)			(million dollars)		
1961	1,147	107.9	63.6	25.2	782.0	0	782.0
1962	1,250	123.3	68.1	28.2	843.0	0	843.0
1963	1,195	132.4	72.6	24.5	462.0	382.0	844.0
1964	1,243	132.5	73.5	32.4	886.0	282.0	1,168.0
1965	1,424	132.7	83.2	34.8	951.0	431.0	1,382.0
1966	1,404	133.2	79.0	34.7	710.0	586.0	1,296.0
1967	1,308	114.9	66.3	20.3	324.7	542.4	867.1
1968	1,427	115.1	72.1	32.4	740.5	628.3	1,368.8
1969	1,588	133.1	88.5	39.1	916.6	727.9	1,644.5
1970	1,538	132.9	87.3	37.4	770.8	738.9	1,509.7

[a] Sources: (32, 47).

Table 3. Production, use and carry over of feed grains, 48 states: 1960-70[a]

Marketing year beginning[b]	Acres harvested	Yield per acre	Production	Domestic use	Exports	Gov't stocks[c]	Free stocks	Total	Gov't stocks as a percent of total
	(million)	(tons)			(million tons)				(percent)
1960	127.5	1.22	155.5	133.4	12.3	74.7	10.3	85.0	87.9
1961	105.3	1.33	139.8	134.6	17.6	62.5	9.7	72.2	86.6
1962	101.9	1.35	141.7	133.2	16.6	55.8	8.6	64.4	86.6
1963	105.1	1.46	153.8	130.7	18.9	56.6	12.7	69.3	81.7
1964	97.1	1.38	134.2	126.3	21.9	43.7	11.1	54.8	79.7
1965	96.1	1.64	158.0	141.9	29.1	24.4	17.7	42.1	58.0
1966	97.9	1.62	159.0	142.3	21.9	18.3	18.8	37.1	49.3
1967	101.0	1.77	178.9	144.7	23.0	29.5	18.8	48.3	61.1
1968	97.3	1.75	170.5	151.5	18.4	33.6	16.4	50.2	66.9
1969	95.5	1.86	177.4	158.8	21.7	27.8	20.6	48.4	57.4
1970	99.3	1.61	160.1	154.7	20.2	19.1	13.9	33.0	57.9

[a] Feed grains include corn, grain sorghum, barley and oats. Source: (52) and (56).

[b] Corn, grain sorghum October-September, oats and barley July-June.

[c] Government stocks are those under loan and owned by the CCC.

of corn allotment under the Acreage Reserve in 1958.[5] Payment variables of the Feed Grain Program were changed as needed to encourage planted acreage and production in line with expected utilization and desired stock carry over. Diversion was highest at 37.4 million feed grain acres in 1970 and reached a low in 1967 at 20.3 million acres when only the price support and loan benefits were available for most farms. The 1967 reduction grew out of relaxed program elements following the 1965-66 Asian drought which caused the appearance of a discrete "world food demand increase."

Government stocks (Table 3) were reduced in most years over the period 1961-70. Much of the reduction in stocks was attributable to increased exports. However, production control by acreage diversion both prevented substantial new additions to the yearly carry over and maintained and stabilized feed grain prices. The price support loan and price support payment became separate benefits in 1963, allowing the loan to be set nearer market price. This feature, by stabilizing domestic prices at a lower level, helped reduce the amount of production going under loan at given levels of total price support. With part of the price support paid through a direct payment livestock producers were encouraged to participate. Further, the price support payment allowed benefits to be geared to an income standard, rather than a price standard with its less effective payment limitations (8).

While the Feed Grain Program was popular and successful, as an overall

[5] Land was also retired under the Conservation Reserve of the Soil Bank from 1956-60. In 1960, 3.1 percent of the Corn Belt cropland was in the Conservation Reserve compared to 23.4 under the 1961 Feed Grain Program (20 , p. 45).

supply restraint policy, it had several faults of previous programs. Slippage remained a problem.[6] To illustrate, compare diversion in Table 2 to production in Table 3. Farmers often diverted the least productive acres (6), realized higher yields each year on planted acres, while non-participants could increase their cropland acres. Slippage contributes to the cost of the program and rising costs had become a leading limitation of it.

A breakdown of direct payments under the Feed Grain Program are given in Table 2. Treasury outlays for this purpose ranged from $782 million in 1961 to more than $1.6 billion in 1969. Brandow (1) estimated the net Feed Grain Program cost for 1967 to be $1.4 billion. This amount included, in addition to the direct payments in Table 2, CCC losses on stocks, costs associated with stock ownership plus credits for value of contributions to CCC donations and P.L. 480 programs. Brandow further adjusted the feed grain cost to $1.5 billion adding an estimated share of the long-term land retirement program costs.[7] In 1967, the direct payments were reduced because of a sharp decrease in requested and actual acreage diversion. However, program planners apparently overestimated feed grain demand and increased stock accumulation and CCC costs resulted, although lower direct payments were required. Hence, the $1.5 billion appears to be a typical total Feed Grain Program cost for the late 1960's.

Concern developed in the late 1960's over payment limitations (18, p. 103, 60), the early format allowing per-farmer payments of any magnitude

[6] Slippage is the result of the proportional decrease in production being less than proportional decrease in acreage planted due to diversion.

[7] Long-term retirement programs in force in 1967 were the Conservation Reserve, Cropland Adjustment and Cropland Conversion Programs.

consistent with program participation. A payment limitation of $20,000 per farm for all programs would affect many more wheat and cotton producers than feed grain producers (60, p. 11). Wilcox (59, p. 71) estimated that for 1968 a $5,000 limitation on payments per farmer would have reduced feed grain acreage diversion by only seven percent.

Despite the upsurge in foreign demand and elimination of surplus stocks and acreage diversion programs in 1972-73, 1973 legislative discussions seemed to favor continuing a feed grain program with provisions somewhat similar to those of the 1960's. Hence, the analysis which follows is designed, from historical experience, to measure the quantitative effects of variables in the Feed Grain Program as they affected farmer participation, amount of acreage and production involved and other goals of an acreage-based supply control program.

HYPOTHESES FOR VARIABLES INFLUENCING ACREAGE DIVERSION

The theoretical basis for this study is the profit maximizing behavior of the farm decision maker.[8] Decisions about participation in the Feed Grain Program involved the level of production for feed grains and other related enterprises. Information is needed on the price of product to be controlled in supply, its variable costs of production, the yield both for feed grain and for alternative crops, one of which is diverted acres. Expectations must be formulated for yields and product prices since they are uncertain for the farmer. Variable costs are held with relative certainty compared to feed grain prices and yields. Provisions of the Feed Grain Program for a farm were known with certainty. Normal or projected yield, feed grain and conser-

[8] For an extended discussion of theoretical considerations see Harrison (9, pp. 48-66).

vation bases were assigned by the local ASCS committee and hence were known. The provisions for price support loan rate, price support payment, diversion payment rates, maximum amount of base that may be diverted for payment and other features were announced annually before the farmer made the program decision and are certain in this time framework.

Feed Grain Program decisions, like other decisions on choice or size of farm enterprises, also were believed to be influenced by considerations other than the basic economic data and expectations already mentioned.

Several characteristics of the farm and attributes and opinions of the operator also may be important in the farmer's decision on whether or not to participate in a program. Some of these are of a nonpecuniary nature, e.g., operator age and opinion on government programs. Other considerations such as capital position, tenure arrangement and off-farm employment opportunities directly influenced the optimum farm organization as it relates to participation in an acreage diversion program. Table 4 summarizes variables which are expected to affect (a) the number of farmers participating in a decision opportunity of the nature of the Feed Grain Program, and (b) the number of acres and the extent of participation in which they might engage. Since the Feed Grain Program generally provided a minimum level necessary for participation level, farmers participating could do so at different levels.

The variables listed in Table 4 include those which relate directly to the profitability of participating in the program relative to alternative use of land and other resources, those which are characteristics of farms and those representing attributes of farmers. The direction of expected influence for each of these variables or conditions also is summarized in Table 4. Where data are available on an appropriate level of aggregation,

Table 4. Summary of hypotheses or expected variables and factors influencing acreage diversion under the Feed Grain Program: 1961-70

Variable	Direction of expected influence	Level of data aggregation available for a hypothesis test (county and state)
Direct profitability variables		
Diversion payment rate	Positive	County and state
Price support payment	Positive	County and state
Ratio of price support loan to the expected market price (or loan minus expected price)	Positive	County and state
Ratio of normal yield to expected yield	Positive	County
Variable cost per unit of feed grain production	Positive	Data for a direct test unavailable
Size of farm	Negative	Data unavailable
Ratio of feed grain base to cropland	Positive	County and state
Profit from soybeans relative to profit from corn, per acre	Positive	County and state
Off-farm work	Positive	County
Livestock production per acre of cropland (or livestock prices)	Negative	County and state
Cash grain farming	Positive	County
Crop-share tenant	Positive	County

(continued on next page)

Table 4 (continued)

Variable	Direction of expected influence	Level of data aggregation available for a hypothesis test (county and state)
Farm characteristics		
Variance of cropland productivity	Positive	Data unavailable
Ratio of farm labor demand to supply	Negative	County
Capital position (or debt ratio)	Negative	Data unavailable
Storage facilities	Negative	Data unavailable
Field size	Negative	Data unavailable
Farmer characteristics		
Operator age	Positive	County
Operator education	Positive	County
Off-farm residence	Positive	County
"Favorable attitude" toward programs	Positive	County

these variables and influences then are tested in the regression models which follow. (Some of the variables were considered only in an analysis of the primary data obtained from the 1962 Feed Grain Program survey data carried out in Harrison (9) but not reported in this paper). However, before the models are discussed and presented, we review the logic underlying the suggestion that the variables relate to decisions to participate in a Feed Grain Program and to the amount of land to allocate to this use.

Variables Directly Affecting Profit

Diversion payment rates are expected to positively influence diversion. The higher the direct price support payment per unit of production and the proportion of planted acres the payment covers the more profitable is minimum diversion. The level of the minimum diversion payment and price support payments are expected to have a joint positive influence on participation. The price support loan rate also is expected to positively influence participation as it increases relative to the expected market price for the commodity.

Conversely, as the expected market price increases relative to the loan rate, it is less likely that farmers will participate. However, this measurement can be difficult since the expected market price is not known with certainty. A similar problem prevails for the expected yield. The higher the expected yield relative to normal yield, the less profitable should be farmer participation in acreage diversion.

Variable costs per unit of production are expected to be positively related to diversion. A producer with high unit production costs sacrifices less net returns from crop production if he shifts land to acreage diversion with low costs. Further, due to economies of size, it can be hypothesized that the larger the feed grain acreage per farm the lower the production cost per acre. As the assigned feed grain base approaches the desired feed grain acreage, the profitability of participation should increase since a farmer was required to restrict feed grain production to his eligible base acres.

Additional Factors Influencing Profit

Numerous other factors, other than those discussed above and which directly affect profit, are expected to influence participation and level of acreage diversion. Not all of the hypothesized relationships reviewed here can be tested empirically because of the lack of data.

Profitability of crops competing with feed grains is expected to have an effect on participation in a Feed Grain Program. Soybeans serve as such a competitor in the Corn Belt. It is hypothesized that as the expected profitability of soybeans improves relative to corn, farmer participation in a Feed Grain Program which reduces acreage for production is less likely.[9] However, given provisions of the Feed Grain Program, it is possible that the relative soybean profitability also could have a positive influence upon the amount of acres diverted from corn. Participation in the program excludes feed grain production on other than eligible base acres. When soybeans have a favorable net return, a farmer with additional cropland which is not in the feed grain or the conserving base may be encouraged to participate in the program, since he can plant "extra" cropland to soybeans while corn is prohibited.

An alternative use of resources that may influence participation and the level of diversion is off-farm work. Where opportunities for off-farm work prevail, it is expected that the influence should be positive. Part-time farmers have an affinity for participation because of the conveniences

[9] Expected net returns for soybeans, like corn, is influenced by expected yield, expected market price, price support loan and variable costs of production.

of farm income through "idle" acres.

Provisions of the Feed Grain Program had implications which differ among operators with different types of farms. Farms using a large portion of their feed grain production for livestock were less likely to participate. There are two related reasons: (1) When grain production from the farm is used for livestock, the loan provision may not be of interest, (2) Reduction in grain production is not convenient when the farm has a feed grain deficit and must buy additional quantities. (The first reason became less important with the initiation and implementation of direct price support payments). In general, profitability of livestock production is expected to negatively affect participation and the amount of land diverted from feed grains. Hence, within limits of short-run flexibility in livestock enterprises, increased livestock prices are expected to induce additional feed grain production for on-farm use and to discourage participation. Cash-grain type farms are expected to be inclined towards participation. The price support loan is more convenient and of greater economic importance for cash-grain farms than for livestock farms.

Farm Characteristics Related to Participation

Crop-share tenants are hypothesized to favor program participation. Acreage diversion reduces variable costs and the tenant pays a larger proportion of variable costs than he does of total cost. Of course, the net advantage of participation to the tenant depends on the proportions in which the direct program payments are shared with the landlord.

Farmers with small bases (especially 25 acres or less) are more likely to participate and divert additional acreage than those with larger bases. This hypothesis stems primarily from the small farm option in the program provisions and the additional convenience of diversion on the small farm;

e.g., retiring an entire field rather than a proportion of it. The small farm option provided direct payments for minimum diversion which were at a higher rate than for larger farms not eligible for this option. Additional diversion, beyond the minimum acreage, under the small farmer option also was encouraged because in all years direct payments were available for diversion of up to 100 percent of the base.

Five characteristics of farms which may directly affect profits of crop production and availability of resources for diversion include productivity of cropland, labor supply, capital position, storage facilities and field size. Farmers are likely to divert base acreage that is least productive since program diversion payments are the same regardless of which acres of the total cropland acreage base are diverted. Where land eligible for diversion has inherent productivity below the average for the farm, both participation and a higher level of diversion is likely. Relative shortages of labor and capital also should encourage participation. Farms with heavy peak season labor needs on feed grain crops are expected to favor participation. Shortages of capital or a high debt equity ratio and the desire to avoid income uncertainty also is expected to be a positive inducement.

Returns from conventional crops are subject to the normal uncertainties of prices and yields, as opposed to the certainty of direct payments from participation. In addition, advanced program payments were believed to encourage participation, especially where production capital and expenses were problems for farmers. Shortage of on-farm storage facilities should have discouraged participation. Farmers with inadequate storage may choose to market at harvest, rather than invest in more storage to take advantage

of price support loans. If off-farm storage was used, the farmer had to bear the full direct cost of storage, as compared with the farmer who had on-farm storage available for which fixed costs need not be covered in a given year. "Field size" and crop rotation plans were expected to be associated with participation and amount of diversion for the following reasons. Small farms generally have field sizes that are relatively more costly to cultivate than do larger farms. However, larger farms also may have small or odd-sized fields that are convenient to divert at minimum levels. In addition, fields larger than the minimum diversion acreage may be diverted because the fields are inconvenient to cultivate and keep in rotation.

Operator Characteristics Influencing Program Decisions

Characteristics of farmers expected to affect participation are age, education, location and program attitudes. Increased age or retirement status was expected to be conducive to participation (6, 21). Operators advanced in age could divert acres from production, reduce labor used and remain in active farm operation. Harms (8) has shown that level of education had a positive association with the use of cost-and-return analysis for deciding on participation. Slaughter (21) shows, in effect, a positive association between participation profits and farmer education. Further, off-farm residence is expected to encourage participation since land diversion provides a return more convenient for the travel and costs required for farm operation. Finally, it is expected that farmers who have participated in previous government programs may have favorable attitudes toward government activities such as the Feed Grain Program and thus are more likely to participate. Farmers who once participated in government programs are likely to continue participation, although Vermeer (58) pointed out that it was difficult to determine if this inclination was an attitude mainly of operators for whom programs tend to be profitable.

The above factors affecting participation are not necessarily considered of equal importance, although the order of importance may parallel the order of presentation above. Further, several of the factors mentioned are not mutually exclusive. For example, intensity of livestock production has a close negative relationship with prevalence of cash-grain farms. Thus, in an explanatory model, one variable might serve in lieu of the other. Several of the hypotheses suggested above are tested in one phase of this study. Others are not subjected to testing because appropriate data are not available to link them with observations of program participation at levels of measurement or aggregation which were available for the latter.

METHODOLOGY

Multivariate statistical models are employed in this study to test hypotheses. The multiple regression models used in this study are expected to better quantify the nature and extent of influence of the numerous variables on allocation of land to supply control measures represented in the Feed Grain Program than related other prior studies (15, 16, 19, 21).

Cross Section and Time Series Models

All of the statistical models considered are based on either time series or a combination of time series and cross section data with the latter identified as a mixed model (2, p. 11). This nomenclature for the models arises from the characteristics of the sample of data being analyzed and the conceptualization of the model describing the data.

Both cross section and time series models can be written as

$$Y_i = B_o + \Sigma_j B_j X_{ij} + u_i \quad (i = 1,2,\ldots,n;\ j = 1,2,\ldots,k). \tag{1}$$

However, the interpretation is different in each case. For the cross section data, the n observations in the sample are taken from different members of a population at a given point in time. Inferences from the model fitted to the cross section data extend to the population from which the sample was taken only for that period in time. Time series data are n observations on a single unit, at equispaced points in time. Thus, parameters B_j, for the time series model are assumed to be constant from period to period, but inferences extend only to a single entity (e.g., individual, firm or geographical or political entity, from which observations were taken). The environment in which the observed entity is residing or functioning is assumed to remain constant for the duration of the sample periods.

<u>Mixed model</u> refers to a combination of the two pure-models and may be expressed as

$$Y_{it} = B_o + \Sigma_j B_j X_{ijt} + u_{it}$$

$$(i = 1,2,\ldots,m;\ j = 1,2,\ldots,k;\ \text{and}\ t = 1,2,\ldots,n).$$

Sample data span m observational units in each of n years. Interpretations for the cross section and time series models are jointly applicable. In short, the population parameters B_j are assumed to apply across all of the common set of observational units in each of the periods included in the sample.

Furthermore, each observational unit in each period in the sample is assumed to provide an independent observation. Total degrees of freedom are equal to mn. When pooling of cross section samples is appropriate, substantial gains in degrees of freedom and information are possible. There is a chance that the observations at each point in time are merely repeats (sub-samples on a single observation) or that the observations are close together in the independent variable space (4, p. 63). However, independence of the observational units in the cross section is not an explicit assumption of least squares regression.

Model Specification and Classification Variables

Theoretical considerations, intuition concerning variables logically having an influence on participation and findings of previous studies served as a guide for model specification in this study. Limited use was made of simple correlation coefficients for preliminary investigations of high independent variable covariances. Search techniques are employed for the purpose of selecting the subset of variables that "best" explain variation in the dependent variable and yet are theoretically consistent.[10]

Classification or dummy variables have been used widely in previous economic research, for example, as intercept shifters between periods in consumption function studies for war periods.

They are specified similarly in this study, using a zero-one technique to account for possible differences in intercept for source of observation (e.g., areas, states and regions) and are coded:

$X_m = 1$, if the observation is from source m, or

$X_m = 0$, if the observation is not from source m.

Classification variables are used where the information for a variable is amenable to a broad grouping such that an integer can be assigned to a variable representing the status of the experimental unit with respect to the classification. In time series models the time trend variable (i.e., year 1 = 1, year 2 = 2,..., year n = n) is another classification variable used.

[10] A stepwise model building algorithm (4, p. 171; 7) is frequently employed in this study.

However, by specifying m-1 zero-one variables (setting $B_m = 0$ for the mth source dummy), along with the usual unit vector for the overall mean, the coefficient estimate for the overall mean is the intercept for the mth source and coefficients on the m-1 zero-one variables are estimates of differences between the kth source intercept and the mth source, k = 1,2..., m-1. Thus, the standard t-tests which are part of multiple regression computer programs for the m-1 zero-one variables tests the hypothesis of no significant difference between the intercepts for the kth and mth sources. Results of these tests are an indication of the need to specify a separate variable for a source effect.

Often it is appropriate to remove from the explanatory variables those sources whose coefficients fail the t-test, letting the overall mean serve as the estimate for the intercept of these sources. However, even though two different sources (e.g., areas A and B) fail the t-test for their respective zero-one variables, it does not follow directly that differences are not significant between the intercepts of areas A and B. Therefore, it is not valid to use the overall mean estimate for areas A and B when this situation exists. Before the latter is appropriate and as is done in this study, a t-test for a difference between two coefficients should first be made. Acceptance of the null hypothesis for this test gives a valid basis for dropping, where necessary as indicated by the test, the zero-one variables for areas A and B.

Model Verification and Prediction

The predictive ability of fitted models is of particular interest in this study. Hence, some problems involved in verifying a predictive equation, as well as providing predictions from new data, will be mentioned. Even though a statistical model may explain a significant proportion of the variation in the dependent variable, we cannot be sure how well the model will serve for forecasting. A predictive model used for forecasting may be tested by confronting it with new data.

Models in this study are evaluated by comparing the model predictions over the sample period with the observed values of the dependent variable. Ideally there should be a set of data that were not available when the model was chosen for use in trying out the model. No new data were available for a valid test of fitted models since the decision structure of the 1971 "Set-Aside" Program for feed grains offers a much wider range of alternatives than the 1960-70 Feed Grain Programs.

Hence, a "second best" alternative considered for this study was to drop the final year of data (1970 which was used to fit the models) and apply the same model to all years preceeding 1970. With the refitted model, the 1970 observation then could be predicted. Although this is not a valid test according to the "new data" criterion, (4, p. 546) it perhaps provides a more challenging test for the model than only comparing predicted with observed values from the sample period data used in fitting the model.

Limitations of the Model Building Procedure

Significance tests are used as a criterion in this analysis to select between alternative explanatory variables. Once variables are included or excluded based upon their significance in an initial specification the significance tests should no longer be treated as exact (2, pp. 547-548). Statistical inference techniques based on distributions of random variables are not applicable when maintained hypotheses have been chosen so

as to conform to the data with which parameters will be estimated or hypotheses will be tested (2, pp. 547-548; 13, chap. 4). Technically, once the model is changed a new set of data should be obtained in order to keep the coefficient estimates and the significance tests free of bias. However, economic models are not known with certainty and it is rational to hypothesize and experiment with a competing, plausible model (2, p. 224). It is difficult to choose a model without making some use of the data to be used in the estimation.

The implication of this methodological limitation is that parameter estimates and test of significance presented below can be taken only as an indication. They lack the rigorous mathematical justification normally available for such statistics and inferential procedures.

ESTIMATING ACREAGE DIVERSION: 1961-70

Several regression models are presented below with variables expressing their effect on acreage diversion through differential effects by years, among counties and states and among sizes and types of farms. For example, the level of loan rates which changes over time is expected to cause variation in program participation and acreage diversion by years. A diversion payment rate within a year, or for a period of years, which bears a different ratio to profitability of crop production among counties, states and regions is expected to be reflected in geographic variations in the number of farmers participating and in the proportion of elibible feed grain base diverted to supply control purposes.

Appendix B includes a complete listing of the variables hypothesized as having an influence upon feed grain program diversion. The variables are classified into tables according to whether they are expected to vary by year, state or county and with an indication as to how the variable is expected to influence participation. In general, those variables which proved to be statistically insignificant or inconsistent in sign with the hypothesized relationship were dropped from the regression analysis and are not presented below.

An Acreage Diversion Model for Iowa Counties[11]

Table 5 includes regression model results for total feed grain program diversion for Iowa counties.

Six areas were specified for the Iowa counties derived from the economic areas established for the 1950 U.S. Census of Agriculture (27) and appear in Figure 1. Eight census areas are combined into six for this study based

[11] An examination of residuals for this model is discussed in Appendix D.

Table 5. Statistical summary of a regression model for total diversion for Iowa counties, 1961-70[a]

Variable	Coefficient	t-value
Overall mean	-14.6010	---
Area 2 effect	0.3944	1.573
Area 3 effect	2.0935	7.687**
Area 4 effect	-0.3049	-1.256
Area 5 effect	2.1054	8.036**
Area 6 effect	0.4938	1.640
Feed grain base/cropland	21.6951	20.952**
Time	0.7487	12.151**
Normal yield/expected yield	4.899	3.938**
Weighted minimum "DPF"[b]	4.1132	4.313**
21-40% DPF x TPSR[c]	7.8414	21.139**
41-50% DPF x TPSR[c]	2.3547	13.470**
Soybean net revenue Corn net revenue (per ac.)	4.3138	7.167**
Weighted hog price (t-1)[d]	-11.6600	-11.896**
$\bar{R}^2$ [e]	0.67	
s	1.8003	
F-statistic	203.8**	

* Denotes significance at the 0.05 level.

** Denotes significance at or above the 0.01 level.

[a] Dependent variable for the total diversion model is percent of cropland diverted. The number of observations is 990. Basic data is available in Appendix B of Harrison (9, p. 240).

[b] Weighted min. "DPF" = (PSP x max. percent of base eligible for PSP) x "large farm index" + (min. div. DPF x TPSR for corn).

[c] Total price support rate is for corn.

[d] Hog weights were calculated from the ratio of the 10-year average of 1959-68 of spring and fall farrowings for each county to the same 10-year average for the state.

[e] $\bar{R}^2$ is corrected for state and region effects. $\bar{R}^2$ is 0.73 and 0.72 before correcting for these effects.

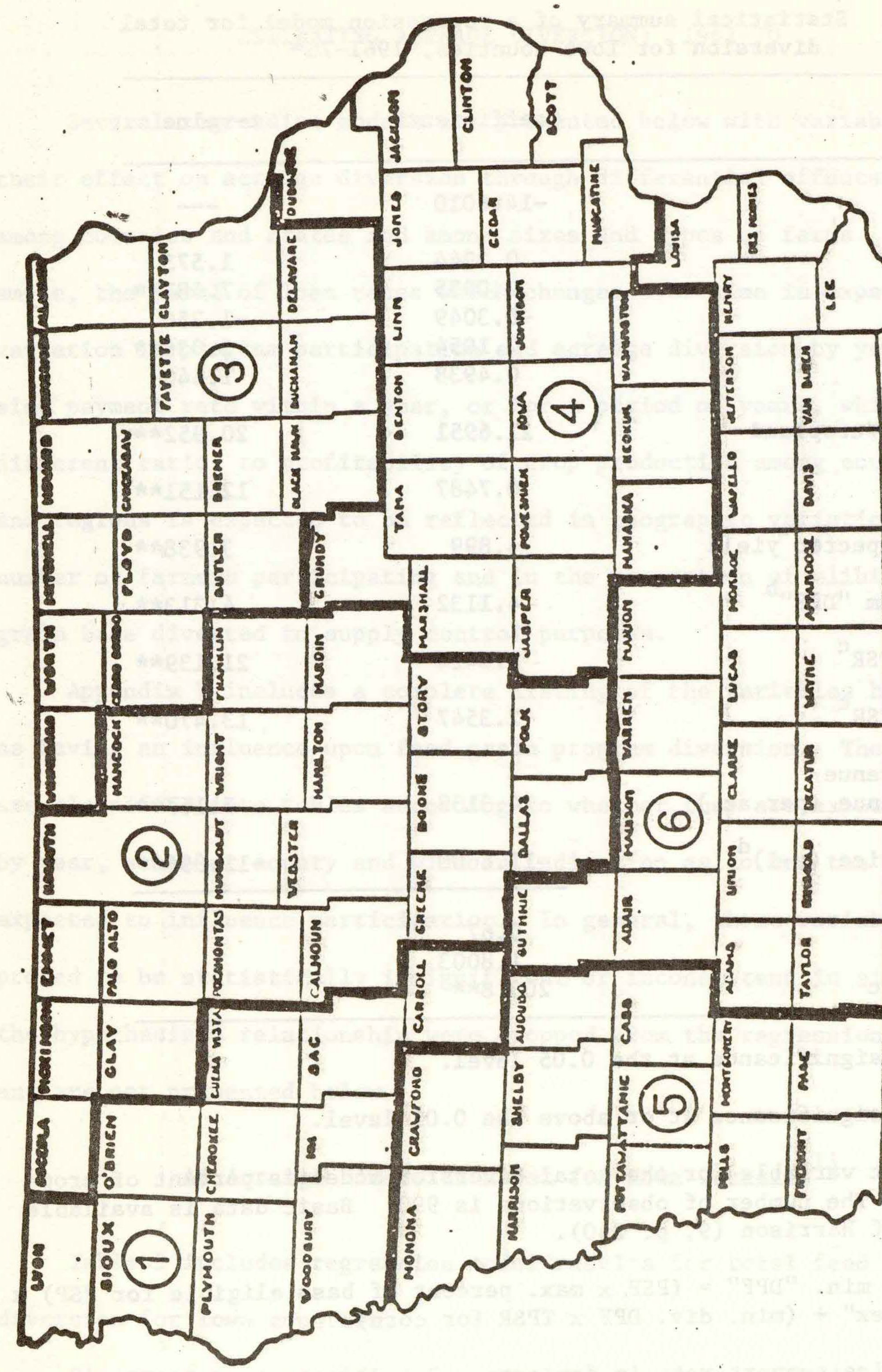

Figure 1. Modified Census of Agriculture Economic Areas for Iowa

on a priori judgment concerning similarity of means and standard deviations for certain farm and farm operator characteristics discussed in Harrison (9, p. 110).

Area 1 is estimated by the overall mean. Only two area effects, three and five, are significant from the overall mean. Both areas are traditionally livestock producing areas (dairy in the Northeast, and beef cattle in the Southwest), but they have positive effects upon diversion of 2.09 and 2.11 percent of the cropland, respectively. Farmers in these areas may tend to participate more than in other areas because of high variability in feed grain yields, low intensity livestock enterprises as well as a relatively strong philosophical acceptance of the program. Area four, the eastern livestock region, has the expected negative coefficient for the total diversion model even though it is not significant. We expect the predominately livestock producing regions to have an average acreage diversion response below the overall average for Iowa.

Feed grain base divided by cropland is highly significant in the total diversion model. When feed grain base as a proportion of cropland increased by 10 percent then cropland diverted increased by 2.17 percent. The influence of this variable upon diversion is supported by the basic structure of the feed grain program provisions and the income maximizing behavior of the farmer (9, p. 58). If the farmer participates only that part of his designated feed grain base not diverted can be planted to feed grain. Thus the closer the feed grain base approaches farm cropland (i.e. where cropland > feed grain base) the more likely the farmer will participate in the program because there is less penalty from holding available cropland out of feed grain production.

"Time" is specified as a trend variable from 1960 (set at "1") through 1970 (set at "10"). Its significance at a high level of probability indicated the influence of covariates of time not specified explicitly, (e.g., technology and program acceptance) on acreage diversion. In the diversion model, there was increased diversion of 0.75 percent of the base each year.

The ratio of normal corn yield to expected corn yield has the expected positive sign. This variable reflects profitability of participating in the program and accepting payments based on the normal yield. Since diversion payments are calculated by multiplying normal production (based on normal yield), the greater normal yield the greater a diversion per acre (see Table 1 above). Expected yield is an average of the past three years. While the normal yield was based in part of the farm's past yields many farmers had normal yields which lagged behind their expectations. The graphical analysis in Harrison (9, p. 50) makes it quite clear that the greater the normal yield compared to the expected yield the greater the possible gain in profit for participation in the Program.

A composite weighted minimum diversion payment variable (see footnote b Table 5) is specified for the diversion model. It is a composite of two parts because minimum participation (20% diversion) in general entitled the farmer to a two part payment: (a) price support payment on a certain amount of the feed grain base production and (b) a diversion payment for the 20% diverted.

The price support payment (PSP) part of the weighted minimum "DPF" is multiplied by the "max. percent of base eligible for PSP" in order to reflect the annual impact of this component of the minimum diversion payment (from Table 1 above: "0" in 1961-62, 80% in 1963-65 and 50% 1966-70). Combined,

the PSP and the eligible percent of the base logically reflect this part of the minimum diversion payment component.

Total PSP component is weighted by an index for prevalence of large farms to reflect the fact that the PSP is more important for large farms. Farms with a small feed grain base, less than 26 acres, had the option to divert their entire base and receive diversion payments for all acres diverted (see Table 1). Since the PSP was only available to those farmers who participated in the program, but had production on the remainder of their feed grain base, it is reasoned that primarily farms with feed grain bases of 126 acres or more collect the PSP which is triggered by simply diverting at the minimum level. The large farm index was formed by subtracting from one the ratio formed by dividing the acres in farms of less than 100 acres by the acres in all farms in the county.

Program payment variables for 21-40 percent and 41-50 percent diversion each include the total price support payment (TPSR) multiplier in order to more closely reflect the level of these respective payments. This is true also for the minimum diversion payment component of the "weighted minimum DPF" discussed above. Since the payment variables are in terms of dollars we can state, for example, that an effective one cent per bushel increase in the 21-40 percent diversion range would stimulate diversion by about 0.08 percent of the cropland. This would be about 0.16 percent of the feed grain base on the average since the average of feed grain base divided by cropland is 0.50 for Iowa.

Soybeans net revenue as a ratio to corn net revenue has a positive relation as hypothesized and is highly significant. Participation in the program excludes feed grain production on other than feed grain base acres.

When soybeans have favorable net returns, a farmer with available cropland not included in the feed grain base as the conserving base is encouraged to participate in the program and plant "extra" cropland in soybeans rather than corn as a nonparticipant.

The revenue components for soybeans and corn were calculated from prices for the first three months of the current marketing year times the yield obtained from a past three year moving average. Production costs were estimated from budget data summarized in Appendix Table B-4.

Weighted hog prices of the previous year is a product of the production weights and prices. This variable has a significant influence upon diversion and has the negative sign that was hypothesized. Hog price is a partial indicator of the profitability of the hog enterprise and the tendency of farmers to refrain from diverting acreage so that additional corn can be produced for feed.

Corn loan rate divided by 4th quarter corn of t-1 and the soybean loan rate were also considered, but they did not prove to be significant. The prices received index for all farm products (1957-59 = 100) was considered as a deflator for the last five variables in Table 5, but the results remained essentially the same as in the undeflated version.

An Acreage Diversion Model for the 48 States[12]

For the analysis with state level data, states with less than two million acres feed grain base are grouped into regions as shown in Figure 2. Five regions and 15 states become the units of observation in each of 10 years for purposes of this analysis. All regional variables are constructed as weighted averages of the states in the region.

[12] An examination of residuals for this model is discussed in Appendix D.

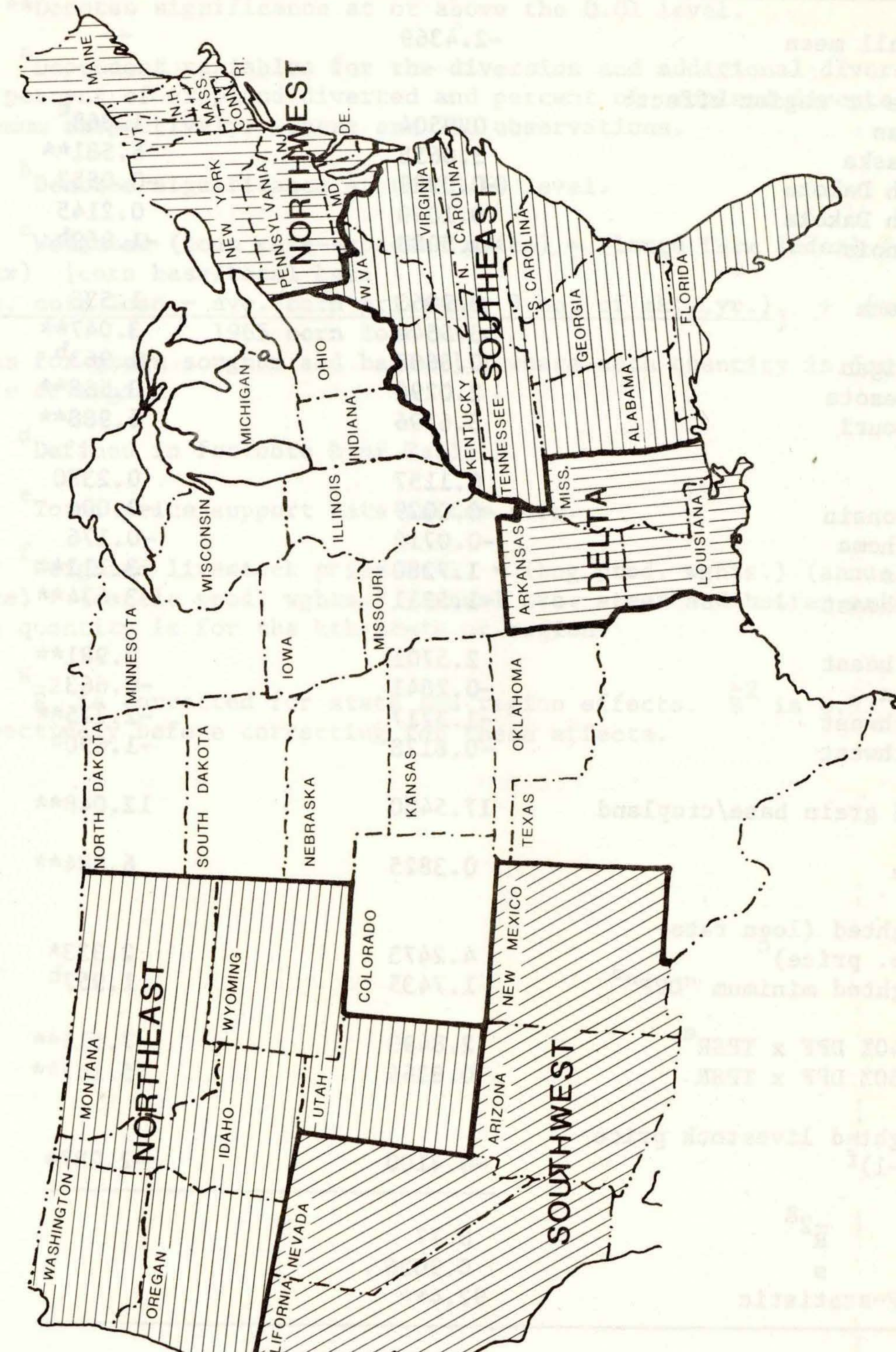

Figure 2. States and regions for the state aggregate data analysis

Table 6. Statistical summary of a regression model for total diversion for the 48 states: 1961-70[a]

Variable	Coefficient	t-value
Overall mean	-2.4369	--
State or region effect:		
Kansas	0.9504	1.868[b]
Nebraska	3.0658	4.581**
North Dakota	-0.0229	-0.0553
South Dakota	0.1040	0.2145
Illinois	-1.5083	-1.969[b]
Indiana	0.9063	1.533
Iowa	3.5544	3.047**
Michigan	0.8668	1.963[b]
Minnesota	2.0296	3.568**
Missouri	3.6796	6.988**
Ohio	0.1157	0.2380
Wisconsin	-0.0029	-0.006
Oklahoma	-0.0716	-0.176
Texas	1.7280	3.111**
Northeast	-1.5311	-3.674**
Southeast	2.5701	3.981**
Delta	-0.2841	-0.663
Northwest	-1.3717	-2.775**
Southwest	-0.8178	-1.690[b]
Feed grain base/cropland	17.5420	12.048**
Time	0.3825	6.884**
Weighted (loan rate-exp. price)[c]	4.2473	2.333*
Weighted minimum "DPF"[d]	1.7435	1.957[b]
21-40% DPF x TPSR[e]	2.8493	7.515**
41-50% DPF x TPSR	0.8364	5.167**
Weighted livestock price (t-1)[f]	-0.4100	-2.287*
$\bar{R}^2$[g]	0.77	
s	0.9026	
F-statistic	92.4**	

Table 6 (continued)

*Denotes significance at the 0.05 level.

**Denotes significance at or above the 0.01 level.

[a]Dependent variables for the diversion and additional diversion models are percent of cropland diverted and percent of cropland diverted above the minimum respectively. There are 200 observations.

[b]Denotes significance at the 0.10 level.

[c]Weighted (loan rate-expected price) = (large farm index) (cash grain index) [corn base/total base · (ave. corn loan - ave. corn price 1st 3 mo. of mkt. yr.) / 1965 corn loan rate] + [analogous terms for grain sorghum and barley] ; where each quantity is for the kth state or region.

[d]Defined in footnote b of Table 5.

[e]Total price support rate is for corn.

[f]Weighted livestock price (t-1) = (hog prod. wghts.) (annual ave. hog price) + (cattle prod. wghts.) (annual ave. steer and heifer price); where each quantity is for the kth state or region.

[g]$\bar{R}^2$ is corrected for state and region effects. $\bar{R}^2$ is 0.93 and 0.83 respectively before correcting for these effects.

State and region effects were obtained by specifying a set of zero or one classification variables. Colorado's intercept is represented by the overall mean. Most states and region effects were significant at beyond the 0.01 level.

The t- values shown represent tests of significance between the intercepts for Colorado and the other 14 states and 5 regions. These results indicate that estimating the individual state and region effects is appropriate because of the large number of significant coefficients. Further even though a given coefficient may not be significantly different from the overall mean that coefficient may be significantly different from the coefficient for another state or region effect.

Five variables have specifications and interpretations similar to those in the Iowa counties model above: (1) feed grain base divided by cropland, (2) time, (3) weighted minimum "DPF", (4) 21-40% DPF x TPSR and (5) 41-50% DPF x TPSR.

Weighted loan rate minus expected price for each of the feed grains is significant in the states and regions. This variable can be expressed symbolically as:

$$\text{Weighted (loan rate} - \text{expected price)} = S_k \cdot G_k \left[\sum_j \frac{B_{kij}}{T_{ki}} \frac{(L_{kij} - E_{kij})}{L_{ki5}} \right]$$

where:

S_k is a large farm index for the kth state or region which is feed grain base acres on farms with base greater than 25 acres divided by total base acres in 1964.

G_k is a cash grain index for the kth state or region and is corn, grain sorghum and barley acres on cash-grain farms divided by the corresponding crop acreages on all commercial farms in 1959.

B_{kij} is the base for the jth feed grain (i.e. corn, grain sorghum and barley) in the kth state or region in the ith year.

T_{ki} is the total feed grain base in the kth state or region in the ith year.

L_{kij} is the loan rate for the jth feed grain in the kth state or region for the ith year.

E_{kij} is the "expected" price for the jth feed grain in the kth state or region in the ith year which is approximated by the average price in the first three months of the marketing year.

The loan minus the expected price difference is divided by the loan rate for 1965 and is weighted by the proportion of the individual feed grain bases to the total base in order to reflect the importance of the particular feed grain in a given state or region and year. This proportional weight will be zero for some feed grains in certain states and regions and in certain years. It is hypothesized that the difference between the loan rate in relation to the expected price is more important to the cash grain farmer rather than the livestock farmer, thus a cash grain index is added as a weight. Livestock producers are less likely to want to take advantage of the loan provision since they need what feed grain they produce for livestock rations. Only very large differences between the loan and expected price are likely to make delivery to the CCC profitable.

A large farm index is used because this variable is also expected to be more important for farms with the larger feed grain bases. We hypothesize this because the program provided for farms with a feed grain base of 25 acres or less to divert the entire base resulting in no feed grain production with which to take advantage of the loan provision. Thus emphasis on this variable ought to vary with the larger potential for feed grain production.

The overall influence of the "loan-price" variable is that if the weighted price differences increase by 10 percent of the 1965 loan rate then diversion increases by 0.42 percent of the cropland. Due to its complex formulation a simplified situation is assumed to clarify its influence. Assume a state where there is a base for only one feed grain, e.g., corn. The total cropland is five million acres, cash-grain and large farm indices are 0.6 and 0.9, respectively and the 1965 corn loan rate is $1.05. If the loan rate increases by 10 cents over the average of the first three months of the marketing season (e.g., October, November and December of t-1 for corn in the Corn Belt) then we have an increase of 0.042473 (5 million acres x $\frac{0.10}{1.05}$ x 0.6 x 0.9) = 10,921 acres in diverted acres because of the increase of the loan rate over the expected price for corn.

A composite, weighted livestock price variable was significant (See note f Table 6) as hypothesized. The hog price variable alone was not significant as in the Iowa counties model. This result is not surprising given the importance of hog production in Iowa as relative to the remaining states. However, it was expected that a hog price variable is more likely to have a significant relationship with diversion given the relative responsiveness of hog production to corn price changes. Normal corn yield divided by expected corn yield was not considered in the states and regions analysis since it was not believed to be plausible to expect a meaningful difference between states. No soybean price or loan variable considered proved to be significant.[13]

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[13] See Appendix C for some alternative specifications of the "48 states" diversion model.

Acreage Diversion Models for Individual States and Regions

Results for total diversion models for individual states and regions delineated in Figure 1 above and additional "regions" consisting of two or more states are presented in Table 7. With the results in Table 7, we have an indication of the relative importance of the independent variables considered in this study in the various states and regions.

Only 10 observations are available for Iowa, Colorado and the five regions (Northeast, Southeast, Delta, Northwest and Southwest) whose data are a weighted aggregate of the states included. North Central, Northern Great Plains and Oklahoma-Texas consist of eight, four and two observations respectively in each year (80, 40 and 20 observations respectively in total). States with similar crop production patterns were pooled into the three additional regions to reduce the amount of analysis necessary in presenting these models. Iowa is in the North Central pooled model, but is presented separately to obtain estimates for comparison with those from the pooled Iowa counties and the national pooled states and regions models. Colorado is not pooled into a region because cropping patterns differ from that of surrounding states.

Examination of Table 7 indicates that for most states and regions, there are fewer significant independent variables than for the pooled models reported in Tables 5 and 6. The shortage of degrees of freedom alone in most of these models reduces the chances of obtaining statistically significant results.

A cropland deflator for the dependent variable is chosen when a lower $\bar{R}^2$ is obtained than for the feed grain base deflator. Differences in results for alternative deflators with the individual state and region models indicate that in some states and regions the cropland deflated dependent

Table 7. Statistical summary of state and region diversion models: 1961-70[a]

Variable	Iowa	North Central[b]	N.G. Plains[c]	Northeast	Southeast
Intercept	10.628	17.132	-2.539	9.827	11.649
Feed grain base/cpld.					
Coefficient	--	--	19.049	--	--
t-value	--	--	9.556**	--	--
Time					
Coefficient	0.517	--	--	1.020	2.014
t-value	3.769**	--	--	16.256**	8.210**
Loan-exp. price					
Coefficient	--	23.954	--	--	--
t-value	--	2.922**	--	--	--
21-40% DPF x TPSP					
Coefficient	14.935	10.318	4.256	--	--
t-value	7.795**	6.066**	4.927**	--	--
41-50% DPF x TPSP					
Coefficient	5.525	1.614	1.955	--	--
t-value	6.133**	2.246*	5.170**	--	--
Weighted div. pymt.					
Coefficient	--	--	--	17.107	33.155
t-value	--	--	--	8.418**	4.047**
Maximum % of base for div.					
Coefficient	--	--	--	--	--
t-value	--	--	--	--	--
$\bar{R}^2$	0.94	0.89	0.93	0.97	0.88
s	1.148	2.129	0.964	0.505	1.980
F	44.4**	54.3**	73.3**	132.6**	33.8**

(continued on next page)

Table 7. (continued)

Variable	Delta[d]	Oklahoma-Texas[e]	Northwest[f]	Colorado	Southwest[g]
Intercept	17.097	-2.292	14.996	1.828	10.854
Feed grain base/cpld.					
Coefficient	--	14.362	--	--	--
t-value	--	2.277**	--	--	--
Time					
Coefficient	0.214	0.339	0.303	2.507	--
t-value	3.030**	4.238**	3.189*	6.823**	--
Loan-exp. price					
Coefficient	--	--	--	19.170	--
t-value	--	--	--	2.338[h]	--
21-40% DPF x TPSP					
Coefficient	2.646	--	--	--	18.081
t-value	1.489	--	--	--	5.846**
41-50% DPF x TPSP					
Coefficient	2.562	--	1.999	--	--
t-value	2.837*	--	2.661*	--	--
Weighted div. payt.[j]					
Coefficient	--	12.876	--	59.170	--
t-value	--	5.220**	--	5.185**	--
Maximum % of base for div.					
Coefficient	-17.309	--	16.112	--	--
t-value	-2.626	--	3.802	--	--
$\bar{R}^2$	0.48	0.89	0.97	0.87	0.78
s	0.367	0.805	0.814	2.550	2.101
F	2.665	40.0**	83.3**	20.4**	17.1**

(Continued on next page)

Table 7. (continued)

*Denotes significance at the 0.05 level.

**Denotes significance at or above the 0.01 level.

[a]Dependent variables are acres diverted as a percent of feed grain base except Northern Great Plains, Oklahoma-Texas, and the Delta where acres diverted is a percent of the cropland.

[b]North Central State effects are Illinois = -5.2671, Indiana = 1.9, Iowa = 11.8631, Minnesota = 1.9619, Missouri = 9.6200, Ohio = -4.1711 and Wisconsin = 3.5007. Iowa is significant at the 0.05 level and Missouri, Ohio and Wisconsin are significant at 0.01 level. The Michigan mean response is the intercept. Weighted livestock price (t-1) had a coefficient of -3.0098 and is significant at the 0.01 level.

[c]Northern Great Plains State effects are Nebraska = 1.7183, North Dakota = -0.1608 and South Dakota = -0.5972. Nebraska is significant at the 0.01 significance level. The Kansas mean response is the intercept.

[d]Soybean price 4th quarter (t-1) was also significant at the 0.05 level with coefficient = -4.1614.

[e]Texas effect is significant at the 0.10 level.

[f]A barley program (zero-one) variable has a coefficient = -17.3093 and is significant at the 0.01 level.

[g]A barley program (zero-one) variable has a coefficient = -2.7374.

[h]Denotes significance at the 0.10 level.

[j]Weighted div. pmt. = (TPSR x 1st 20% DPF x 0.20) + (TPSR x 21-40% DPF x 0.1) + (TPSR x 41-50% DPF x 0.1).

variable gives a higher overall significance of regression than feed grain base deflator. We thus have an indication of which regions account for the performance of the cropland deflator. A weighted diversion payment variable is present in some of the models; however, two of the components of this variable "21-40%" and "41-50%" payment rates usually prove significant when specified separately.[14]

Miller and Hargrove (15, p. 20) report results from analysis of similar data for their "final state models". Errors (s) and R^2's are of a similar magnitude; however, signs and magnitudes of intercepts and other coefficients differ substantially in some cases. For example the corresponding intercept (constant) for Iowa is -53.82 in the Miller and Hargrove model compared to 10.63 in Table 7 and the coefficient on the "21-40%" payment rate is 67.82 for Miller and Hargrove compared to 14.93 for this study. These differences may be expected given the differences in variable specification and adjustments. For example, Miller and Hargrove indicate no "PSP adjustment" in the 21-40%" and "41-50%" variables. These adjustments are expected to have a significant impact in a short series.

Miller and Hargrove obtained a few significant variables for the Arkansas, Louisiana and Mississippi models (R^2's were 0.46, 0.14, 0.78, respectively). These states constitute the Delta region in the present study. Similar results were obtained in this study. Significant results were obtained for the Delta only when certain combinations of variables were considered. Thus little confidence should be placed in the results reported for the Delta in Table 7.

[14]The min. div. payment component of the weighted div. pmt. variable in these models does not include a PSP component leaving the variable as specified in the Houck and Ryan study (10).

Similar difficulty was encountered in fitting a model to the data for the Northwest region. A "barley variable", coded as "1" when barley was included in the Feed Grain Program and "0" when it was not, proved to be highly significant. Its inclusion permitted significant results to be obtained for other independent variables. The barley variables (see footnote f, Table 7) has a negative coefficient because of the percent of total base diverted is less when barley is in the Program than when barley is not in the Program (and the total feed grain base consists only of corn and grain sorghum). A barley variable adjustment also contributed to obtaining significant results in the Southwest.

DIVERTED ACREAGE PREDICTION AND COMPARISON OF SELECTED MODELS FOR PROGRAM PLANNING

An important objective of this study was to identify models which provide reliable estimates of diverted acreage under supply control programs. Although various state and regional estimates may be useful in program planning, emphasis in this study is on models for reliable estimates for the United States. The purpose of the following discussion is to compare predictive ability in estimates from different models. Model estimates are compared with observed diverted acres over the sample observations. Alternative levels of data aggregation (county versus state) and alternative assumptions about model specification are examined briefly by comparing estimates for Iowa diversion. Estimates for Iowa are obtained from the pooled states and regions model, the pooled Iowa counties model and the Iowa time series model.

Validation and Comparison of Models Over the Sample Period (1961-70)

Actual diverted acres for the 48 states and the summed estimates from the states and regions model are presented in Table 8 and Figure 3. From

Table 8 we can compare the estimates from the pooled states and regions model with the actual diverted acres, by examining the ratio of the estimated to the actual diversion. The largest error of an estimate is five percent. A large drop in diversion in 1967 is predicted as well as other results for the 1961-70 sample period. Overall, performance of the states and regions model is believed to be acceptable. Figure 3 gives a graphic illustration of the closeness of the estimates to the actual diversion.

In Table 9 and Figure 4 a comparison of actual diversion for Iowa and estimated diversion for three alternative models is presented. From this information we can assess the relative predictive ability of three alternative models presented above. The state and regions model estimates for Iowa are compared with the estimates for the Iowa time series and pooled Iowa counties models. The Iowa counties model has the lowest maximum percent error of four percent while it is six percent for the Iowa time series and 31 percent for the states and regions model estimates for Iowa. Figure 4 geographically depicts the estimates of the three models relative to each other and the actual Iowa diversion.

Since the Iowa counties model is based upon 990 observations (99 counties over 10 years), we expect this model to have the most accurate esti-

Table 8. Comparison of actual and estimated diverted acres for the 48 states based on the states and regions model (1961-70)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Actual div. (10,000 ac.)	2573	2827	2447	3243	3471	3470	2029	3241	3906	3741
Est. div. (10,000 ac.)	2509	2873	2573	3311	3395	3288	1984	3379	3840	3855
Est./act.	0.97	1.02	1.05	1.02	0.98	0.95	0.98	1.02	0.98	1.03

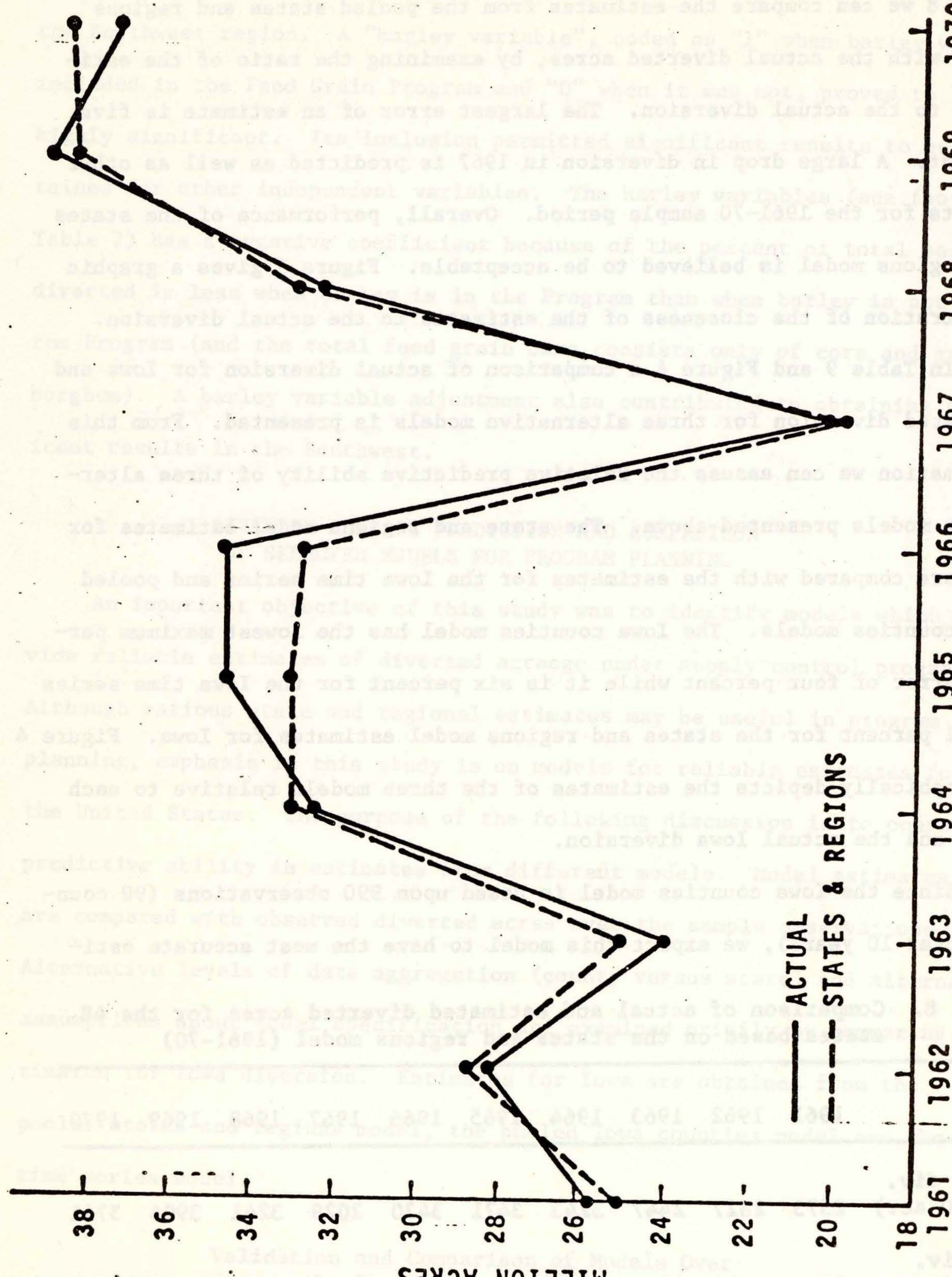

Figure 3. United States annual diverted acres; actual and States and regions model estimates, 1961-70

mates. However, estimates from the Iowa time series model are near those of the Iowa counties model especially after 1966. States and regions estimates for Iowa have an error of over five percent in six of the ten years in the series with the error in 1967 being very high at 31 percent.

Table 9. Comparison of actual and estimated diverted acres for Iowa by alternative models, (1961-70)

		Model					
		Iowa time series		Iowa counties		Iowa states & reg.	
Year	Actual div.	Est. div.	Est./act.	Est. div.	Est./act.	Est. div.	Est./act.
	(1000 ac.)	(10000 ac.)		(1000 ac.)		(1000 ac.)	
1961	2784	2828	1.02	2778	1.00	2994	1.08
1962	3095	2924	0.94	3041	0.98	3079	0.99
1963	2399	2484	1.03	2432	1.01	2846	1.19
1964	3558	3492	0.98	3409	0.96	3273	0.92
1965	3459	3450	1.00	3520	1.02	3343	0.97
1966	3329	3609	1.08	3464	1.04	3206	0.96
1967	1959	1941	0.99	1924	0.98	2575	1.31
1968	3721	3682	0.99	3649	0.98	3467	0.93
1969	3888	3745	0.96	3834	0.99	3548	0.91
1970	3590	3630	1.01	3630	1.01	3452	0.96

Predictions for 1970 and 1971 with Selected Models

When adequate data are available, it is often possible to test the predictive ability of a model by confronting it with "new" data. The "new" data are sample data that are not used in obtaining the parameter estimates of the prediction equation. Because there were only ten years of data available for this study, all the data are used in the analysis. As an alternative procedure, once final models were obtained, the 1970 data were

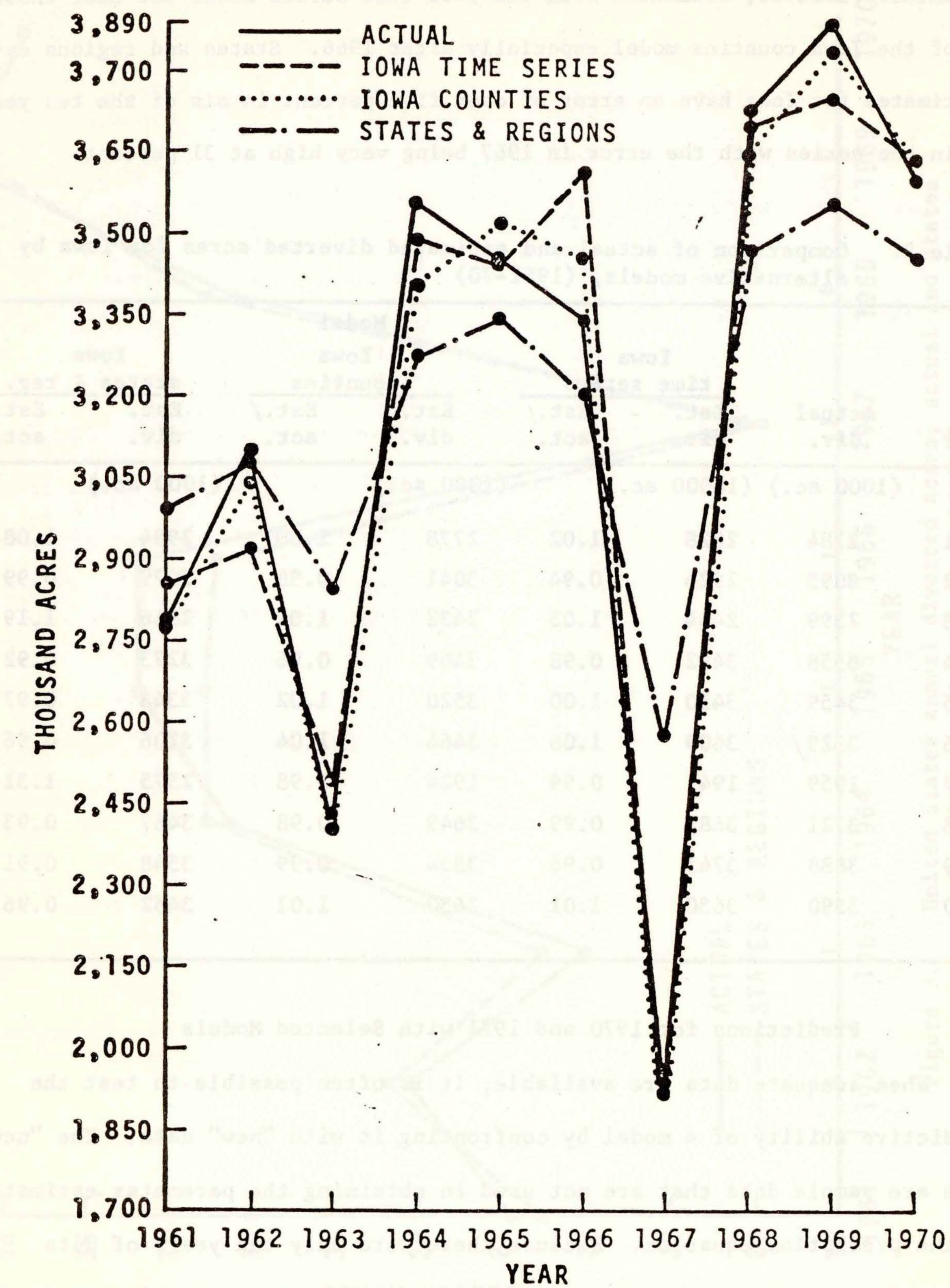

Figure 4. Iowa annual diverted acres; actual and estimates from Iowa time series, Iowa Counties and States and regions models, 1961-70

"dropped" in order to find parameter estimates for the final model with only the 1961-69 data.

This procedure was followed for the Iowa time series, Iowa counties and Iowa from the states and regions models. Except for the Iowa time series model, the coefficients for the 1961-69 models are of similar magnitude and significance compared to those for the 1961-70 models.[15] Table 10 shows estimates from the three alternative models for 1970 using coefficients, from regressions on 1961-69 data. Errors of two percent and three percent, respectively for the Iowa time series and Iowa counties are small and similar. Again, the error for the Iowa estimate from the states and regions model is relatively high, at five percent. This predictive test suggests that the models compared may give reliable predictions within the same range of values for the explanatory variables that were considered in the sample period.

Table 10. Diverted acreage predictions for Iowa for 1970 and 1971

		Model					
		Iowa time series		Iowa counties		Iowa states & reg.	
Year	Actual div.	Est. div.	Est./act.	Est. div.	Est./act.	Est. div.	Ext./act.
	(1000 ac.)	(1000 ac.)		(1000 ac.)		(1000 ac.)	
1970	3590	3509	0.98	3695	1.03	3410	0.95
1971[a]	2740	2216	0.90	--	--	2939	1.19

[a]The 1971 performance is not directly comparable to the model estimates because of changes in the 1971 Program as compared to the 1961-70 Program.

[15]When the 1961-69 regression is attempted for the final Iowa time series model in Table 7, mathematical difficulties are encountered and no solution is obtained. Adding two additional nonsignificant variables to the model permitted a solution.

Two estimates for 1971 are also given in Table 9 for diverted acres in Iowa. Since the Feed Grain Program for 1971 has more flexibility in the provisions compared to the 1961-70 programs (11), the estimates for 1971 may not compare favorably with the actual diverted acres. For example, in 1971 participating farmers (with 20 percent of the feed grain base "set aside") were allowed to plant feed grains on acreage not previously considered as part of the feed grain base. Further, no small farmer option was in effect in 1971. The only direct payment was the price support payment for minimum diversion.

Estimates for the 48 states were calculated for 1970 and 1971 with the states and regions model in a manner similar to those for Iowa above. A 1970 estimate of 39.4 million acres, from the 1961-69 regression, compares favorably with the actual diversion of 37.4 million. However, the prediction for 1971 is 25.8 million acres, higher than expected from this model since there were no additional diversion payments in the 1971 program. Final "set-aside" acreage for 1971 was 18.2 million acres (57).

Since the 1971 corn loan and price support payment rates of $1.05 and $0.32, respectively, were similar to that of 1967, a prediction somewhat closer to the 19.6 million actual diversion of 1967 was expected. Of course, the positive influence of the time trend coefficient tends to increase the prediction above that of 1967, regardless of changes in other program variables.

Implications for Program Planning

More precise knowledge about farmer response to past programs is useful in program evaluation and planning. Information on models and their relative predictive ability add to this knowledge. These models measure the joint influence of program variables upon the level of acreage diversion

and supply control. Individual coefficients and the overall ability of various program provisions and prices, along with adjustments in areas and trend to explain farmer response may serve as guides for evaluating similar programs which might be used in the future.

Both the Iowa time series and the pooled Iowa counties models' prediction average errors of 2.6 percent and 2.0 percent, respectively. Since the Iowa estimates obtained from the states and regions model for the sample period have an average error of 9.4 percent, the parameter estimates obtained in the two Iowa models are much more reliable for Iowa predictions than those from the states and regions model.

It may be questionable, based on the information obtained in this study, whether the collection of county data is merited for obtaining diverted acreage predictions. Obtaining and analyzing data on each county is much more costly than simply analyzing the aggregate performance for a state. Additional cost of obtaining and analyzing data must be compared to the value of more precise predictions.

While the states and regions model has a high average error (as well as errors up to 31 percent) in predicting diversion for Iowa, we see from Table 8 that the average error for estimates for the 48 states is only 2.8 percent. If estimates are desired for aggregate Feed Grain Program performance, the pooled states and regions model appears to be a reliable estimating equation. Thus, on the basis of these findings, the model selected for program planning depends upon whether an estimate is desired for a state or the 48 states. For further application of the models discussed, it is advisable to add each year of new program's experience and obtain new parameter estimates on the basis of this additional data.

Such a practice is a necessity when only a few years (e.g., ten years for this study) of data are available. Additional data may be safely added to a series under study only when the data generating mechanism has not been substantially modified. This presents a particular problem in view of the flexible provisions added to the Agricultural Act of 1970 (11). When the program under the 1970 Act was administered in 1971, with provisions strikingly different from those in the 1961-70 period, it was doubtful that these data should be added to the 1961-70 series. If the 1970 Act should be administered in the future with provisions similar to those of the 1961-70 program, then it may be appropriate to add this data to the 1961-70 data for further analysis.

Schaller in 1968 reported that an early version of a national LP model had an average error of 11 percent for estimating feed grain diversion for 1962-64 (17, p. 42). The overall 2.8 percent error (3.0 percent for 1962-64) for the states and regions model in this study represents an improvement. Estimating equations for diversion have application as behavioral relationships within simulation models. A diversion response equation could be incorporated with production and market relationships in a simulation, in order to study the impact of changes in program provisions upon program costs, feed grain stocks and net farm income (19).

SUMMARY

This study examines farmer response to the Feed Grain Program from 1961-70. Program provisions and numerous other variables are hypothesized to explain the farmers' diversion response under the Feed Grain Program. Classification variables are used to quantify time and location of data and other relationships studied.

In order to obtain a single equation for predicting acreage diversion for Iowa, county data were pooled for this purpose. Seventy-three percent of the variation in percentage of cropland diverted was explained by (with signs of coefficients): (1) feed grain base divided by cropland, positive; (2) time, positive; (3) normal corn yield divided by expected corn yield, positive; (4) three diversion payment rates, all positive; (5) soybean net revenue divided by corn net revenue (per acre), positive; and (6) weighted hog price, year t-1, negative. All of the coefficients have the expected signs.

Mixed states data were also considered in a pooled model with observations on 15 states and five regions for 10 years. Variables (1) and (2) and the combination in (4) listed above for the Iowa counties model were also significant with a positive influence in the states and regions total diversion model. A weighted livestock price in place of a similar variable for hog price in the Iowa model lagged one year was found to be significant with a negative influence. In addition, a weighted variable for difference in loan rate and expected price of corn, barley and grain sorghum was significant with a positive influence in the states and regions model. Twelve of the 20 zero-one variables specified to measure state and region effects were significantly different from the overall mean at or above the 0.10 level of probability. The full set of variables explained 93 percent of the variance in total land diversion for the United States.

Total diversion models were fitted for ten individual states and regions (three of the regions, North Central, Northern Great Plains and Oklahoma-Texas being pooled states data). Various combinations of the independent variables significant in the pooled states and regions model are significant in these models. Maximum percentage of base eligible for diversion payment

(Delta and Northwest) and a zero-one variable for the presence of barley in the Program (Northwest and Southwest were also significant. The $\bar{R}^2$'s range from 0.97 (Northeast) to 0.48 (Delta).

The estimating ability of the selected pooled and time series models was considered over the 1961-70 sample period. In a comparison of predictions from the states and regions model with the actual diverted acres for the 48 states, the average error was 2.8 percent. Average percentage of errors when estimating Iowa diversion for three alternative models as: 2.6 percent for the Iowa time series model; 1.9 percent for the Iowa counties model; and 9.4 percent for the states and regions model. When 1970 estimates were obtained for the same three models with fits on the 1961-69 data, the errors were two, three and five percent, respectively, for the three models.

This study proposes that reliable prediction equations can be obtained from regression analysis of mixed and time series data. Evidence from the analysis of ten years of data for the Iowa counties and the 48 states supports this contention. Comparative estimates for acreage diversion in Iowa from three alternative models indicate that the pooled Iowa county model yields an average error of estimate which is seven percent less than for estimates from the other two models, pooled states and regions model. Estimates for the 48 states, from the states and regions model, are believed to be reliable within the range of the experience of the 1961-70 Feed Grain Program.

Findings of the statistical analysis are useful for explaining farmer behavior on an aggregate basis as well as for predicting response to possible future feed grain programs. However, certain limitations exist in the use of time series models for predicting economic behavior. Prediction equations may be used in confidence only as long as the decision environment prevailing during the sample period continues to exist. For predicion of future diversion response, based on regression models from time series observations, it must be true that variables which characterize the decision environment for the farmer remain constant unless their change is accounted for in the predicion equation.

BIBLIOGRAPHY

1. Brandow, George E. Cost of farm programs. In benefits and burdens of rural development, some public policy viewpoints. Iowa State University Center for Agricultural and Economic Development. pp. 77-88. Ames, Iowa, Iowa State University Press. 1970.

2. Christ, Carl F. Econometric models and methods. New York, John Wiley and Sons, Inc. 1966.

3. Christensen, Raymond P. and Ronald O. Aines. Economic effects of acreage control programs in the 1950's. U.S. Dept. of Agr. Economic Research Service-Farm Economic Division. Agr. Econ. Rpt. 18. Oct. 1962.

4. Draper, N.R. and H. Smith. Applied regression analysis. New York, John Wiley and Sons, Inc. 1966.

5. Ferguson, C.E. Microeconomic theory. Homewood, Illinois, Richard O. Irwin, Inc. 1966.

6. Flinchbaugh, Barry Lee. The 1968 voluntary feed grain program: characteristics of participation and intrafarm cropland diversion in Indiana. Unpublished Ph.D. thesis. West Lafayette, Indiana, Library, Purdue University. Jan. 1971.

7. Hanson, Bonnie L. MOUFLON: Reference Manual. Iowa State University, Statistical Laboratory, Statistical Numerical Analysis and Data Processing Series, No. 12. 1969.

8. Harms, Alfred Glen. Analysis of Illinois farmers' decisions on participation in the feed grain program. Unpublished Ph.D. thesis. Urbana, Illinois, Library, University of Illinois. 1965.

9. Harrison, Gerald A. Alternative statistical models for estimation of acreage diversion with farm, county and state level data: Feed Grain Program (1961-70). Unpublished Ph.D. thesis. Ames, Iowa Library, Iowa State University. 1971.

10. Houck, J.P. and M.E. Ryan. Supply analysis for corn in the United States: the impact of changing government programs. Unpublished paper. St. Paul, Minnesota, Dept. of Agr. and Applied Econ., University of Minnesota. Jan. 1971.

11. House of Representatives, 91st Congress, 2nd Session. Agricultural Act of 1970. United States Government Printing Office, House of Representatives Rpt. No. 91-1594. Oct. 1970.

12. Houthakker, Hendrik W. The causes of the farm problem. In Dennis R. Starleaf, ed. Economic readings in analysis and policy. pp. 164-168. Glenview, Illinois, Scott, Foresman and Co. 1969.

13. Johnston, J. Econometric methods. New York McGraw-Hill Book Co., Inc. 1963.

14. Kuh, Edwin. The Validity of Cross-Sectionally Estimated Behavior Equations in Time Series Applications. Econometrica 27: 197-214. April 1959.

15. Miller, Thomas A. and Stanley H. Hargrove. Factors affecting acreage diverted under the U.S. feed grain program. U.S. Dept. of Agr. Economic Research Service ERS 453. Nov. 1970.

16. Robinson, Bobby H. and Dale M. Hoover. An economic analysis of factors affecting the acreage of corn in North Carolina. North Carolina Agr. Expt. Sta. Tech. Bul. 182. Jan. 1968.

17. Schaller, W. Neil. A national model of agricultural production response. Agr. Econ. Res. 20: 1-46. April 1968.

18. Schnittker, John A. Distribution of benefits from existing and prospective farm programs. In benefits and burdens of rural development: some public policy viewpoints. pp. 89-104. Iowa State University Press. 1970.

19. Shechter, Mordechai and Earl O. Heady. Response surface analysis and simulation models in policy choices. Amer. J. of Agr. Econ. 52: 41-50. Feb. 1970.

20. Shepherd, Geoffrey S. Farm policy: new directions, Part I. Ames, Iowa, Iowa State University Press. 1964.

21. Slaughter, Rudie Wright, Jr. Analysis of feed grain program participation rates, Illinois counties 1961-66. Unpublished Ph.D. thesis. Urbana, Illinois, Library, University of Illinois. 1967.

22. Suggested costs and returns in crop and livestock production for use in farm budgeting. Iowa State University, Coop. Ext. Serv. FM 1886 (Rev.) Sept. 1960, Aug. 1962, Nov. 1964, Oct. 1965, Nov. 1966, Oct. 1968, Oct. 1970.

23. Theil, H. and H.L. Nagar. Testing the independence of regression disturbances. Amer. Statis. Assoc. J. 56: 793-806. 1961.

24. U.S. Bureau of the Census. Current industrial reports 1965 through 1969. Fats and oils crushers summaries. United States Government Printing Office. Oct. 4, 1966; Nov. 30, 1967; Oct. 18, 1968; Jan. 6, 1970; Jan. 8, 1971.

25. U.S. Bureau of the Census. United States census of agriculture: 1959. Vol. I, parts 1 through 48. State Table 19. United States Government Printing Office. 1961.

26. U.S. Bureau of the Census. Census of agriculture, 1959. Vol. 1, part 16 (Iowa). Statistics for counties. Table 4, Table 5 and Table 6. United States Government Printing Office. 1961.

27. U.S. Bureau of the Census. United States census of Agriculture: 1950 counties and state economic areas. United States Government Printing Office. 1952.

28. U.S. Bureau of the Census. Census of agriculture, 1964. Vol. 1, part 16 (Iowa). Statistics for counties. Table 1, Table 3 through 8 and Table 13. United States Government Printing Office. 1967.

29. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. 1962, 1963 and 1966-69 feed grain program regulation. (reprints). Federal Register 27: 146, Jan. 6, 1962; 28: 4282, May 1, 1963; 31: 8339, June 15, 1966.

30. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. The 1965 feed grain program. U.S.D.A. - ASCS PA-650. Jan. 1965.

31. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. The feed grain program 1967. U.S.D.A. - ASCS PA-784. Dec. 1966.

32. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. ASCS commodity fact sheet. Jan. 1970.

33. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. 1964 and 1967 crop corn basic support rates for counties. Unpublished data. Des Moines, Iowa, Iowa ASCS State Office. 1964 and 1967.

34. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. Final 1966 feed grain program summary. Des Moines, Iowa, Iowa ASCS State Office. October 26, 1966.

35. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. Cropland, Iowa counties for 1967, 1969, and 1970. Unpublished data. Des Moines, Iowa, Iowa ASCS State Office. ca. 1967, 1969 and 1970.

36. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Iowa 1967 feed grain program sign-up report. Des Moines, Iowa, Iowa ASCS State Office. March 28, 1967.

37. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. Iowa 1967 annual activity summary. Des Moines, Iowa, Iowa ASCS State Office. April 1968.

38. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. Iowa program summary 1968. Des Moines, Iowa, Iowa ASCS State Office. 1968.

39. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. Base acres on farms enrolled in the 1969 U.S.D.A. feed grain program. Des Moines, Iowa, Iowa ASCS State Office. April 30, 1969.

40. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. 1970 feed grain bases and yields. Iowa notice PA-201. Des Moines, Iowa, Iowa ASCS State Office. Nov. 4, 1969.

41. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. 1970 feed grain program compliance data, Iowa counties. Unpublished data. Des Moines, Iowa, Iowa ASCS State Office. ca. Dec. 1970.

42. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Data Division. 1963, 1964, 1965 county, 1959-60 adjusted average corn yields, Iowa. (Xerox copies). Federal Register 28: 6044, June 14, 1963; 29: 3337, March 13, 1964; 30: 5340, April 1965.

43. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Data Division. 1962 through 1966, 1968, 1969 and 1970 feed grain program annual summary for Iowa counties. Unpublished data. 1962 through 1966, 1968, 1969 and 1970.

44. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Data Division. 1964 feed grain program frequency distribution. Pp. 36, 37. Oct. 1965.

45. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Data Division. 1966 through 1969 county projected corn yields, Iowa. Unpublished data. 1966 through 1969.

46. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Data Division. 1970 crop corn, grain sorghum and barley basic support rates for counties. Unpublished data. 1970.

47. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Data Division. 1966 through 1970 feed grain and wheat program summary. April 1967; April 1968; Jan. 1969; Mar. 1970; Dec. 1970.

48. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service, Information Division. Fact sheet--35th anniversary of agricultural adjustment act of 1933. May 1, 1968.

49. U.S. Dept. of Agr. Commodity Credit Corporation. 1962 through 1966 and 1969 crop barley basic support rates for counties. (reprints). Federal Register 27: 8159, Aug. 16, 1962; 28: 8273, Aug. 13, 1963; 29: 11826, Aug. 19, 1964; 30: 10936, Aug. 24, 1965; 31: 9842, July 21, 1966; 34: 9796, June 25, 1969.

50. U.S. Dept. of Agr. Commodity Credit Corporation. 1961, 1962, 1963, 1965, 1966, 1968 and 1969 crop corn basic support rates for counties. (reprints). Federal Register 27: 10031, Oct. 26, 1961; 28: 10203, Oct. 18, 1962, 28: 11224, Oct. 19, 1963; 30: 14361, Nov. 17, 1965;

31: 14307, Nov. 5, 1966; 33: 14449, Sept. 26, 1968; 34: 16423, Oct. 16, 1969; and 34: 17385, Oct. 28, 1969.

51. U.S. Dept. of Agr. Commodity Credit Corporation. 1961 through 1969 crop grain sorghums basic support rates for counties. (reprints). Federal Register 26: 5569, June 22, 1961; 27: 8169, Aug. 16, 1962; 28: 8277, Aug. 13, 1963; 29: 11830, Aug. 19, 1964; 30: 10940, Aug. 24, 1965; 31: 9847, July 21, 1966; 32: 9824, July 6, 1967; 33: 9948, July 11, 1968; 34: 12081, July 18, 1969 and 34: 13078, Aug. 13, 1969.

52. U.S. Dept. of Agr. Economic Research Service. Feed Situation Fds 184, Nov. 1960; Fds 185, Feb. 1961; Fds 191, Feb. 1962; Fds 207, Feb. 1965; Fds 212, Feb. 1966; Fds 217, Feb. 1967; Fds 222, Feb. 1968; Fds 227, Feb. 1969; Fds 232, Feb. 1970; Fds 237, Feb. 1971. Fds 247, Feb. 1973.

53. U.S. Dept. of Agr. Economic Research Service. Feed Situation. Fds 196, April 1961; Fds 197, Feb. 1963, Fds 199, May 1963; Fds 206, Feb. 1965; Fds 221, Nov. 1967; Fds 227, Feb. 1969; Fds 232, Feb. 1970; Fds 237, Feb. 1971.

54. U.S. Dept. of Agr. Economic Research Service. Feed Situation. Fds 232, Fds 236, Fds 239. Feb. 1970; Nov. 1970; May 1971.

55. U.S. Dept. of Agr. Economic Research Service. Feed statistics through 1966, feed grain. Statistical Bul. 410. Sept. 1967.

56. U.S. Dept. of Agr. Economics Research Service. Supplement for 1969 to feed statistics, feed grains. Supplement for 1969 to Statistical Bul. 410. Oct. 1969; Supplement for 1971 to Statistical Bul. 410, July 1972.

57. U.S. Dept. of Agr. Agricultural Stabilization and Conservation Service. 1971 Set-aside programs annual report: cotton, wheat, feed grain. Jan. 1972.

58. Vermeer, James. An economic appraisal of the 1961 feed grain program. U.S. Dept. of Agr. Economic Research Service, Farm Production Economic Division Agr. Econ. Rpt. 38. June 1963.

59. Wilcox, Walter W. Economics of expiration or extension of the food and agricultural act of 1965. In farm program choices. Pp. 67-72. Center for Agricultural and Economic Development, Iowa State University CAED Report 35. 1970.

60. Wilcox, Walter W. Large farm program payments and implications of proposals for limitations. Washington, D.C., Legislative Reference Service, Library of Congress. Feb. 19, 1969.

APPENDIX A

DETAILS ON FEED GRAIN PROGRAM PROVISIONS

The following rules and provisions prevailed over the period of the program:

Over the period 1961-70, the base acreages of feed grains (corn and grain sorghum) were determined by average acreages planted in 1959-60 subject to adjustment by the County Agricultural Stabilization Committee.

Normal, projected or total production was normal, projected or actual yield per acre x acres of feed grain base planted.

Small producers (small farms) were those with a feed grain base of 25 acres or less. In all years, 1961-70, they had the option to divert 100 percent of their base for a diversion payment.

Over the period 1961-63, farmers with feed grain bases of 26-99 acres could divert 20 acres plus 20 percent of the base as a maximum while farmers with bases of 100 or more acres were limited to 40 percent. Producers could temporarily assume a 25 acre base and receive diversion payments as a small producer, providing no feed grains were planted on the farm.

Over the period 1964-65 if any farmer diverted in the range from 40 percent through 50 percent of his base the payment factor became 50 percent for the minimum diversion.

For 1964-70 producers who signed up for wheat and feed grain programs could substitute acreages of these grains. Farmers requesting an oats-rye base could substitute wheat for oats and rye. Plantings of other feed grains on such farms could not exceed the feed grain base.

A farmer planting at least 45 percent of his feed grain base acreage for payment was considered to have planted 50 percent for price support payment for 1966-70.

Farms with feed grain bases of 26-73 acres in 1966 (26-125 acres in 1967-70) could temporarily assume a 25 acre base and receive diversion payments as if he were a small producer, providing no feed grains were planted on the farm.

In 1968, participants could plant soybeans in lieu of feed grains without loss of feed grain price support payments.

APPENDIX B

FEED GRAIN PROGRAM TIME SERIES AND CROSS SECTION DATA, 1961-70

Numerous sources were used in compiling data on the various categories of variables. Feed Grain Program eligibility, enrollment and compliance data were obtained from ASCS sources for the 48 states (29, 30, 31, 46, 47, 48) and the 99 counties in Iowa (33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45). The ASCS data are an enumeration of the entire population (i.e., acres diverted in a given county or state). Other major sources were: 1959 and 1964 U.S. Census of Agriculture, Iowa Annual Farm Census, Iowa Crop and Livestock Reporting Service, Federal Register and several USDA periodicals (24, 25, 26, 28, 44, 46, 48, 49, 51, 52, 53, 54, 55, 57).

Lists are presented in Table B-1 through B-3 of data which are assumed to vary with years, counties or states. Some variables are listed in the form taken from the source and are transformed or combined with another variable before analysis while other variables are presented as ratios or proportions and are transformed before analysis. Some data referenced will serve only as weights in constructing other variables.

Variables of Direct Profitability for Participation

Variables in Table B-1 are those which directly affect the profitability of farmer participation in the feed grain program and also relate to the proportion of land or feed grain base he might be expected to divert. The column on the right indicates whether the variable is likely to express its affect largely through different magnitudes among years, geographic areas or both.

Variables relating to the diversion of 21 to 40 percent of the feed grain base and 41 to 50 percent of it, items six and seven in Table B-1,

Table B-1. Variables directly relating to participation profitability, 1961-70

Variable	Effect expressed through difference among
Corn national loan rate (dollars)	years
Price Support Payment rate for corn ($/bu.)	counties, states and years
Soybean national loan rate (dollars)	states and years
Maximum proportion of base eligible for price support payment (1st 20% Div.)	counties, states and years
Minimum diversion payment rate	counties, states and years
21-40 percent diversion payment rate	counties, states and years
41-50 percent diversion payment rate	counties, states and years
Maximum proportion of base eligible for diversion	counties, states and years

require adjustment on 1963-65 for use in statistical analysis. In 1963-65 the Price Support Payment (PSP) was paid on a maximum of 80 percent of the normal production of the farmer's feed grain base. Details on payment provisions for diverting various acreages and proportions of the farmers feed grain base are provided in Table 1 above and Appendix A. For any additional diversion he did not receive the PSP for normal production but did gain a diversion payment per acre. Thus, a "PSP adjustment" factor is required to obtain the "Effective" Diversion Payment Factor (EDPF).

Another adjustment is required for the 41 to 50 percent Diversion Payment Factor (DPF), based on a program provision indicated in the fifth note of Appendix A for 1964 and 1965. This provision allowed the DPF for minimum diversion to increase to 0.50 if the farmer diverted as much as 41 percent of his feed grain base. This provision has the effect of increasing the magnitude of the "EDPF" for 41 to 50 percent diversion. The calculations for the EDPF and adjustments are obtained by considering a hypothetical farmer influenced by actual program provisions as follows:

Normal Yield (NY) = 100 bushels per acre (bu./ac.)

Feed grain base = 100 acres

Total Price Support Rate (TPSR) for corn = $1.25 (1963-65 actual)

PSP is $0.18/bu. in 1963, $0.15/bu. in 1964, and $0.20/bu. in 1965.

The diversion payment factor (DPF) is 0.50 for both 21-40 percent in 1963-65 and 41-50 percent in 1964-65.

Diversion Payment (DP) per acre is:

(NY/ac.) x (TPSR/bu.) x (DPF) = DP/ac.

and "PSP adjustment" = (PSP/bu.) x (NY/ac.)

Since NY/ac. = 100 bu., we conveniently use a per bushel basis giving a 1963 DP/bu. of (1.25) x (0.50) - 0.18 = $0.445/bu. To determine an adjustment, X, to the DPF, set:

(0.50-X) x ($1.25) = (0.50) x ($1.25) - $0.18

solving

X = $0.18/$1.25 = 0.144

For 1963 with consideration for a "PSP adjustment" we calculate the effective diversion payment factor (EDPF) as EDPF = 0.50 - 0.144 = 0.356

Similarly

X = $0.15/$1.25 = 0.12

X = $0.20/$1.25 = 0.16

and

EDPF = 0.50 - 0.12 = 0.38

EDPF = 0.50 - 0.16 = 0.34

for 1964 and 1965 respectively.

Consider the information for the hypothetical farmer and the program with the additional assumption that diversion is at the maximum level of 50 percent of the base. The gain in revenue for the first 20 percent of diversion, with the DPF going from 0.20 to 0.50 for the entire 20 acres is:

(20 ac.) x ($1.25/bu.) x (0.30) x (100 bu.) = $750

while the total payment for the 10 acres diverted for 41 to 50 percent of the base is:

(10 ac.) x ($1.25/bu.) x (0.50) x (100 bu.) = $625

Adding these two quantities and equating the result, $1,375, to the left-hand side of the second equation

(10 ac.) x ($1.25/bu.) x (X) x (100 bu.) = $1,375

solving for the EDPF:

X = 1.10

the EDPF for 41 to 50 percent diversion in 1964-65 with the above assumption of 50 percent of base diverted. Since DPF for minimum diversion increases to 0.50 with only 41 percent diversion EDPF would be larger if we assumed the farmer diverted less than 50 percent of the base. This maximum diversion assumption reflects the maximum possible outcome to the farmer exploiting the full range of the provision. Correcting the EDPF of 1.10 for the "PSP adjustments" of 0.12 and 0.16, the adjusted EDPF's are 0.98 and 0.94 for 1964 and 1965 respectively.

Summarizing the adjustments, the diversion payment factors, DPF, become:

	For diversion of	
	21-40%	41-50%
Year		
1963	0.356	none
1964	0.38	0.98
1965	0.34	0.94

Since the DPF's are important in the Program decision, the above adjustments are applied in using data for the statistical analysis.

Variables Expressing Differences Among States

Variations among states with respect to type of farm (for example, cash grain as compared to livestock as the main profit source) and farm size also relate to profitability of program participation. Other differences among states with similar expected effects relate to size of feed grain base, base acreage on farms with a base greater than 25 acres, total cropland and production of livestock. These variables, or transformation of them, are listed in Table B-2.

The first and second variables, expressed as ratios, in Table B-2 are referred to as "large farm" and "cash-grain farm" indices and serve as weights when it is assumed that the variable weighted is of importance for large or cash-grain farms. Production weights reflect the relative importance of certain enterprises. The beef and hog weights are the ratio of pounds of production in 1960, 1965 and 1969 for the state to the same quantity for the 48 states. Soybean weights are based on 1959 and 1960 production rather than include years from 1961-70, since the pattern of soybean production by states may have been influenced by the Feed Grain Program.

Table B-2. Variables affecting profitability of participation among states and/or counties and used as weighting factors for program variables directly relating to profitability of participation.

Variable	Affects participation through:
1964 acres in farms of less than 100 ac. divided by acres in all farms (small farm index)	farm or base size
1964 base acres on farms with base > 25 acres divided by total base acres (large farm index)	farm or base size
1959 corn, grain sorghum and barley acres on cash-grain farms divided by the corresponding crop acreages on all commercial farms (cash-grain farm index)	type of farm
Production of hogs, cattle and soybeans	profitability of other enterprises
1964 feed grain base weights for states within a region: barley, corn, grain sorghum and total	relative importance of feed grain production
1970 cropland acres	relative feed grain production potential

Choice of hogs and cattle as production weights to be incorporated into independent price variables is a result of both logical considerations and past studies. Harms (8, p. 195) in his analysis of participation and nonparticipation from a 1962 Feed Grain Program in Illinois found significant differences for beef cattle sold and hogs raised but not for dairy farmers. These findings and relatively heavy utilization of cattle and hog feeding for feed grains as opposed to dairying supported the choice of weights and corresponding price variables. Dairy intense areas such as northeast Iowa and Wisconsin might show a feed grain program response to the price of milk. However, the dairy enterprise production is likely to be less variable in the short than hog and cattle production.

For models explaining diversion for the 48 states with state data only, several states which are relatively less important feed grain producers are aggregated into regions. Figure 2 above shows the grouping of states by regions. Feed grain base weights are formed from each state's base (total and for each feed grain) as a ratio to the similar base for the region. Cropland data for states were obtained for only 1970 and thus are listed in Table B-2 even though cropland may have varied somewhat over years.

Variation by States or Counties and Years

Table B-3 includes variables which vary by county or state and years, along with the variables of Table B-1, are expected to influence participation rate through differences among counties and states and over time. Data which vary by counties or states and years are the mixed data referred to earlier. Most of these variables are formulated for both counties in Iowa and the 48 states (actually 15 states and five regions). Some variables (such as the bases for the several feed grains) for the states were compiled in developing weights for reflecting differences across states and regions in importance of various feed grains.

Price support rates for loans are published by counties for program administration purposes. As an approximation of the relevant loan rate for a state model, the simple average was obtained over all counties for each feed grain and soybeans where rates differed among counties in a state.

Weights determined according to each county's share of the feed grain base or production in the state are appropriate for these averages, but were not used because of the high cost of calculating the weights. While

Table B-3. Variables for analysis with variation by county or state and years, 1961-70[a]

Variable	Units	Aggregation level for analysis	Affects participation through:
Price support rate (loan):			
Barley	$/bu.	state	returns from participation
Corn	$/bu.	county state	
Grain sorghum	$/bu.	state	
Soybeans	$/bu.	county state	profit relative to feed grains
Normal (projected) yield	bu./ac.	county	level of payment
Barley base	ac.	state	profit of cropping
Corn base	ac.	state	profit of cropping
Grain sorghum base	ac.	state	profit of cropping
Total diversion and price support payments	$/ac.	county	profitability of diversion
Cropland	ac.	county	acreage feed grain eligible
Acres diverted divided by cropland		state[b] county[b]	dependent variable
Corn yield, past 3 yr. moving average	bu./ac.	county	relative profit
Soybean yield, past 3 yr. moving average	bu./ac.	county	profit relative to feed grain
Barley price, 1st 3 mo. of current marketing season	$/bu.	state	loan rate relative to expected price

Table B-3. (continued)

Variable	Units	Aggregation level for analysis	Affects participation through:
Corn price, 1st 3 mo. of current marketing season	\$/bu.	county state	loan rate relative to expected price
Grain Sorghum price 1st 3 mo. of current marketing season	\$/cwt.	state	loan rate relative to expected price
Soybean price 1st 3 mo. of current marketing season	\$/bu.	county	profit relative to feed grain
Hog price, average for previous year	\$/cwt.	Iowa state	livestock profitability
Cattle price, average for previous years	\$/cwt.	Iowa state	livestock profitability
Corn variable production cost	\$/ac.	county	profit of cropping
Soybean variable production cost	\$/ac.	county	profit of cropping

[a] Selected data for States and regions and Iowa Counties are reported in Appendix B, Tables B.5, B.6 and B.7 of Harrison (9). The remaining data may be obtained from the authors.

[b] Total diverted acres for 1966-70 were obtained from the individual "state annual reports" in the Feed Grain and Wheat Program Summaries while 1961-65 data were given on page 159 of the 1969 edition (47). In 1967, acres diverted for Iowa counties were estimated as 0.96 of the diversion intention (sign-up) since the final diversion was not available.

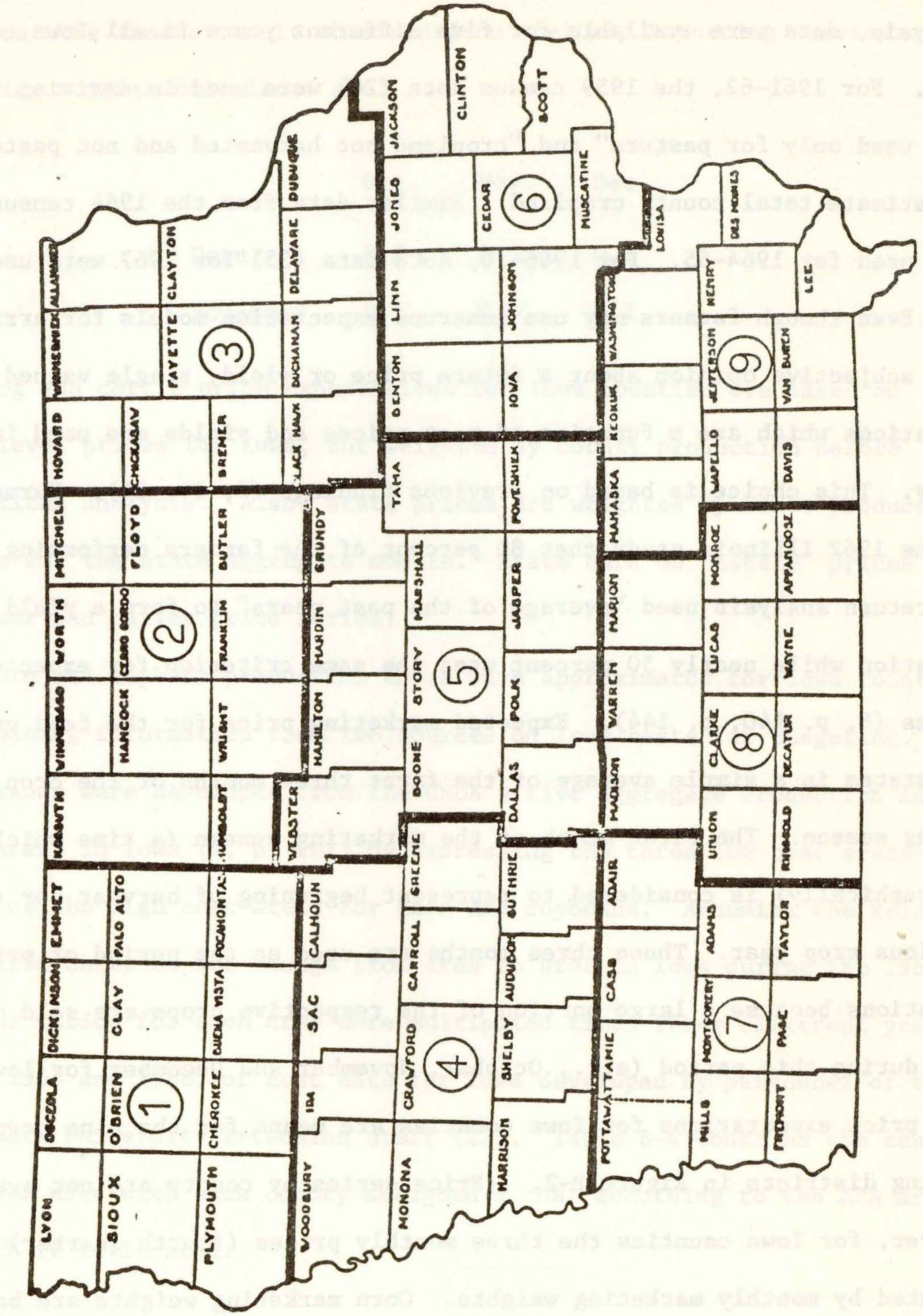

Figure B-2. Iowa Counties by the Nine Crop Reporting Districts.

only one set of cropland averages (1970) was available for the state analysis, data were available for five different years in all Iowa counties. For 1961-62, the 1959 census data (26) were used in deriving "cropland used only for pasture" and "cropland not harvested and not pastured", to estimate total county cropland. Similar data from the 1964 census (28) were used for 1964-65. For 1966-70, ASCS data (35) for 1967 were used.

Even though farmers may use numerous expectation models for arriving at a subjective opinion about a future price or yield, single valued expectations which are a function of past prices and yields are used in this study. This choice is based on previous findings (8, 16, 21). Harms found in the 1962 Illinois study that 80 percent of the farmers performing a cost and return analysis used "average of the past years" to form a yield expectation while nearly 50 percent used the same criterion for expected prices (8, p. 140, p. 144). Expected marketing price for the feed grains for states is a simple average of the first three months of the crop marketing season. The first month of the marketing season (a time which varies geographically) is considered to represent beginning of harvest for the previous crop year. These three months are used as the period of price expectations because a large portion of the respective crops are sold off the farm during this period (e.g., October, November and December for Iowa corn). Crop price expectations for Iowa counties are means for the nine crop reporting districts in Figure B-2. (Price series by county are not available). However, for Iowa counties the three monthly prices (fourth quarter) were weighted by monthly marketing weights. Corn marketing weights are based on the 1958-59 average monthly marketing receipts at the "13 primary markets" (54, 55) while soybean marketing weights were based on the 1965-69 average "Iowa soybean receipts at mills" (24). The first three months of

the Iowa soybean markting season are September-November, but October-December data were inadvertently obtained from the Crop Reporting Service. The marketing weights calculated are:

	Oct.	Nov.	Dec.
Corn	0.2	0.5	0.3
Soybeans	0.5	0.3	0.2

Hog and cattle price expectations for Iowa counties are based on state level prices for Iowa, but weighted by county production before statistical analysis. Also, state prices are weighted by state production weights for the state aggregate models. State data on "cattle" prices are the steer and heifer price series.

Corn and soybean production costs were approximated for Iowa counties by combining information from two sources on Iowa costs for budgeting. Proportions were developed from the USDA's five Aggregate Production Analysis (APA) areas in Iowa (9, p. 101) by expressing the three low cost areas as ratios of the high cost areas for corn and soybeans. Assuming the relative cost differences do not change from area to area in Iowa during the 1960's, the four ratios for each crop were multiplied times three different years (1962, 1965 and 1968) of cost data for Iowa developed by personnel of the Iowa State University Extension staff (22). Table B-4 contains the cost estimates used with each county assigned a cost according to the APA area in which it is located.

Table B-4. Estimated corn and soybean production costs for Iowa, 1961-70.

Source Year	For	APA area 4 Corn	4 SB	5 and 8 Corn	5 and 8 SB	6 Corn	6 SB	7 Corn	7 SB
		(Dollars/acre)							
1962	1961-63	23	19	27	19	23	21	27	20
1965	1964-67	27	20	31	20	27	22	31	21
1968	1968-70	39	24	45	24	39	27	45	26

Production costs in Table B-4 include machine depreciation but are otherwise comparable to total variable costs. Cost estimates are used to develop net revenue variables for corn and soybeans in Iowa counties for statistical analysis.

APPENDIX C

RESULTS OF ALTERNATIVE SPECIFICATIONS FOR DIVERSION MODELS OF THE 48 STATES

Deflating the policy and price variables, as in the case of the Iowa model, left the overall significance of the regression and the relative significance of the individual coefficients essentially unchanged. The level of significance for the weighted livestock price (t-1) was reduced to the 0.10 level while the significance of other deflated variables increased slightly. When deflating diverted acres with feed grain base as an alternative, an $\bar{R}^2 = 0.77$ (uncorrected for state and region effects) was obtained. Feed grain base divided by cropland was not included, but the national soybean loan rate had a positive and significant relationship.

In order to gain additional information on the importance of choice of deflators, diverted acres were regressed upon the set of independent variables for the diversion model in Table 6 plus the feed grain base acreage in one case and the cropland acreage in another [see Appendix D, Table D.3 of Harrison (9) for results]. Both fits adjusted for sums of squares due to cropland or feed grain base have $\bar{R}^2 = 0.95$ (unadjusted for state and region effects). In both of the alternative specifications, the minimum diversion payment variable is not significant at 0.10 level. Further adjusting for the sums of squares due to states and regions gives $\bar{R}^2 = 0.53$ and 0.55 respectively for the models with feed grain base as an independent variable and cropland as an independent variable. These findings cast doubt on the higher overall significance of regression obtained by using cropland as deflator for the dependent variable in lieu of the feed grain base deflator.

The analysis of the data for 15 States and five regions is similar to the Miller and Hargrove study (15). Three of the variables for the diversion model in Table 6 ("loan-price" and the 21-40% and 41-50% diversion) are similar to those specified by Miller and Hargrove. All of these variables were significant in the Miller and Hargrove model. The "loan-price" variable differs in this study in that the crop loan rate and the expected price is an average of the first three months of the market year for the respective crop and State or region. Alternatively, Miller and Hargrove take the difference between the total price support rates and the January 15 prices of each feed grain for the United States.

Miller and Hargrove reported a "maximum proportion of base eligible for diversion" variable = (maximum proportion of base eligible for diversion payments) (large farm index) + (1 - large farm index) as significant. A similar variable was specified for consideration, along with the variables in Table 6, but did not prove to be significant. In fact, the analogous variables reported by Miller and Hargrove as significant in their national pooled model were considered for the data set analyzed in this study (with diverted acres divided by total base as the dependent variable). Time trend, "loan-price", 21-40% and 41-50% payment rates were all highly significant, but the maximum diversion variable was not significant while $\bar{R}^2 = 0.75$, unadjusted for State and region effects [Appendix D, Table D.4 of Harrison (9)].

They also considered a minimum DPF x TPSR variable in an initial part of their study but removed it from the analysis because of intercorrelation with the time trend variable. However, as indicated in footnote b of Table 5, a PSP component is included in the weighted minimum DPF variable. This variable is significant in both the Iowa Counties (Table 5) and the 48 States (Table 6) diversion models along with time

trend. Intercorrelation between "time" trend and the weighted minimum DPF is also very high, -0.90, while in comparison "time" and the "21-40%" and "41-50%" variables have simple correlation coefficients of only -0.21 and 0.31 respectively.

APPENDIX D

EXAMINATION OF RESIDUALS FOR SELECTED MODELS

Autocorrelation

One of the assumptions of linear regression used in this study is that of independence of disturbances, $E(u_i u_j) = 0$ for all i and j, i not equal to j. This implies that the u_i are pairwise uncorrelated or that successive residuals $(Y_i - \hat{Y}_i)$ are drawn independently of previous values. Deviations from the assumptions of independence of residual errors is referred to as serial correlation or autocorrelation of errors (13, p. 177). Autocorrelation is often a problem in time series analysis so it is of special interest in this study.

Two general situations may lead to autocorrelation. First, explanatory variables that are a part of the true relationship have been omitted. If there is serial correlation in the omitted variables that does not cancel out, autocorrelation of errors is possible. Secondly, if there is measurement error in the dependent variable or independent variables, this also can create autocorrelation in the disturbance.

When autocorrelation of disturbances is present, the ordinary least squares estimators, b, will provide unbiased estimates of the B parameters, but sampling errors of b may be larger than by an alternative method of estimation, generalized least squares (13, p. 179). Application of the least squares formulae are likely to underestimate the variances of the b. Thus, we have inefficient predictions because of large sampling variation and the precise forms the t- and F- tests are not valid.

A commonly used test for the presence of a serious autocorrelation problem is the Durbin-Watson d-statistic (13, p. 192):

$$d = \sum_{t=2}^{n} (e_t - e_{t-1})^2 / \sum_{t=1}^{n} e_t^2$$

where e_t ($t = 1, 2, \ldots, n$) are the residuals ($e_t = \hat{u}_t$) from a fitted least squares regression equation. Durbin-Watson have tabled lower and upper bounds (d_l and d_u) for a one-sided test of positive autocorrelation (2, p. 672). If $d < d_l$, the hypothesis of random disturbances is rejected admitting positive autocorrelation. With $d > d_u$, we accept the above hypothesis and $d_l < d < d_u$ permits no conclusion. To check for negative serial correlation in the disturbances a test $4-d_l < d < 4$ is used (2, p. 526).

Theil and Nagar (23, p. 802) have calculated alternative significance points for this test which eliminates the Durbin-Watson "grey area" ($d_l < d < d_u$). If the Durbin-Watson d-statistic is greater than the Theil and Nagar table value then we cannot reject the null hypothesis of no autocorrelation. Theil and Nagar have provided formulae to handle positive autocorrelation tests when the number of observations and independent variables are greater than for those of the tabled significance points (23, p. 803). The test statistic is:

$$y = [d-2(n-1/n-P)]/2/\sqrt{n+2})]$$

An alternative procedure for testing for the presence of autocorrelation is based on the first-order autoregressive model which is:

$$u_t = \rho u_{t-1} + z_t$$

where u_t are the residuals, ρ is the autocorrelation coefficient, $/\rho/<1$, u_t is NI(0,1) and $t = 2, \ldots, n$. With simple regression, of u_t on u_{t-1}, the estimate of ρ may be tested for significant difference from zero. The least squares estimate of ρ is biased and may be adjusted adding an approximate correction of 1/n-1. (This procedure and approximate correction for bias was suggested by Dr. Wayne Fuller of the Statistics Department, Iowa State University).

When testing for autocorrelation of errors for the mixed model regression with the Durbin-Watson d-statistic, special care must be given to order of the residuals. A d-statistic is based on differencing the regression residuals for successive observations in the time series. In the case of the mixed regression model, there are m-1 differences at a given point in time, i.e. $e_{2,1} - e_{1,1}$; $e_{3,1} - e_{2,1}$; ...; $e_{m,1} - e_{m-1,1}$; $e_{1,2} - e_{m,1}$; ...; $e_{m,n} - e_{m-1,n}$. This situation would result because of ordering the mixed data sample by observations within years. When the data are ordered by cross section over time, the proper numerator for the d-statistic is $\sum_{i}^{m} \sum_{t=2}^{n} (e_{i,t} - e_{i,t-1})^2$ so that each observational unit is differenced only with itself lagged over time for m x n-1 differences.

Despite the re-ordering procedure the Durbin-Watson d-statistic may not be strictly applicable to the mixed or pooled data analysis. Kuh (14) points out that the error term, u, of the mixed model has two additive components: (1) the constant individual observational unit effect and (2) a random component which varies with time. However, Kuh points out that if the individual observational unit effect is not persistent over time then the first component would be of little importance.

Nevertheless, the Durbin-Watson d and the Theil Nagar transformation of d is considered for selected time series and mixed data models. Also an estimate of the first order serial correlation is calculated for Iowa Counties and the "48 States" mixed models. Even though these procedures may not be strictly applicable they are carried through here to give some indication of the presence of autocorrelation.

The models considered for testing for autocorrelation are those in Tables 5 and 6 above. Durbin-Watson d-statistics are reported below, along with an estimate of the autocorrelation coefficient from a first order autoregressive model.

Mixed model	Durbin-Watson d	Theil and Nagar y	Theil and Nagar 1% Sign. point	Autocorrelation Coefficient	Test
Iowa Counties	0.607	-22.262	1.879	0.798	30.548
"48 States"	1.592	-5.033	1.973	0.220	3.089

Number of observations and explanatory variables for both models exceed what are available in significance point tables. The Theil and Nagar results indicate that the hypothesis of random errors must be rejected for both models. Autocorrelation appears to be much more serious in the Iowa Counties mixed model. Results from the least squares estimation of ρ adjusted for the approximate bias of 1/n-1 with n equal to 10, the number of years in the series. The t-tests for "48 States" and Iowa Counties have 178 and 890 degrees of freedom respectively. Both t-values are highly significant, but the Iowa Counties model appears to have a much higher serial correlation than the "48 States" model.

Restraint must be exercised in interpreting the level of significance obtained for t-values especially for the Iowa Counties model. Even though significant serial correlation has been identified in both models, they may still give reliable predictions.

A Durbin-Watson d of 2.453 was calculated for the Iowa time series model reported in Table 7. Since there are no significant points tabled for only 10 observations, we cannot compare this d directly. Since 2.453 is greater than 1.97, the nearest appropriate Durbin-Watson table value (2, p. 672), this shows a tendency for the presence of serial correlation. But it appears that 2.453 is short of the negative serial correlation (rejection range) being within a "grey" area defined by the bounds $4d_u$ (2.03) and $4d_l$ (3.31) shown in Christ (2, p. 526) where $d_u = 1.97$ and $d_l = 0.69$, the nearest appropriate Durbin-Watson table values.

Examination of Plots

Plots were examined for the states and regions total diversion model reported in Table 6. A plot of residuals on time did not reveal a trend suggesting autocorrelation. Since there are only 10 years for this plot, limited reliance should be placed in this test. However, the test does suggest that autocorrelation is not severe.

An additional plot of residuals against predicted values for the model indicated no apparent pattern. This suggests an adequately specified model and homogeneity of variances. A plot of normalized residuals revealed no evidence to negate the assumed normal distribution of residuals for the States and regions model.

Implications for Estimating Procedure and Models

Where autocorrelation is shown to exist, generalized least squares is an alternative estimation procedure which reduces sampling variances of the estimates. However, this procedure requires knowledge of the

serial correlation, ρ, for the disturbances of the model (13, p. 180). For the special case when ρ can be assumed to be unity, the appropriate transformation of all variables is to take first differences then estimate parameters by ordinary least squares (13, p. 187).

Graphic analysis may suggest that certain explanatory variables should be added in order to remove autocorrelation. One important possibility is a time variable which may contribute to randomizing the residuals. A time variable is already present in the models for this study. Plotting residuals against other candidates for explanatory variables may help identify which variables might be contributing to autocorrelation in the residuals (4, chap. 3). Numerous possibilities arise which may improve an autocorrelation problem.

Plots may suggest that a nonlinear form of a variable would reduce autocorrelation such as a quadratic form of a variable where a curvilinear relationship appears. It is possible that further analysis may show that one or more non-linear variables might improve the models discussed above. However, prior studies on feed grain program response and theoretical and intuitive considerations do not support the presence of non-linear relationships.

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ACREAGE DIVERSION RESPONSE UNDER THE 1961-70 FEED GRAIN PROGRAM

CARD Report 71

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