AN ECONOMETRIC ANALYSIS OF U.S. WHEAT ACREAGE RESPONSE: THE IMPACT OF CHANGING GOVERNMENT PROGRAMS

By

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FOREWORD

This study is an attempt to evaluate effectiveness of farm commodity programs and farmers' response to market prices. The author gratefully acknowledges the valuable assistance and suggestions from the faculty and staff of the Department of Agricultural Economics, North Dakota State University. The author expresses his special appreciation to Lori Clark for her helpful assistance.

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Highlights

A dynamic supply response model is developed to evaluate effectiveness of farm commodity programs and farmers' responses to market prices. Particular attention is focused on the wheat programs of the 1970s. Variables specified in this study are acreage allotment, additional diversion, set-aside, dummy variable representing no allotments, another dummy variable representing the farmer owned reserve program, season average wheat price received by farmers, and the feed grain price index. The basic structure of the acreage response model used in this studv is the second order difference equation with season average wheat price lagged one year.

All government programs entered significantly in all, winter, and spring wheat models. However, producers' responses to government programs are different for winter and spring wheat. The acreage allotment program appears to be more important in the acreage response model for winter wheat than for spring wheat.

On the other hand, the set-aside, diversion and farmer owned reserve programs are more important in acreage response for spring wheat than for winter wheat. This is mainly due to the interrelation between production practices and the nature of government programs. This study also indicates that all government programs are simultaneously significant at the 99 percent probability level for all, winter, and spring wheat.

In addition to government programs, wheat and feed grain prices are also important when making a production decision. Acres planted are positively related to wheat prices and the feed grain price index. This indicates that wheat is a good substitute for feed grain. The price elasticities of acreage response are inelastic for all, winter, and spring wheat. The price elasticity for winter wheat is more inelastic than that for spring wheat. The reason for this is that while production of spring wheat can be replaced with other crops such as sunflower and barley, such replacements are not available in winter wheat regions.

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Wheat producers face greater market uncertainty than producers of any other grains. Reasons for this are: 1) the percentage of exports to total production is greater for wheat than for other grains, and 2) the exports are largely dependent on generally uncontrollable crop conditions in importing countries as well as other exporting countries.

Because of the uncertainty in wheat production and exports, various government programs have been introduced to control domestic wheat production. Since 1961, the major acreage control programs, such as the acreage allotment with diversion program, the national acreage program, and the set-aside program have significantly influenced producers' decisions to plant wheat. Participation in recent wheat programs has been voluntary rather than mandatory. Consequently, one unequivocal aspect of agricultural supply response is its complex structure which is based on government programs and the dynamic behavior of market prices.

This paper has two objectives: to evaluate effectiveness of farm commodity programs and farmers' response to market prices. Particular attention is focused on the wheat programs of the 1970's, especially the national acreage and farmer owned reserve programs based on the Agriculture Act of 1977.

After a few comments about the institutional setting in which the wheat programs have operated, the analytical model underlying the empirical measurements is developed. Then the results of applying this model to the U.S. wheat sector are presented and discussed.

U.S. Wheat Industry and Government Programs

Wheat can be categorized as winter and spring wheat. Because of differences in production practices between these two types of wheat and

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differences in quality, producers' responses to government programs and market prices differ between them. Figure 1 shows the amount of acres planted for winter, spring, and all wheat. Winter wheat production is much greater than spring wheat production in the United States. The total winter wheat acres planted is approximately 74 percent of the total wheat acres planted in the United States, and the total spring wheat acres is about 26 percent. Spring wheat production is highly concentrated in the northern plains (North Dakota, South Dakota, Minnesota, and Montana). On the other hand, winter wheat is produced in the rest of the plains states. In general, spring wheat prices were higher than winter wheat prices over the last 20 year period (Figure 2). The average price of spring wheat was $1.74 in 1967 dollars for this period, which is about $.14 higher than the average winter wheat price. Except for this, both wheat prices moved in the same direction. Both wheat prices were highest in 1974 and lowest in 1969, in 1967 dollars.

Major government programs associated with wheat acreage control in the 1960's were allotment and diversion programs.[1] Under these programs, participating wheat producers were given acreage allotments which served as upper limits in their plantings. For some years, the programs offered the additional option of diverting acres below the allotments for additional payments. Participants of the programs were eligible for program benefits such as use of the loan support option and receipt of diversion payments.

Under the Agricultural Act of 1970, the allotment program was replaced with the set-aside program for the 1971-73 crop years.[2] Participating producers were required to withdraw cropland from production under the set-aside program. Benefits for participants included use of the loan support program and receipt of certificate payments as a compensation for the required set-aside.

The diversion and set-aside programs appear to be similar, but they are significantly different. The diversion program <u>limited wheat allotment acres</u> and the set-aside program <u>idled acres</u> from total cropland on the farm as a unit. Consequently, the programs have different impacts upon acres planted to wheat.

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[1]Cochrane, Willard, and Mary E. Ryan, <u>American Farm Policy, 1948-1973</u>, (Minneapolis: University of Minnesota Press), 1976. U.S. Department of Agriculture, <u>Wheat Situation</u>, (Washington, D.C.: USDA), various issues.

[2]Cochrane and Ryan, 1976. U.S. Department of Agriculture, various issues.

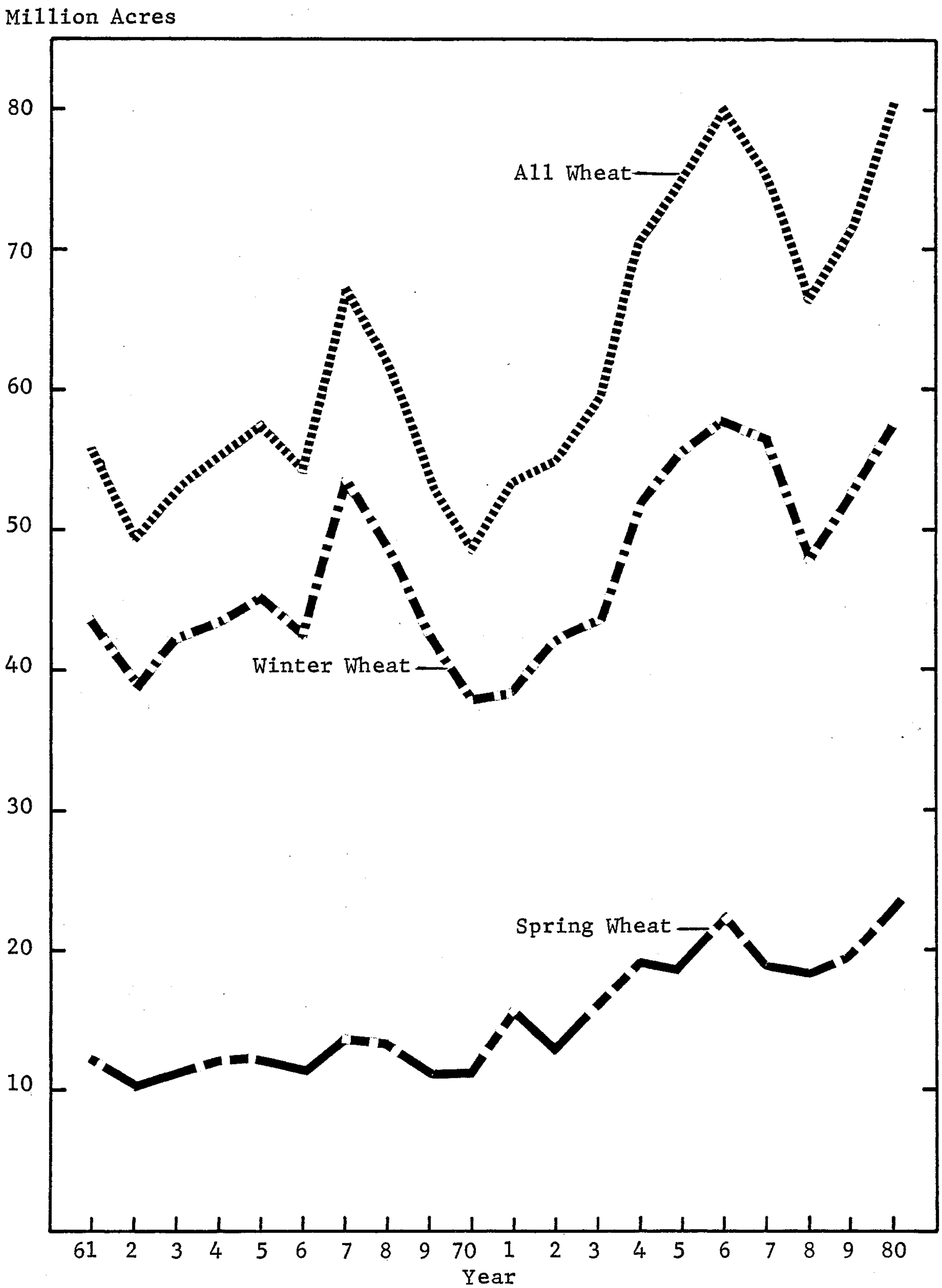

Figure 1. Planted Acres for Spring, Winter, and All Wheat, U.S.

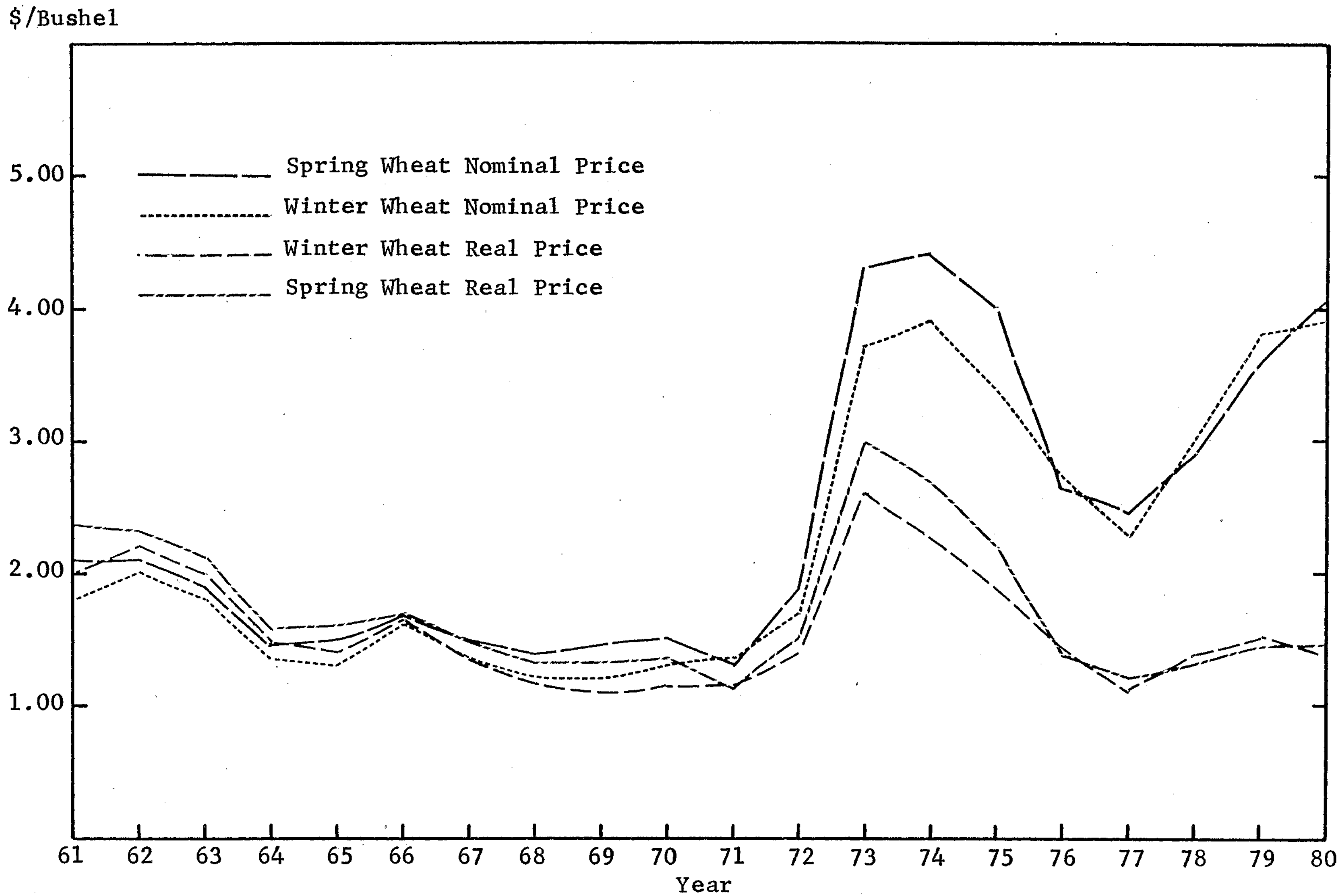

Figure 2. Nominal and Real Season Average Wheat Price, U.S.

The acreage allotment program was reintroduced with deficiency payments under the Agricultural Act of 1973.[3] The program was, however, not effective during 1974-77 because wheat prices were much higher than the target prices during that period. Under the Agricultural Act of 1977, the acreage allotment program was replaced with the national acreage and farmer owned reserve programs. The set-aside program was reintroduced in 1978 and 1979 to reduce wheat supply. The national acreage program introduced in 1978 was similar to the acreage allotment program used during 1974-77.

Although the government programs are applied to all wheat, producers' responses to the programs are different for spring and winter wheat. For example, winter wheat producers have the option of declaring certain planted acres to be diversion or set-aside during the following spring. No such option is available to the spring wheat producers.

Methodology

Because of the complex dynamic structure in supply response, various forms of a distributed lag model have been used for analysis of agricultural supply response.[4] The models are developed on the basis of dynamic behavioral assumptions of exogenous and endogenous variables used in the model. One of the dynamic models is Nerlove's geometric lag model. This model is based on an assumption that price effects on agricultural supply decline geometrically with respect to time measured backwards from the present. Consequently, the model includes only lagged exogenous variables. With unlimited lag effects introduced to exogenous variables, the geometric lag model yields the first order difference equation with the Koyck transformation.[5] Consequently, the

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[3]U.S. Department of Agriculture various issues.

[4]Labys, Walter C., Dynamic Commodity Models: Specification, Estimation, and Simulation, (Lexington, Massachusetts: Lexington Books), 1973:35-59. Griliches, Zvi, "Estimates of the Aggregate U.S. Farm Supply Function," J. Farm Econ., 42(1960):282-93. Nerlove, Marc, "Estimates of the Elasticities of Supply of Selected Agricultural Commodities," J. Farm Econ., 38(1956):496-509.

[5]Nerlove, Marc, The Dynamics of Supply: Estimation of Farmers' Response to Price, (Baltimore: John Hopkins Press), 1958. Kmenta, Jan, Elements of Econometrics, (New York: Macmillan Co.), 1971:473-95. Maddala, G. S., Econometrics, (New York: McGraw-Hill Book Co.), 1977:355-404. Pindyck, Robert S. and Daniel L. Rubinfeld, Econometric Models and Econometric Forecasts, Second Edition, (New York: McGraw-Hill Book Co.), 1981:230-45.

geometric lag model can be interpreted as a difference equation in the dependent variable of the model.

Justification for using the lag model in supply response is based on dynamic behavior in supply with the formation of price expectation and/or expection in the final output. The formation of price expectation used in supply response has a linear relationship between dependent and lagged price variables with geometrically declining weights on lagged price backwards in time. This model is known as the adaptive expectation model of Nerlove. After a suitable transformation, this specification can be reduced to a first order difference equation in the supply response variable. Nerlove's partial adjustment model is based on an assumption of expectation of the final output. This model directly implies a difference equation in the dependent variable with a suitable transformation.

Dynamic Wheat Acreage Response Model

The model used for this study is a compound geometric lag model which is a combination of adaptive expectation and partial adjustment models. Describing annual wheat acreage response begins with the assumption that producers anticipate expected price and the planned long-run or desired level of acreage. Planned or desired wheat acreage can be explained as follows:

$$A_t^* = a_0 + a_1 P_t^* \qquad (1)$$

where A_t^* is desired acreage planted in a particular year, and P_t^* is expected future price of wheat.

Dynamic adjustments of actual acres planted to the desired acres can be expressed as follows:

$$A_t - A_{t-1} = \delta(A_t^* - A_{t-1}) \qquad (2)$$

where is the coefficient of adjustment and A_t is acres planted in year t. This adjustment equation indicates that the actual changes in the planted acreage in season t are only a fraction of the planned changes in acreage.

Combining Equations 1 and 2 yields a first order difference equation:

$$A_t = \delta a_0 + \delta a_1 P_t^* + (1-\delta)A_{t-1} \qquad (3)$$

The price variable is now the only variable left in expectation form. Nerlove indicates that it can be removed by making certain assumptions regarding the way in which producers form their expectations. It is assumed that expected price, $P_t{*}$, is based on an adaptive expectation. The expectation indicates that the influence of previous forecast error implies that current expected price differs from the past experienced price by an amount proportional to the previous forecast error.

$$P_t{*} - P_{t-1}{*} = \beta(P_{t-1} - P_{t-1}{*}) \qquad (4)$$

or

$$P_t{*} = (1 - \beta)P_{t-1}{*} + \beta P_{t-1} \qquad (4a)$$

where β is greater than 0 and less than 1.0.

Continuous iteration of Equation 4a gives

$$P_t{*} = \sum_{i=0}^{n} (1 - \beta)^i \beta P_{t-i+1} \qquad (5)$$

In Equation 5, expected price is a linear equation in lagged prices with the coefficients on them declining geometrically with respect to time measured backwards from the present.

Substituting Equation 5 into Equation 3 results in the following geometric lag model:

$$A_t = \delta a_0 + \delta a_1 \sum_{i=2_0}^{n} (1 - \beta)^i \ P_{t-i+1} + (1 - \delta)A_{t-1} \qquad (6)$$

The Koyck transformation of Equation 6 gives the second order supply response equation with the first order lagged price as follows:

$$A_t = \beta\delta a_0 + \delta a_1 \beta P_{t-1} + (\beta + \delta)A_{t-1} + (1 - \delta)A_{t-2} \qquad (7)$$

The final equation used to estimate the U.S. wheat acreage equation is obtained by adding government wheat programs to Equation 7. The government programs are wheat acreage allotment (X_{1t}), additional diversion acreage in addition to mandatory diversion (X_{2t}), wheat set-aside acreage (X_{3t}), a dummy variable representing no acreage allotment (X_{4t}), and a dummy variable representing farmer owned reserve program (X_{5t}). In addition, the feed grain price index is used as another price variable in the wheat acreage equation. It is hypothesized that wheat acreage is positively related to the feed grain price index because wheat can be substituted for feed grain in the final consumption while production replacement of wheat with feed grains is limited in wheat producing areas. Finally, wheat acreage response to the government wheat program is specified as follows:

$$A_t = b_0 + b_1X_{1t} + b_2X_{2t} + b_3X_{3t} + b_4X_{4t} + b_5X_{5t} + b_6P_{t-1} + b_7A_{t-1} + b_8A_{t-2} + b_9FP_{t-1} + E_t \qquad (8)$$

where FP_{t-1} is the feed grain price index at time t-1, E_t is the disturbance term and the other variables are as previously defined. Variables associated with the government wheat program in Equation 8 are similar to those defined by Garst and Miller[6] except for variable X_5, which represents the farmer owned reserve program under the Agriculture Act of 1977.

Since wheat acreage response to government wheat programs is quite different between winter and spring wheat, the wheat acreage responses are separately estimated for winter, spring, and all wheat.

Data Collection

Data for the period from 1961 to 1980 are used to estimate acreage response equations. Prices used in this study are season average wheat price received by farmers in 1967 dollars (deflated by the index of prices paid for all production items). The feed grain price index was also deflated by the index of prices paid for all production items. Variables representing government wheat programs are summarized in Appendix Tables 1, 2, and 3 for all, winter, and spring wheat. For 1961-70, acreage allotments were allocated to participating wheat producers. These allotments served as upper limits for producer plantings. The diversion of allotment acreage reduced participating farmers' limit on wheat acreage to their allotment less the additional diversion. It was hypothesized that this more restrictive definition of diversion would better explain changes in wheat acreages for a year in which a wheat allotment was in effect. Thus, the diversion shown in the tables represents only those acres of allotment voluntarily diverted for payment. The acreage allotment program for 1974-80 was different from the earlier one. This allotment was simply determined as an administrative guideline for

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[6]Garst, Gail D. and Thomas A. Miller, "Impacts of the Set-Aside Programs on the U.S. Wheat Acreages," Agricultural Economics Research, 27(1975):30-37.

deficiency payments to farmers. However, effects of the allotment program were similar to the earlier one, since it restricted acres planted in order for farmers to receive the benefits of the program. This is the reason the two allotment programs are considered as the same variable.

Beginning with the implementation of the set-aside program in 1971, acreage allotments were no longer used as a limit for wheat acreage. This program continued until 1973. Those years in which allotments were not applied are identified by dummy variable D1 in the tables.

Since the Food and Agriculture Act of 1970 was passed in November 1970, after the date when winter wheat had been planted, only spring wheat farmers (approximately 26 percent of the total wheat acreage) had an opportunity to adjust planting decisions. Consequently, allotments were excluded for spring wheat but were included for winter wheat for the 1971 data. The 1971 set-aside acreage for all wheat also includes the set-aside for the spring wheat acres (about 26 percent of the total wheat acres). Dummy variable D2 represents the farmer owned reserve program started in 1978 under the Agriculture Act of 1977.

Data for allotment, diversion, and set-aside acres are available for individual states but are not available by type of wheat. Therefore, allotment, diversion, and set-aside acres used for the acreage response equation for spring wheat are calculated from the major spring wheat producing states. For those states which produce both spring and winter wheat, allotment, diversion, and set-aside acres are divided into spring and winter wheat by proportion of spring and winter wheat acres to the total wheat acres. In general, Minnesota, South Dakota, and Montana produce both spring and winter wheat. North Dakota is the only state in which spring wheat is virtually the only type of wheat produced. The acreages for winter wheat are calculated by substracting the acreages for spring wheat from those for all wheat.

Empirical Results

Three econometric models are specified to evaluate the dynamic structure of all, winter, and spring wheat acreage responses. Estimated acreage response models for all, winter, and spring wheat are shown in Table 1. The structure of the models used in the estimation of acreage response equations is the same as that specified in Equation 8 except variable P_{t-2} which is used in acreage response equations for winter wheat. The second order lagged prices are

TABLE 1. ESTIMATED ALL, WINTER, AND SPRING WHEAT ACREAGE RESPONSE

Variables	All Wheat		Winter Wheat		Spring Wheat	
	Coefficient	(t-Value)	Coefficient	(t-Value)	Coefficient	(t-Value)
Constant	-21.2985	(-2.264)	-18.2943	(-3.892)	-6.1001	(1.816)
AA	0.5181	(4.346)	0.6045	(8.602)	0.2648	(1.238)
AD	-1.3022	(-2.810)	-0.8084	(-2.198)	-1.0959	(-1.473)
WS	-0.5858	(-2.194)	-0.4130	(-2.109)	-1.6213	(-3.814)
D1	39.9636	(5.055)	31.0020	(8.071)	13.2412	(4.342)
D2	4.9661	(1.276)	1.1858	(0.659)	5.2932	(3.417)
P_{t-1}	5.0009	(2.354)	2.9034	(2.520)	1.9014	(2.719)
P_{t-2}			-1.5923	(-1.318)		
A_{t-1}	0.1672	(1.039)	0.1541	(1.351)	0.4134	(2.289)
A_{t-2}	0.3310	(2.138)	0.2719	(2.404)	0.3309	(1.965)
FP_{t-1}	17.0246	(1.028)	18.1180	(3.822)	3.3312	(1.051)
ρ_1	0.2278	(0.993)	0.4358	(1.8676)	0.4076	(1.894)
ρ_2			0.1413	(0.6058)		
R^2	0.9797		0.9933		0.9815	
SE	2.468		1.165		1.043	

Variable Descriptions

AA = acreage allotment in million acres
AD = additional diversion in million acres
WS = wheat set-aside acres
D1 = no allotment (takes the value 1 for 1971-73 for spring wheat, 1972 and 1973 for winter wheat, 0.26 in 1971, and zero otherwise)
D2 = dummy variable representing the farmer owned grain reserve program (takes the value 1 after 1977 and zero otherwise)
P = deflated season average wheat price (1967 base)
FP = deflated feed grain price index (1967 base)
ρ_1 = coefficient of the first order autoregressive error term
ρ_2 = coefficient of the second order autoregressive error term
SE = standard error of estimate

explicitly included in the response equation for winter wheat. The extra lagged price taken jointly with the lagged values of the response variable can capture information on rigidities in the industry that would otherwise fall into the error term. The reason the winter wheat response equation has an additional lagged price is that winter wheat is produced in more areas of the United States than spring wheat and consequently, it requires extra information beyond that provided by lagged values of the response variable conjunctively with an exogenous variable at the same time period.

The all and spring wheat models fit best with the first order autoregressive errors. The all wheat model has an R^2 value of 97.97 and a standard error of estimate less than 2.5 million acres. The estimated acreage response equation for spring wheat (spring wheat model) is shown in Table 6. The spring wheat model has an R^2 value of 98.15 and has a standard error of 1.04 million acres. Most coefficients are highly significant in both all and spring wheat models.

Unlike all and spring wheat response models, the winter wheat model fits well in the second order autoregressive error structure. The response equation has an R^2 value of 99.33 and a standard error of estimate near 1.2 million acres.

Effects of Government Programs

All variables representing government programs except for D2 appear to be significant at the 95 percent probability level in the acreage response model for all wheat. The farmer owned reserve program, represented by variable D2, is significant at the 80 percent probability level. Acres planted in the United States have a positive relationship with the acreage allotment program and have a negative relationship with the additional diversion and set-aside programs. The additional diversion program is more effective in controlling all wheat acres than the set-aside program because, while the additional diversion program restricts wheat allotment acres, the set-aside program idles acres from total cropland. Dummy variables D1 and D2 shift the acreage response equation of all wheat upward, indicating that the no allotment and farmer owned reserve programs increase planted acres for all wheat.

Because of differences in production practices between winter and spring wheat, effects of government programs differ between the two types of wheat.

The acreage allotment program is more effective in the winter wheat acreage model than in the spring wheat acreage model. This is mainly due to availability of alternative crops in spring and winter wheat regions. Alternative crops such as sunflower and barley could be produced in spring wheat areas, but such alternative crops do not generally exist in winter wheat regions. On the other hand, the set-aside and diversion programs are more important in the spring wheat acreage response model than in the winter wheat response model. The reason for this is mainly due to interrelationships between production practices and the nature of government programs. Since winter wheat is planted in the fall, farmers planting winter wheat have the option of declaring certain planted acres to be diversion or set-aside during the following spring. However, farmers planting spring wheat do not have such an option. Therefore, spring wheat producers are more sensitive to government programs than winter wheat producers. This implies that each acre of diversion or set-aside in spring wheat areas reduces planted acres to a greater extent than a similar idle acre in winter wheat areas. In addition, availability of alternative crops in spring wheat regions makes the set-aside program much more effective in controlling spring wheat acres than the diversion program. Spring wheat is the main crop in spring wheat regions and competes with other crops. Therefore, all idled acres under the set-aside program can be applied to spring wheat. For example, 10 percent set-aside on 2 million acres cropland where 1 million acres are used for spring wheat production and the other 1 million acres for sunflower production is 200 thousand acres. The idle 200,000 acres could be used to reduce only wheat acres. In this case, wheat acres reduced under the set-aside program is 20 percent of the total spring wheat acres. However, such additional reduction is not allowed in the acreage diversion program, and it is also not applicable for winter wheat because alternative crops are not generally available in winter wheat regions. Estimated acreage response models indicate that each acre of set-aside and diversion reduces total spring wheat plantings by 1.6 acres and 1.1 acres, respectively, in spring wheat regions and 0.4 acre and 0.8 acre, respectively, in winter wheat regions (Table 1).

Dummy variables D1 and D2 shift spring and winter wheat acreage response equations upward, indicating that the no allotment and farmer owned reserve programs increase winter and spring wheat acres. However, effects of the no allotment program are larger than effects of the farmer owned reserve program. The no allotment program increases winter wheat acres by 31 million and spring wheat acres by 13 million (Table 1). Increases in wheat acres with the farmer owned reserve program are 1.2 million acres in winter wheat regions and are 5.3 million acres in spring wheat regions. The farmer owned reserve program increases spring wheat acres to a greater extent than winter wheat acres because spring wheat has a comparative advantage over other crops which are not included in the program.

All government programs are simultaneously tested with a null hypothesis that estimated coefficients associated with government programs are equal to zero. The traditional F-test with sum of square errors obtained from restricted and unrestricted models is used to test the null hypothesis. The unrestricted models for all, winter, and spring wheat are the same as the models in Table 1. The restricted models do not include all policy variables specified in the unrestricted models. The sum of square errors obtained from restricted and unrestricted models, and the F-values calculated from them are shown in Table 2. The calculated F-values indicate that the government programs are significant at the 99 percent probability level for all, winter, and spring wheat. This implies that overall, government programs have been effective in controlling wheat acres over the last 20 years.

TABLE 2. SUM OF SQUARE ERRORS AND F-VALUES FOR ALL, WINTER, AND SPRING WHEAT TO TEST EFFECTS OF ALL GOVERNMENT PROGRAMS SIMULTANEOUSLY

Wheat	SSE_{UR}	SSE_R	F-values[a]
All	48.74	441.54	10.6
Winter	9.51	197.74	27.3
Spring	8.71	59.46	13.3

$$^{a}F_{rq} \simeq \frac{\left[SSE_R - SSE_{UR}\right]}{SSE_{UR/q}}$$

where: SSE_R = sum of square errors in the restricted model

SSE_{UR} = sum of square errors in the unrestricted model

Price Effects

Wheat acreage planted is positively related to both wheat price and the feed grain price index in all, winter, and spring wheat response models. The wheat price lagged one year is significant at the 95 percent probability level in all, winter, and spring wheat acreage response models. The second order lagged price is included in only the winter wheat model to capture extra information on prices. While the feed grain price index is significant at the 95 percent probability level for all and winter wheat acreage response models, it is not significant in the spring wheat acreage model. The positive coefficient of the feed grain price index in the models indicates that wheat is a good substitute for feed grains for final consumption while production replacement of wheat with feed grains is limited in wheat producing areas. Spring and winter wheat can be substituted with barley and sorghum, respectively, which are a small portion of total feed grains. Approximately 10 percent of total quantity of wheat produced is used as feed grain in the United States.

The price variables are simultaneously tested to identify effects of both wheat and feed grain prices in the models. The F-values are calculated from the sum of square errors obtained from restricted and unrestricted models to test a null hypothesis that all price effects are zero. The unrestricted models for all, winter, and spring wheat are the same as the all, winter, and spring wheat models in Table 1. The restricted models do not include price variables specified in the unrestricted models. Table 3 shows the sum of square errors obtained from the unrestricted and restircted models and the F-values calculated from them. The F-values indicate that wheat prices and feed grain price index are significant at the 99 percent probability level.

The price effects can be interpreted with price elasticities of acreage response. The elasticities calculated with price and acreage at their sample means are given in Table 4. Price elasticities of acreage response are all inelastic, but the elasticities for winter wheat acreage are much more inelastic than the elasticities for spring wheat. The reason for this is that spring wheat competes with other crops such as barley and sunflower, but winter wheat does not compete with other crops.

Long-run price elasticities of wheat acreage response reflect dynamic adjustments of wheat producers with wheat price over time. Long-run price

TABLE 3. THE SUM OF SQUARE ERRORS AND F-VALUES FOR ALL, WINTER, AND SPRING WHEAT TO TEST EFFECTS OF WHEAT AND FEED GRAIN PRICES SIMULTANEOUSLY

Wheat	SSE_{UR}	SSE_R	F-values[a]
All	48.74	178.07	12.9
Winter	9.51	76.91	27.7
Spring	8.71	37.74	9.3

$$^{a}F_{rq} \simeq \frac{\left[SSE_R - SSE_{UR}\right]/r}{SSE_{UR/q}}$$

where: SSE_R = sum of square errors in the restricted model

SSE_{UR} = sum of square errors in the unrestricted model

TABLE 4. PRICE ELASTICITIES OF ACREAGE RESPONSE FOR U.S. WHEAT

Wheat	Short-Run	Long-Run
All	0.132	0.263
Winter	0.099	0.239
Spring	0.218	0.840

elasticities for all, winter, and spring wheat are less inelastic than short-run elasticities. Changes in price elasticities of wheat acreage responses between short-and long-run are much larger for spring wheat than for winter wheat. The reason for this is that while production of spring wheat can be replaced with other crops, such replacements are not generally possible in winter wheat regions.

Model Performance and Dynamic Stability

Performance of the model is demonstrated in Figures 3, 4, and 5 for all, winter, and spring wheat, respectively. The figures show the actual acreage of the wheat planted as well as the estimated acreage based on Model 1 of all, winter, and spring wheat. All and winter wheat followed similar movements in

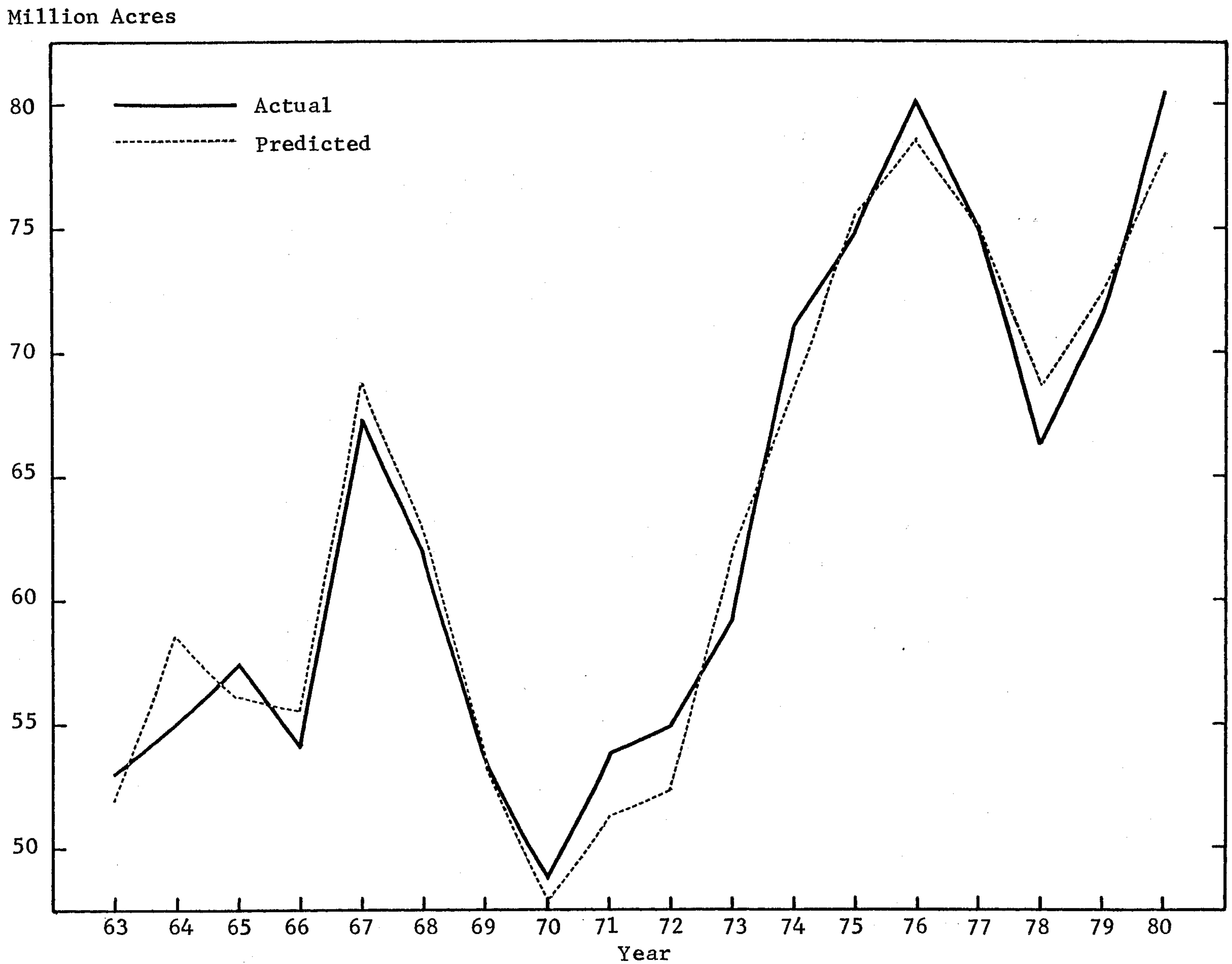

Figure 3. Actual and Predicted Acreages for All Wheat, U.S.

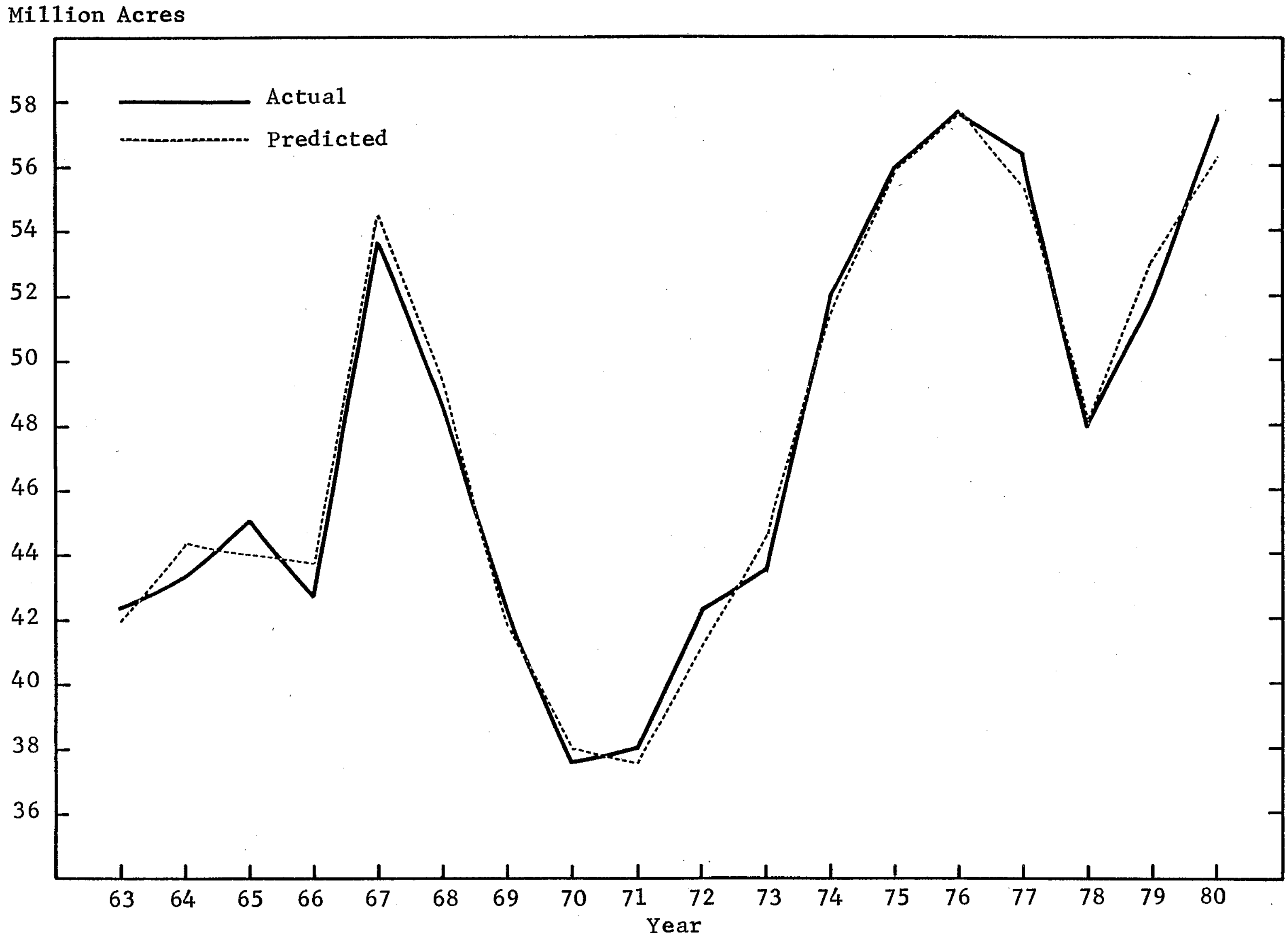

Figure 4. Actual and Predicted Acreages for Winter Wheat, U.S.

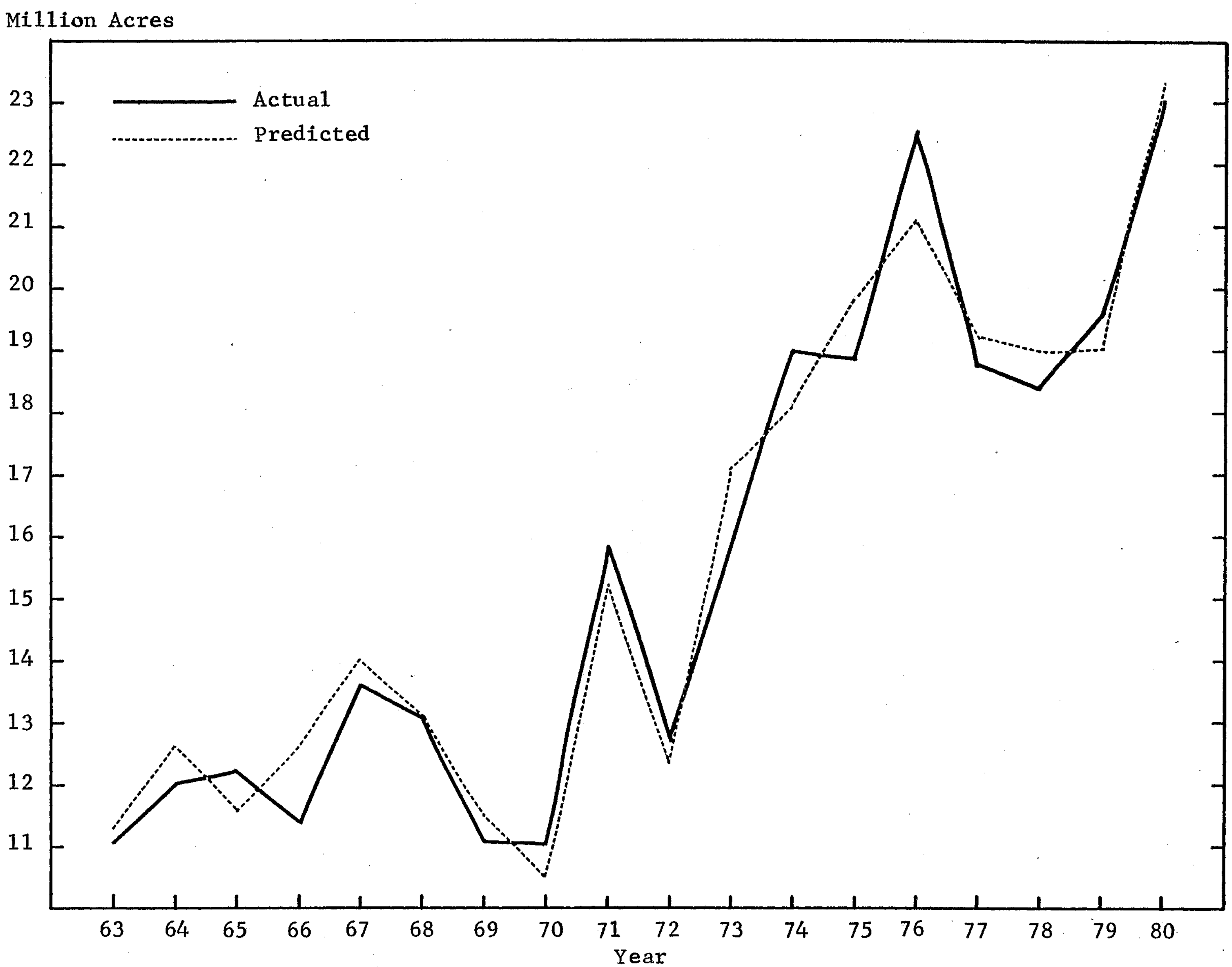

Figure 5. Actual and Predicted Acreages for Spring Wheat, U.S.

acres planted. Planted acres reached its peaks in 1967 and 1976 and its troughs in 1970 and 1978. The estimated acreage response functions capture the long term cyclical movements of acres planted accurately. Movements in spring wheat acres planted are different from all and winter wheat. Spring wheat acres vary with greater frequency than other wheat. Spring wheat acres planted reached its peaks in 1965, 1967, 1971, 1974, and 1976, and reached its troughs in 1966, 1968, 1972, 1975, and 1978.

The dynamic behavior of acreage response can be expressed in terms of the solution of the second order difference equation specified in Equation 8. Equation 8 can be expressed as an autoregressive model with dependent variables as follows:

$$A_t + b_7A_{t-1} + b_8A_{t-2} = C \tag{9}$$

where C is a constant term including variables associated with government programs and prices at their means.

The general solution of Equation 8 can be expressed as follows:[7]

$$A_t = A_1\alpha_1{}^t + A_2\alpha_2{}^t + \overline{A} \tag{10}$$

where α_1, and α_2 are characteristic roots of Equation 9, A_1 and A_2 are constant terms associated with α_1 and α_2, respectively, and A is long-run equilibrium acreage obtained from complementary function. In the case where characteristic roots of Equation 9 are complex, the general solution of Equation 8 can be expressed as follows::

$$A_t = R^t(A_1\cos\theta t + A_2\sin\theta t) + \overline{A} \tag{11}$$

where $R = \sqrt{b_8}$ and other variables are previously defined.

Stability of Equation 9 is, therefore, dependent upon characteristic roots of the equation. If characteristic roots α_1 and α_2 are greater than 1.0, the equation is explosive and is dynamically unstable. In the opposite case, where α_1 and α_2 are less than 1.0, the equation is dynamically stable. Further, the equation is dynamically unstable as long as one of the characteristic roots

[7]Chiang, Alpha C. Fundamental Methods of Mathematical Economics, 2nd Edition. (New York: McGraw-Hill), 1974:549-621. Miller, Ronald E. Dynamic Optimization and Economic Applications, (New York: McGraw-Hill), 1979:219-290.

is greater than 1.0. Stability of the equation is clearer when the roots of the equation are complex. In this case, the equation is dynamically stable with a cyclical path when R is less than 1.0.

The general solutions obtained from all, winter, and spring wheat acreage response models are as follows:

$$A_t = 15.126(0.8951)^t - 6.126(-0.7281)^t + 62.15 \qquad (12)$$

$$A_t = 10.7427(0.6327)^t - 6.6927(-0.4786)^t + 47.04 \qquad (13)$$

$$A_t = 7.9049(0.8180)^t - 3.4449(-0.4046)^t + 15.14 \qquad (14)$$

Equations 12, 13, and 14 represent dynamic behavior of acreage response for all, winter, and spring wheat respectively. Since characteristic roots of each equation are less than 1.0, all, winter, and spring wheat acreage response models are dynamically stable. The second terms of the right hand side of equations 12, 13, and 14 are negative, indicating that characteristic roots associated with the terms are all negative. This means that the models behave cyclically over time.

Conclusions

The complex dynamic structure of agricultural supply response is best approximated by difference equations jointly with lagged exogenous variables. Variables specified in the models are acreage allotment, additional diversion, wheat set-aside, dummy variable representing no allotments, another dummy variable representing the farmer owned reserve program, season average wheat price received by farmers, and the feed grain price index. Wheat price and the feed grain price index are deflated by the index of price paid by farmers for all production items.

All government programs entered significantly in all, winter, and spring wheat acreage response models. However, producers' response to government programs are different for winter and spring wheat. The acreage allotment program appears to be more important in the acreage response model for winter wheat than for spring wheat. On the other hand, the set-aside, diversion, and and farmer owned reserve programs are more important in acreage response for spring wheat than for winter wheat. This is mainly due to the interrelation between production practices and the nature of government programs.

The F-values obtained from restricted and unrestricted models further indicate that all government programs are simultaneously significant at the 99 percent probability level for all, winter, and spring wheat.

In addition to government programs, wheat and feed grain prices are also important for producers to make production decisions. The prices are significant at the 95 percent probability level for all, winter, and spring wheat. Acres planted is positively related to the feed grain price index. This indicates that wheat is a good substitute for feed grain. Price elasticities of acreage response for all, winter, and spring wheat are inelastic. The price elasticity for winter wheat is more inelastic than that for spring wheat. The reason for this is that while production of spring wheat can be replaced with other crops, such replacements are not generally possible in winter wheat regions.

Mathematical evaluation of the models indicates that all, winter, and spring wheat acreage response models are dynamically stable with cyclical behavior. This implies that government programs and market price work jointly to stabilize wheat supply.

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APPENDIX TABLE 1. GOVERNMENT PROGRAMS USED TO ESTIMATE ALL WHEAT ACREAGE RESPONSE EQUATION

Years	Acreage Allotments (AA)	Additional Diversion (AD)	Wheat Set-Aside (WS)	Dummy For No Acreage Allotment (D1)	Dummy for Farmer Owned Reserve Program (D2)
			(million acres)		
1961	55.0	0.0	0.0	0.0	0.0
1962	49.5	6.1	0.0	0.0	0.0
1963	55.0	7.2	0.0	0.0	0.0
1964	53.2	0.8	0.0	0.0	0.0
1965	53.3	2.4	0.0	0.0	0.0
1966	51.5	1.9	0.0	0.0	0.0
1967	68.2	0.0	0.0	0.0	0.0
1968	59.3	0.0	0.0	0.0	0.0
1969	51.6	4.3	0.0	0.0	0.0
1970	45.5	3.6	0.0	0.0	0.0
1971	33.7	0.0	3.4	0.26	0.0
1972	0.0	0.0	20.1	1.0	0.0
1973	0.0	0.0	7.2	1.0	0.0
1974	55.0	0.0	0.0	0.0	0.0
1975	53.5	0.0	0.0	0.0	0.0
1976	61.6	0.0	0.0	0.0	0.0
1977	62.2	0.0	0.0	0.0	0.0
1978	58.8	0.0	9.6	0.0	1.0
1979	70.1	0.0	8.2	0.0	1.0
1980	75.0	0.0	0.0	0.0	1.0

APPENDIX TABLE 2. GOVERNMENT PROGRAMS USED TO ESTIMATE WINTER WHEAT ACREAGE RESPONSE EQUATION

Years	Acreage Allotments (AA)	Additional Diversion (AD)	Wheat Set-Aside (WS)	Dummy For No Acreage Allotment (D1)	Dummy for Farmer Owned Reserve Program (D2)
			(million acres)		
1961	42.2	0.0	0.0	0.0	0.0
1962	37.9	4.5	0.0	0.0	0.0
1963	42.0	5.2	0.0	0.0	0.0
1964	41.6	0.7	0.0	0.0	0.0
1965	41.6	1.8	0.0	0.0	0.0
1966	39.7	1.8	0.0	0.0	0.0
1967	52.6	0.0	0.0	0.0	0.0
1968	45.7	0.0	0.0	0.0	0.0
1969	39.8	3.5	0.0	0.0	0.0
1970	35.1	2.8	0.0	0.0	0.0
1971	33.7	0.0	0.0	0.0	0.0
1972	0.0	0.0	13.5	1.0	0.0
1973	0.0	0.0	3.5	1.0	0.0
1974	41.8	0.0	0.0	0.0	0.0
1975	40.5	0.0	0.0	0.0	0.0
1976	46.6	0.0	0.0	0.0	0.0
1977	47.0	0.0	0.0	0.0	0.0
1978	45.3	0.0	6.7	0.0	1.0
1979	53.9	0.0	6.0	0.0	1.0
1980	57.6	0.0	0.0	0.0	1.0

APPENDIX TABLE 3. GOVERNMENT PROGRAMS USED TO ESTIMATE SPRING WHEAT ACREAGE RESPONSE EQUATION

Years	Acreage Allotments (AA)	Additional Diversion (AD)	Wheat Set-Aside (WS)	Dummy For No Acreage Allotment (D1)	Dummy for Farmer Owned Reserve Program (D2)
			(million acres)		
1961	12.8	0.0	0.0	0.0	0.0
1962	11.6	1.4	0.0	0.0	0.0
1963	13.0	1.9	0.0	0.0	0.0
1964	11.7	0.1	0.0	0.0	0.0
1965	11.7	0.6	0.0	0.0	0.0
1966	11.8	0.1	0.0	0.0	0.0
1967	15.6	0.0	0.0	0.0	0.0
1968	13.6	0.0	0.0	0.0	0.0
1969	11.8	0.8	0.0	0.0	0.0
1970	10.4	0.8	0.0	0.0	0.0
1971	0.0	0.0	3.4	1.0	0.0
1972	0.0	0.0	6.3	1.0	0.0
1973	0.0	0.0	3.7	1.0	0.0
1974	13.2	0.0	0.0	0.0	0.0
1975	13.0	0.0	0.0	0.0	0.0
1976	15.0	0.0	0.0	0.0	0.0
1977	15.2	0.0	0.0	0.0	0.0
1978	13.6	0.0	2.9	0.0	1.0
1979	16.2	0.0	2.2	0.0	1.0
1980	17.4	0.0	0.0	0.0	1.0

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