Wheat Acreage Response to Changes in Prices and Government Programs in Oregon and Washington

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SUMMARY

This study compares and evaluates wheat acreage responses among production systems in Oregon and Washington and between this region and estimated national average wheat acreage response. Oregon and Washington are disaggregated into five regions each on the basis of general similarity in soil, climate, substitute crops and production structures. Regional acreage response models that allow differential inter-structural and inter-regional impacts of the major provisions for wheat price support and wheat acreage set-aside and diversion are developed. Parameters of three functions (one each for total, irrigated, and dryland planted wheat acreage) utilizing pooled time-series and cross-sectional data are estimated for each state. Government programs have little impact in Oregon, and only slightly more in Washington. The elasticity of acreage response with respect to market price differs from the national average in all but one case. Finally, the implications of using the national acreage model, influenced by the preponderance of red wheat grown in the Wheat Belt, to predict Northwest regional white wheat acreage response are addressed.

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WHEAT ACREAGE RESPONSE TO CHANGES IN PRICES AND GOVERNMENT PROGRAMS IN OREGON AND WASHINGTON

Debra K. Moe and James K. Whittaker

INTRODUCTION

Background

Conditions of low farm income and commodity price instability have long been motivating forces behind the development of national farm legislation. Major policy directives aimed at mitigating these problems have included programs with the goals of price stability, supply curtailment and price support. Policy makers consider the national implications when judging the effectiveness of a program. Many national models of aggregate commodity supply generally assume that all products of a given commodity react similarly to the provisions in the government commodity programs. If national models of aggregate commodity supply are used as the basis for government policy decisions and if the impact of the farm bill on a given region is not the same as the aggregate impact on the United States, then national models are not appropriate for regional analysis.

The acreage responses of various wheat production systems to the many policy instruments correspond to the aggregated reaction of wheat producers as a whole. There are many suppositions as to why the interregional responses may be dissimilar. The local conditions of soil and climate could lead to regional discrepancies. As many varieties of wheat are grown in different regions of the country, wheat is not a totally homogeneous commodity.

Different regions of the country may produce the same commodity for different markets. One area may produce a given crop mostly for domestic consumption while another region may produce the same crop predominantly for export. Less expensive transportation costs attributed to geographic location may contribute to a distinct market for the production of a certain region. Differing demand and economic conditions in the diverse markets could potentially contribute to varied responses among producers in differing regions.

Inter- or intra-regionally, farms producing the same commodity, but organized along differing structural lines (i.e., utilizing different production methods), may not behave in the same manner when faced with the same commodity programs; they may have the same aspirations. As an example, a farm with high yields but low costs of production may be less inclined to participate in the programs. Differing rates of participation nationally would mean that the magnitude of payments to various regions would differ and, hence, that the program could potentially impact different regions in different ways. Costs of production differing from the national average specified as the basis for computing target prices in the 1977 farm bill could potentially contribute to differential impacts between regions or among structures within a region. It is questionable whether such a situation would correspond with the intent of farm bill legislation.

If a national model predicated on an erroneous assumption of homogeneity of producer response is utilized for regional analysis, then some of the ensuing regional impacts of the national policy decisions may be undetected and/or undesirable to the policy makers. For these reasons, it is important to take a closer look at regional acreage response to determine whether the intended impact on commodity price and supply is equivalent to the actual impact of the commodity programs when incorporating its inter-regional and inter-structural influences.

Study Objectives

1. To develop wheat acreage response models for Oregon and Washington that will allow for differential impacts of the national farm programs.
2. To compare and evaluate the wheat acreage responses between production systems in Oregon and Washington and between this region and the estimated national average wheat acreage response.

The Pacific Northwest states of Oregon and Washington provide an excellent opportunity to study the regional impacts of the national wheat policy mandated by the federal government.[1/] Wheat is of prime importance for farm incomes in these areas as it accounts for about one-half of all acreage planted. The predominant class of wheat grown in Oregon and Washington is a soft white variety used primarily for unleavened bread, cakes, pastries and noodles. Approximately 85 to 90 percent of the total quantity produced is exported every year. The

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1/ Idaho was not included because of the additional time and expense required for data collection.

Pacific Rim and Middle Eastern countries (i.e., Japan, South Korea, Pakistan, Iran, etc.) are the largest importers of Pacific Northwest soft white wheat.

The major aim of this research is to determine the impacts of historical and current farm legislation on planted wheat acreage in Oregon and Washington. To do this, regional wheat acreage response models will be developed in a manner that allows for differential inter-structural and inter-regional impacts of the national farm programs. The government programs considered in the models developed for this research consist of the major provisions for wheat price support and wheat acreage set-aside and diversion.[2/] References to the impacts of the programs herein applies to the effects of these components of the legislation.

The discrepancies/similarities in wheat acreage response between production systems in this region and between this region and the national average is determined and discussed. The implications of using the national model influenced by the preponderance of red wheat grown in the Wheat Belt to predict the Northwest regional white wheat acreage response is addressed.

Brief discussions of the theory applicable to estimation of supply models of acreage response and of the measurement of the included variables are included in the next section. The model specification and functional form also are discussed. The empirical analysis follows, and the paper concludes with a summary and conclusions section.

APPLICABLE THEORY, VARIABLE MEASUREMENT AND ESTIMATION TECHNIQUE

Applicable Theory and Variable Measurement

Economic theory suggests that commodity supply is a function of commodity price, prices of substitute commodities, government programs, prices of the variable inputs, weather, the levels of technology and fixed inputs and the magnitude of risk. Government programs are included because they are a major market influence interacting with the forces determining both commodity price and the farmer's subjective expectations of price.

[2/] A good review of national farm legislation is found in Cochrane and Ryan, American Farm Policy, 1948-1973. Summaries of the major programs will not be repeated here.

Commodity Price

Farmers must base production decisions on subjective expectations of future commodity price. The planting decision must be made several months before the producer knows with certainty what price he will receive for his crop. There are many hypotheses as to how these expectations are formulated. Houck et al. used the naive price expectations model which assumes the price the producer expects to receive for this crop in year t is the price he received in year t-1. Hence, market price is lagged one year to correspond with the timing of the wheat producer's planting decision. Gardner hypothesized that the price of a futures contract for next year's crop reflects the market's estimate of next year's cash price. However, in the case of cotton acreage response, it was found that the futures price and the lagged cash price seem to be good substitutes. Just (1973) hypothesized that expectations are based on geometrically lagged state variables including prices. This study will utilize the lagged market price of wheat as a measure of the price expectations of producers at planting time. Regional wheat prices for the Oregon regions are calculated by summing the weighted county market prices of wheat for all counties comprising each region. Each county price was weighted by the proportion of regional planted wheat acreage occurring in that county. Since only state prices were available in Washington, all regional prices equal the state price in this state. The sign of the estimated coefficient for expected price is anticipated to be positive. Increases in the lagged market price of wheat are assumed to elicit corresponding increases in planted wheat acreage.

Prices of Substitutes

At the national level, Lidman and Bawden found that there are no economically viable substitutes for wheat given favorable weather (i.e., if weather allows at fall planting time, wheat is planted; if not, the producer will wait until spring and plant a different crop). Hoffman included the price of cotton as a substitute for wheat in his national model, but concluded this was only significant in the Southern plains area, particularly Texas. However, the conclusion of no substitutes for wheat derived from the development of national supply models does not imply that no alternatives exist at the regional level. In the Northwest, Winter and Whittaker found that barley was not a significant economic substitute for wheat production when aggregating the data by states (including Oregon, Washington and Idaho). When acreage response is disaggregated by both region and by production system, there may be some crop(s) determined to be an important substitute for wheat production in Oregon and/or Washington. Barley will be hypothesized as a possible substitute in the dryland areas of Oregon and alfalfa and potatoes will be considered in the higher rainfall and irrigated areas. Grass seeds, horticultural truck crops, red clover and barley are likely alternatives in the western valley region of Oregon.[3/] In Washington, barley and peas are hypothesized to be substitutes to wheat production in the dryland areas, and sugar beets and alfalfa are potential economic alternatives on irrigated acreage. However, sugar beets may no longer be a viable alternative in Washington because of the closing of all Washington processing plants (1978).

Regional prices for the hypothesized substitutes in Oregon were computed as a simple average of the county seasonal average prices received by farmers in the counties comprising each region. Only those counties that had planted acreage in the substitute commodity were included (i.e., if there was no production of the substitute commodity in a county, that county price was assumed to be zero). State season average prices were utilized in Washington because they were the only prices available.

Since the decision whether to produce wheat or some alternative must be made at planting time, the prices of the hypothesized substitute crops were lagged one year to correspond with the producer's decision. These lagged prices are assumed to be proxy variables for producers' price expectations for alternatives to wheat. The estimated coefficients on the substitute crop variables are expected to be negative. An increase in the relative price of an alternative commodity will cause a decrease in the acreage planted to wheat, all else held equal, as land is transferred from wheat production into production of the substitute crop.

Government Programs

Two major provisions for wheat price support payments to guarantee farm income and diversion of wheat acreage to curtail supply, will be considered in

[3/] Peas and other vegetable crops are also possible alternatives in western Oregon. From conversations with oounty agents, these crops were not included as economic substitutes to wheat production because vegetable crops are usually contract grown.

this study. An effective support price will be constructed following the reasoning of Houck *et al.*[4/] This measure, based on the announced support payment schedule, is assumed to reflect the price that a farmer would expect to receive for this crop when participating in the government programs. Hence, the support price affects the producer's price expectations. It acts as a guaranteed minimum price.

Participation necessarily entails compliance with all provisions (i.e., including diversions or set-asides as well as other acreage restrictions such as cross-compliance) as written into the farm bill applicable for that year for the commodity in question. The support price variable used in this study is a composite of the announced support price weighted by any acreage restrictions that were in effect in that year plus the direct payment rate (if applicable) weighted by the qualifying acreage.

For the purposes of this study, county loan rates will be aggregated into regional loan rates. The regional loan rate will be computed by summing for each region the county loan rates weighted by the acreage of wheat planted in that county. This total will then be divided by the total acreage planted in the region. The national announced loan rate for wheat in the weighted support rate variable formulation used by Houck *et al.* will be replaced by this regional loan rate. The result is a regional weighted support rate. The sign on the estimated coefficient of this variable is expected to be positive. An increase in the effective support rate, other things held constant, will elicit an increase in the acreage planted to wheat.

Houck *et al.*'s formulation of the weighted support rate is recognized to have some drawbacks. Danin points out that this variable should depend not only on the relative level of the support price and acreage restrictions, but also on the absolute level of the support price. In addition, there are many aspects of the government programs that are difficult to quantify. For example, many of the compliance provisions impose acreage restrictions on several crops simultaneously so they are in accord with the wheat program. Houck *et al.* made an attempt to account for some of the major cross-compliance structures. Whether this was done adequately is beyond the scope of this paper. Just (1973)

[4/] For a more detailed explanation of the formulation of the effective support rate, see Houck *et al.*, *Analyzing the Impact of Government Programs on Crop Acreage*, pp 31-35.

and Lidman and Bawden suggest alternative formulations for the government policy variables. Since the formulation of the weighted support rate developed by Houck et al. is the most common in the literature, this formulation will be used in this study to quantify the government provisions for wheat price support.

A separate variable will be included in the model to account for the voluntary diversion provisions in excess of the diversion required for compliance with the commodity program. Compliance refers to meeting the provisions necessary to qualify for support or deficiency payments. In other words, the participation of the producer in the government wheat programs served as a prerequisite for qualifying for collection of payment from voluntary wheat acreage diversion. In general, the voluntary diversion payment was not at the same rate as that for required diversion, but usually was much lower.

Since the formulation of the weighted diversion payment by Houck et al. is the most common in the literature, this quantification of the government diversion provisions will be used in this study.[6/]

Wheat acreage diversion serves as an alternative to wheat production. Land that can be used for wheat production can also be used for wheat diversion in the same manner that a producer can decide to plant acreage to wheat or to potatoes. As the diversion payment rate was not available at the regional level, Houck et al.'s quantification using the national announced payment rate was assumed representative of the regional payment rate. The expected sign on the estimated coefficient for this variable is negative just as the expected sign on the price of any substitute is negative. An increase in the effective payment rate for wheat diversion will induce fewer acres to be planted to wheat, all else held equal.

[6/] Just (1973) suggests an alternative variable formulation for government programs which incorporates a vector of subsidies and taxes announced before planting decisions are made, another vector for subsidies and taxes not known until after the planting decisions were made, a binary allotment indicator multiplied by the respective rate of participation (defined as the acreage on participating farms divided by the total allotment), a vector of the allotment levels multiplied by the respective rate of participation, a vector of price support levels times the respective rate of participation and a variable measuring the acreage diverted under the government program for a crop (pp 442-449).

Prices of Variable Inputs

The variable input bundle used in wheat production is not unique in the sense of either items or quantity. The variable inputs used are standard inputs applied in a rather standard manner and quantity in the production of most crops, particularly those that might compete with wheat. Therefore, changes in the absolute level of the prices of these inputs do not significantly change the relative cost of wheat production as compared to the cost of producing other crops, such as barley. Therefore, variable input prices will not be included in this study of wheat acreage. It will be assumed that the prices of the variable inputs are the same throughout the region and that any changes in the costs of the variable inputs affects the production of wheat and the production of alternatives to wheat in a similar manner as long as it is still profitable to produce.

Weather

Weather is often included in supply models. In a national acreage model, Houck et al. included an index of range conditions in the Southern Plains Region as a proxy variable for weather conditions at the time wheat is planted. The analysis by Houck et al. found that the Southern Plains was the only region where the effect of weather on planted wheat acreage was significant. Since this study deals with the Northwest states of Oregon and Washington disaggregated into homogeneous production regions by soil and climate, no variables to explicitly measure the effects of weather are included. Any subregional differences in weather conditions among these areas are minimal.

Technology

Many researchers have used linear or logarithmic time trends as proxy variables to account for the increases in production attributable to technological advances. Tomek and Robinson point out that the use of simple time trends in empirical supply analysis is caused by definitional and measurement problems involved in measuring technological improvements. Time trends are utilized as a measure of technological advances without specifically identifying and measuring those factors responsible for the shifts in supply. It is often unclear what the time trends actually measure.

Winter and Whittaker tried using both linear and logarithmic time trends.

Neither of these measures was found to be significant in a Northwest wheat supply model based on pooled cross-sectional and time-series data aggregated by states. Pooling the data reduces the number of years for which observations are necessary for reliable estimation of the coefficients. Shortening the time span under study appears to make it unnecessary to incorporate a time trend into the model to account for technological changes. It is also assumed that the impact of technological innovations has been much greater on yields than on acreage. Since this study will estimate an acreage response model based on pooled time-series observations from twelve recent years, no measure of technological change will be included.

Risk

Risk is hypothesized to affect the planting decisions made by producers. A variable to explicitly measure the effects of risk was incorporated into the model following the previous quantification utilized by Lin. Risk was computed as a moving average based on the previous three years of the standard deviation of gross income per acre for each region. This is a measure of the variability of gross income per acre. Other authors have used various geometric and polynomial lags to weight the relative importance of past income values on current risk expectations. Just (1974) assumed that decision makers formed their expectations following a goemetric lag of the square of the difference between the explanatory variables and their expected values. Traill hypothesized a polynomial lag of the absolute difference between the actual prices and their expected values. Robison and Carman suggest the log of the variance of expected wealth as a risk formulation in an aggregate supply function. Lin's risk formulation was chosen because of the availability of data necessary to compute the variable.

Gross income per acre is defined as the regional weighted price of wheat multiplied by the regional yield of wheat. Gross income will be computed three times utilizing the average regional yields, the regional yield on irrigated acreage and the regional yield on dryland acreage. These three gross incomes per acre will then be used to compute the risk variable for all planted acreage, and irrigated and dryland acreage respectively.

The risk variable as formulated by Lin is computed as follows:

$$RISK_t = \sqrt{\sum_{i=1}^{3} \frac{(GI_{(t-i)} - \overline{GI})^2}{2}}$$

where GI = gross income per acre, $\overline{GI}$ = the mean gross income for the previous three years, and t = year. This formula represents a moving average of the standard deviation of gross income per acre based on the previous three years. The expected sign of the estimated coefficient is negative, i.e., producers are assumed to be risk averse. An increase in the volatility of gross income per acre derived from wheat production is expected to reduce the acreage planted to wheat, other things equal. An increase in economic uncertainty is assumed to induce producers to decrease wheat acreage. A positive sign on this estimated coefficient would indicate a risk taker.

Estimation Technique and Study Area

The parameters of the acreage response models developed in this study were estimated using pooled cross-sectional and time-series data. The time-series observations begin in 1966 and cover the next twelve years through 1977. The year 1966 was designated as the starting point because of the data availability.

The counties in Oregon and Washington were aggregated into five regions for each state. These ten regions constitute the cross-sectional units for the study (Figures 1 and 2, Tables 1 and 2). The counties were grouped in accordance with general similarities in wheat production (i.e., soil, climate, substitute crops and production methods). Admittedly, this aggregation entails some generalizations of intra-county variations to classify these areas as homogeneous producing regions. However, they do represent groups with broad similarities in production.

A major advantage of pooling the data is that it allows for several potentially different populations (i.e., structures) to be combined within one sample. Specifically, it allows the estimated coefficients on the independent variables to differ between the defined cross-sectional units. This factor relaxes the assumption of constant elasticities throughout the entire region studied. As discussed earlier, a second advantage of pooled data is that it reduces the number of time-series observations necessary for reliable estimation of the coefficients and, therefore, minimizes the need to try to quantify technology.

Figure 1. Map of the Five Oregon Wheat Producing Regions.

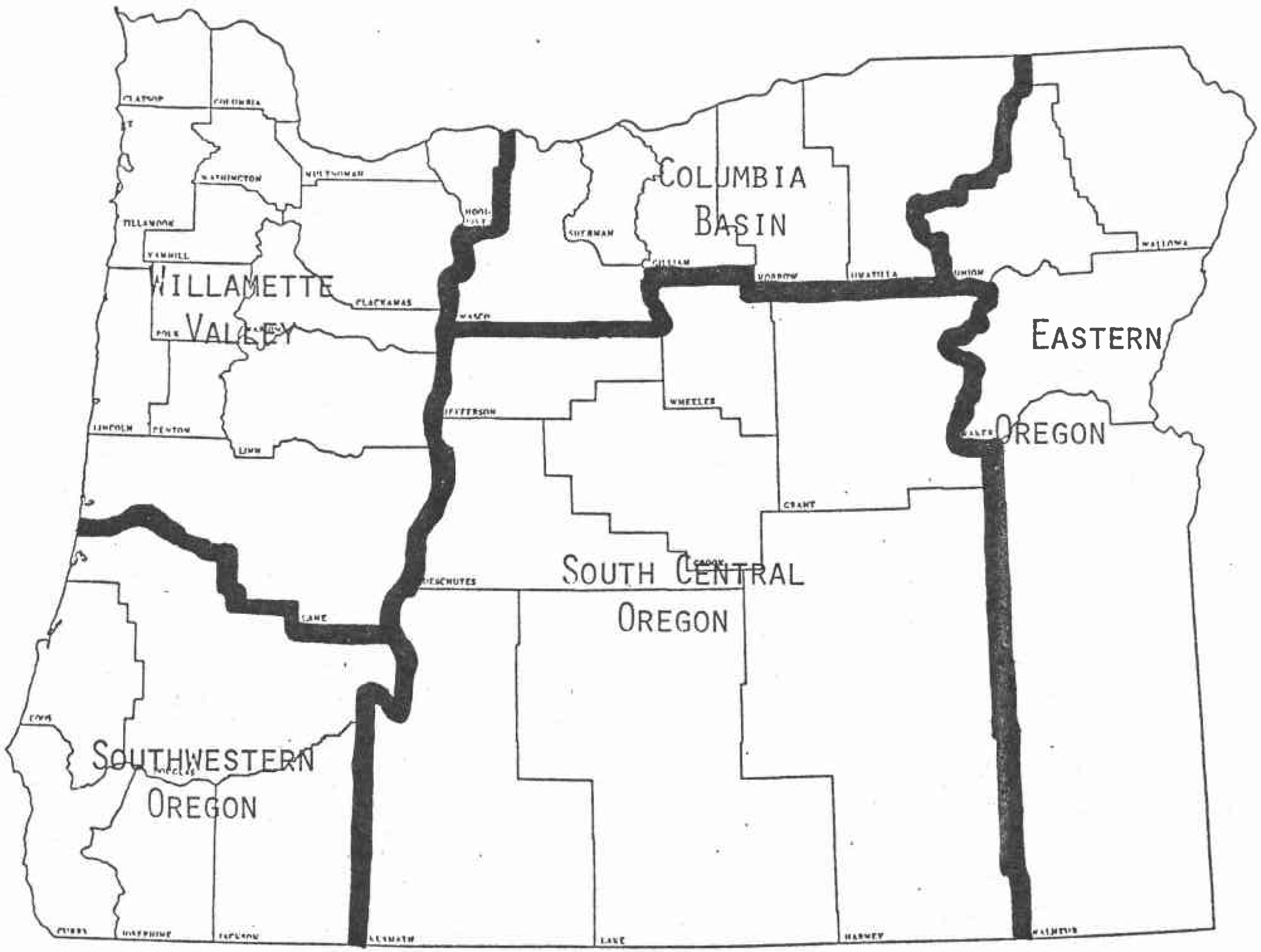

Figure 2. Map of the Five Washington Wheat Producing Regions.

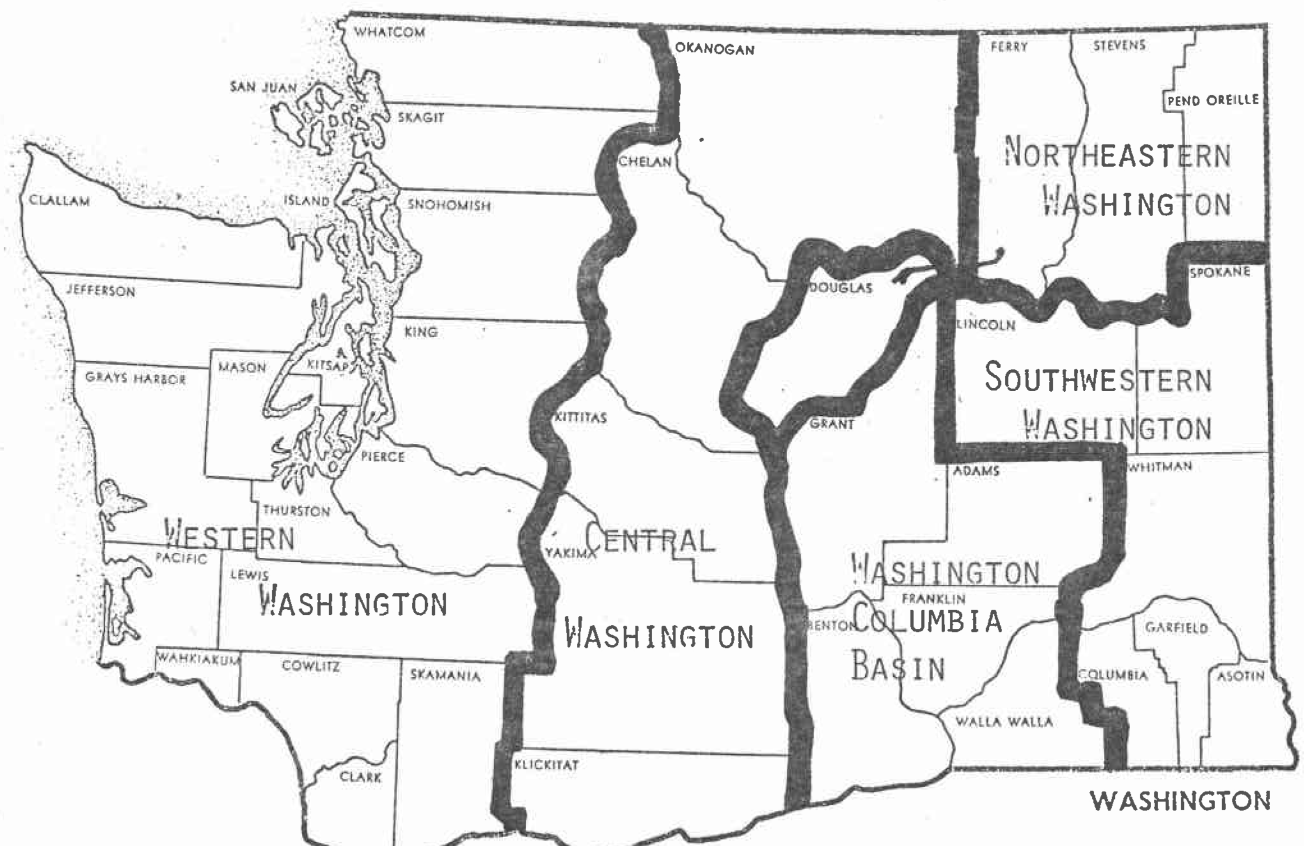

Table 1. Counties Comprising the Five Oregon Regions

Region	Counties
Willamette Valley (WV)	Columbia, Washington, Multnomah, Yamhill, Clackamas, Polk, Marion, Benton, Linn, Lane, Clatsop, Tillamook, Lincoln, Hood River
Columbia Basin (CB)	Umatilla, Morrow, Gilliam, Sherman, Wasco
Eastern Oregon (EO)	Wallowa, Union, Baker, Malheur
South Central Oregon (SC)	Jefferson, Wheeler, Grant, Crook, Deschutes, Klamath, Lake, Harney
Southwestern Oregon (SW)	Coos, Curry, Douglas, Josephine, Jackson

Table 2. Counties Comprising the Five Washington Regions

Region	Counties
Southeastern Washington (SEW)	Spokane, Lincoln, Whitman, Garfield, Columbia, Asotin
Washington Columbia Basin (WCB)	Benton, Walla Walla, Franklin, Adams, Grant
Central Washington (CNW)	Klicitat, Yakima, Kittitas, Cheland, Okanogan
Northeastern Washington (NEW)	Ferry, Stevens, Pend Oreille, Douglas
Western Washington (WWW)	Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Wahkiakum, Whatcom

Separate equations will be estimated for Oregon and Washington. Three models will be estimated for each state. The first is an acreage response model utilizing all planted acreage of wheat as the dependent variable. The second equation is based on irrigated planted acreage of wheat as the dependent variable and the third model estimates the dryland acreage planted in wheat.

Summary of Model Specification

Summarizing the earlier discussion in this chapter on applicable theory and variable measurement, the six pooled acreage response models with the addition of binary intercept shifters are specified as follows:

(Oregon-AWP) $AWP_{r,t} = f(C_r, MP_{r,t-1}, HES_{r,t}, HED_{r,t}, BAR_{r,t-1}, ALF_{r,t-1}, POES_{r,t-1}, GRAS_{WV,t-1}, CLOV_{t-1}, RISK_{r,t})$ (1)

(2) (Oregon-IRR) $AWPIRR_{r,t} = g(.....)$

(3) (Oregon-DRY) $AWPDRY_{r,t} = h(.....)$

(4) (Washington-AWP) $AWP_{r,t} = j(C_r, MP_{r,t-1}, HES_{r,t}, HED_{r,t}, BAR_{r,t-1}, ALF_{r,t-1}, SUGBT_{r,t-1}, PEAS_{r,t-1}, RISK_{r,t})$

(5) (Washington-IRR) $AWPIRR_{r,t} = k(.....)$

(6) (Washington-DRY) $AWPIRR_{r,t} = l(.....)$

where $AWP_{r,t}$ = acres of wheat planted for region r in year t

$AWPIRR_{r,t}$ = irrigated acres of wheat planted in region r in year t

$AWPDRY_{r,t}$ = dryland acres of wheat planted in region r in year t (sum of summer-fallow and after-legumes and continuous cropping production methods)

C_r = binary intercept shift variable for region r (= 1 if observation is in region r; = 0 otherwise)

$MP_{r,t-1}$ = the price of wheat for region r in year t-1; dollars per bushel

$HES_{r,t}$ = the effective support rate of wheat for region r in year t; dollars per bushel

$HED_{r,t}$ = the effective voluntary diversion rate for region r in year t; dollars per bushel

$BAR_{r,t-1}$ = the average price of barley in region r in year t-1; dollars per bushel

$ALF_{r,t-1}$ = the average price of alfalfa in region r in year t-1; dollars per ton

$POES_{r,t-1}$ = the average price of potatoes in region r in year t-1, dollars per hundredweight

$GRAS_{WV,t-1}$ = the average price of orchard grass in the Willamette Valley in year t-1; dollars per bushel; 0 in other regions

$CLOV_{t-1}$ = the average price of red clover in the Willamette Valley in year t-1; dollars per ton; 0 in other regions

$RISK_{r,t}$ = moving average of the standard deviation of gross income per acre in region r in the previous three years

$SUGBT_{r,t-1}$ = the average price of sugar beets in region r in year t-1; dollars per ton

$PEAS_{r,t-1}$ = the average price of peas in region r in year t-1; dollars per hundredweight.

The binary intercept shift variables added to the model account for regional differences in mean planted acreage. The estimated intercepts are expected to be the most positive in the regions where the most wheat is planted.

Functional Form

All six models will be estimated using a double logarithmic functional form. Consequently, all the estimated coefficients are elasticities. The double logarithmic functional formulation assumes that the acreage elasticities are equal in each subregion specified. This is a reasonable assumption (but it will be tested) given the small size of the geographic area and the relatively homogeneous nature of wheat production among subregions. A pooled-data linear functional form, on the other hand, is not acceptable because it implies that a given change in an independent variable will induce the same change in acreage in all regions. This assumption is not reasonable given the large differences in acreage planted among the regions defined.

Serial Correlation

The models in double-logarithmic functional form are estimated using ordinary least squares (OLS). It was initially assumed that the residuals were non-autoregressive and homoskedastic. After the six acreage response models were determined, the residuals of each of the OLS equations were tested for serial correlation in each of the given regions. This is a test of the assumption that the error terms are not correlated over time.

The first order auto regressor, $\hat{\rho}$, was estimated by regressing the residual in year t on the residuals in year t-1 separately for each region following equation (1),

$$e_{r,t} = \hat{\rho} e_{r,t-1} + u_{r,t} \tag{1}$$

where r represents the region. The magnitude of the estimated coefficient $\hat{\rho}$ is compared to the size of its respective standard error to ascertain the degree of serial correlation. Serial correlation was deemed a problem if the estimated coefficient was significantly different than zero. If serial correlation is present, the OLS estimates are still unbiased and consistent, but they are not efficient.

The data were transformed in the regions where serial correlation was present, following the iterative procedure outlined by Kmenta (pp. 287-288) to obtain estimators that are asymptotically equivalent to best-linear-unbiased estimators. This procedure required all the dependent and indepedent variables (including the constant) to be transformed according to equation (2) to correct for the serial correlation.

$$\begin{aligned} Y^*_{r,t} &= Y_{r,t} - \hat{\rho} Y_{r,t-1} \\ X^*_{k,r,t} &= X_{k,r,t} - \hat{\rho} X_{k,r,t-1} \end{aligned} \tag{2}$$

where Y is the dependent variable, X_k represents the kth independent variable, r is the region, and t is the year.

This data tranformation was omitted in those regions where serial correlation was not present. The regression was then repeated using the transformed data (X^* ,Y^*). The standard errors of the generalized least squares (GLS) estimates of the model corrected for serial correlation should be smaller than those in the uncorrected OLS version, and the F for regression should increase.

Heteroskedasticity

Following the tests and the necessary corrections for serial correlation, the residuals for each cross-sectional unit from the resultant model were subsequently tested for heteroskedasticity. To test the assumption of homoskedasticity or equal variances of the error terms among regions, a consistent estimate of the variance for each region was obtained using equation (3).

$$S_r^2 = \frac{1}{T-K} \sum_{t=1}^{T} e^2_{r,t} \tag{3}$$

where r represents the region, t is the year and T-K is equal to the degrees of freedom for one cross-sectional unit.

The hypothesis of homoskedasticity was tested by an F-test (following Kmenta [pp 267-268]) equal to the ratio of the consistent estimates of the variances in two regions. This test is an indication of the degree to which heteroskedasticity is present. If the hypothesis of equal variances is rejected, then the assumption of homoskedasticity is violated, and the OLS estimates are still unbiased and consistent but not efficient. The existence of heteroskedasticity between regions suggests that the data be transformed in a manner such that the assumption of homoskedasticity applies. The appropriate data transformation in this case is to divide the dependent variable and all the independent variables (including the constant) by the standard deviation of the error terms for each of the five regions as in equation (4).

$$Y^{**}_{r,t} = \frac{Y_{r,t}}{s_{e,r}} \qquad (4)$$

$$X^{**}_{k,r,t} = \frac{X_{k,r,t}}{s_{e,r}}$$

where Y is the dependent variable and X_k represents the kth independent variable.[7/]

The regression is then repeated using OLS on the transformed variables (Y^{**}, X^{**}). The standard errors of the estimated coefficients should be smaller using the transformed data than they were in the uncorrected model and the F for regression should increase. The estimators from the corrected GLS version of the model are asymptotically equivalent to best-linear-unbiased estimators.

EMPIRICAL ANALYSIS

Oregon Wheat Acreage Response Model

The parameters of the model of Oregon planted wheat acreage estimated in double-logarithmic functional form are summarized in Table 3. The initial ordinary least squares (OLS) estimation is represented by model Oregon-AWP(1).

[7/] $Y_{r,t}$ and $X_{k,r,t}$ were transformed by equation (2) to correct for serial correlation prior to computing equation (4) in those regions where serial correlation was determined to be a problem.

Table 3. Estimated Oregon Wheat Acreage Response Model

	Constant				Market Price		Support	Risk	Orchard Grass	
MODEL	C	C_{EO}	C_{SW}	C_{SC}	LNMP	$LNMP_{WV}$	$LNHES_{WV,SW}$	LNRISK	$LNGRAS_{WV}$	R^2
Oregon-AWP(1)	13.32	-2.02	-5.90	-2.49	0.47	0.58	1.00	-0.08	-0.76	.98
	(0.08)	(0.08)	(0.18)	(0.08)	(0.10)	(.14)	(0.34)	(0.04)	(0.07)	
Oregon-AWP(2)	13.29	-2.01	-5.87	-2.48	0.43	0.58	0.92	-0.05	-0.75	.99
	(0.03)	(0.03)	(0.19)	(0.04)	(0.04)	(.10)	(0.33)	(0.02)	(0.06)	

(The standard errors are in parentheses)

All coefficients are at least twice the size of their standard errors. All signs are as expected from the discussion of pertinent economic theory in the previous section. The coefficients and variables included in the model will be more fully discussed below.

Model Oregon-AWP(1) was tested for serial correlation. Auto correlation was not found to be a problem with these data for any region. Consequently, the assumption of nonautogression cannot be rejected in any of the Oregon subregions. Model Oregon-AWP(1) was subsequently tested for heteroskedasticity. The assumption of homoskedasticity or equal variances of the error terms between regions was violated and the data were transformed so the assumption of homoskedasticity holds. Model Oregon-AWP(2), presented in Table 3, is the OLS estimation of the parameters of the model using the transformed variables corrected for heteroskedasticity between regions as detailed in the previous section.

The Oregon wheat acreage response model was estimated with the major wheat-producing region of the Columbia Basin designated as the base region. Regional intercept and coefficient shifters defined as the addition to the base coefficient applicable for each region were incorporated into the model. The shifters are represented in Table 3 by the variable labels with a subscript of the abbreviation for the applicable region. For example, the estimated intercept (C = 13.29) applies to the base region which is the Columbia Basin in this case. The intercept shifter for Eastern Oregon, C_{EO}, is -2.01. Hence, the estimated intercept for Eastern Oregon is obtained by adding the base intercept plus the intercept shifter for Eastern Oregon, e.g., 13.29 + (-2.01) = 11.28. If no shifter is included for a region, as in the case of the intercept shifter for the Willamette Valley, then there is no change in the coefficient for this region from the base coefficient. In other words, the intercept for the Willamette Valley is equal to the intercept for the Columbia Basin. When there is no base designated (i.e., no variable label without a subscript), as in the case of the effective support rate, the estimated coefficient for the base was zero. The estimated coefficient for the effective support rate applies only to the two regions subscripted, the Willamette Valley and Southwestern Oregon. There was no response to a change in this variable in the other three regions. As this model is estimated in double-logarithmic form, the estimated coefficients represent the elasticities of acreage response with respect to the associated variables. The intercepts and the elasticity values for all independent variables for each of the five regions are presented in Table 4.

The elasticity of planted acreage with respect to the expected market price of wheat for all regions except the Willamette Valley is 0.43, which is approximately that estimated for national wheat acreage response by Nerlove before the advent of government acreage programs for wheat. Using data from 1910 to 1932, Nerlove made several estimates ranging from 0.38 to 0.45. This level is slightly higher than that estimated by Houck et al. (0.39) in their aggregate supply model. Winter and Whittaker estimated this elasticity for Oregon as 0.376 in a pooled regional model. An elasticity of 0.43 is quite inelastic reflecting the lack of substitutes for wheat production in most parts of the state. The choice open to many farmers, particularly in the eastern regions of the state, is essentially limited to whether to produce wheat.

The elasticity of acreage response with respect to expected price is much greater in the Willamette Valley than in the rest of the state. The estimated elasticity in this region is 1.01, almost unitary elasticity, indicating that wheat producers in this region are more responsive to expected market price than are wheat producers in other parts of the state. The occurrence of a higher elasticity of response for producers in the Willamette Valley reflects the fact that more production alternatives exist for these producers. The conditions for crop production in the fertile Willamette Valley are conducive to raising many commodities. Miles reports that more than 100 crops are produced in the Valley and many of these are technological substitutes for wheat.

The variables measuring the government programs are not significant at the 20 percent level for the most part. Only an estimated coefficient for the support price variable for the westernmost regions, the Willamette Valley and the Southern coast, is included in the model. The effect of the support price on acreage is not significantly different between these two regions. The estimated elasticity of acreage response with respect to the support rate in these regions is 0.92, about the same as the elasticity with respect to market price in the Willamette Valley. This elasticity is much higher than previous regional estimates. Winter and Whittaker estimated this elasticity to be 0.508 in an aggregate regional model (Oregon, Idaho, and Washington) and 0.242 for the state in a pooled data model. This level is also much higher than Houck et al.'s national estimate of 0.58. This high elasticity is also reflective of the fact that

Table 4 Model Oregon-AWP(2): Estimated Intercepts and Elasticities for all Independent Variables by Region

REGION	CONSTANT	Market Price LNMP	Support LNHES	Risk LNRISK	Orchard Grass LNGRAS
Willamette Valley	13.29	1.01	0.92	-0.05	-0.75
Columbia Basin	13.29	0.43	0.00	-0.05	0.00
Eastern Oregon	11.28	0.43	0.00	-0.05	0.00
South Central Oregon	10.81	0.43	0.00	-0.05	0.00
Southwestern Oregon	7.42	0.43	0.92	-0.05	0.00

numerous substitutes for wheat production exist in the Valley. Consequently, producers are highly sensitive to variations in price—both market price and support price.

The coefficient on support price is zero in the Columbia Basin, Eastern, and South Central Oregon regions, indicating that the government wheat price support programs have no influence on the wheat planting decision in these areas. This elasticity is influenced by the same arguments as that for an inelastic response with respect to market price in these regions. These producers have no economic substitutes for wheat production.

The variable measuring the effect of the government wheat diversion programs was not significant at 20 percent for any region in the state. In the eastern regions, wheat producers are not responsive to changes in the acreage diversion provisions, just as they are not responsive to changes in the wheat price support programs since no economic substitutes for wheat production exist in these regions. For the western regions, the relative price received for additional diversion under the wheat programs was less during the estimation period than the relative price that would be received by the producer for diverting the land from wheat into the production of another commodity. Hence, wheat acreage diversion in addition to that required for participation in the price support program is not a viable substitute for wheat production in any region of the state.

Consistent with the hypothesis that many alternatives to wheat production exist in the Willamette Valley while no economic alternatives exist elsewhere in the state, the market price of grass seeds in the Willamette Valley is the only significant substitute crop in the acreage response model. The farm level market price of orchard grass was lagged to act as a proxy variable to measure the effects of the expected price of grass seeds grown in the Willamette Valley. Barley, alfalfa, potatoes, and red clover were also hypothesized to be substitutes for wheat production in the state. None of the estimated coefficients for these variables was significant at 20 percent for any region in the state, substantiating the claim that no alternatives exist for wheat production in the eastern regions of the state. The other technological substitutes for wheat were assumed to have a very minor effect on wheat acreage so they were not included in the model.

Risk was found to affect the planting decision. The estimated coefficient on risk is -0.05 for the state. The negative sign indicates that producers are risk averse. The magnitude of this coefficient implies a five percent reduction in the acreage planted of wheat in the state for a 100 percent increase in the standard deviation of the moving average of the gross income per acre computed for the previous three years. This coefficient implies that stable prices have a positive influence on planted wheat acreage in the state.

Equation AWP(2) was used to predict planted wheat acreage in Oregon from 1966 to 1977. The average annual estimation error of state planted wheat acreage for this model is 6.6 percent with a standard deviation of 3.5. A graph of the predicted versus the actual state planted wheat acreage is presented in Figure 3. The large prediction error in 1977 may have been partially caused by the announcement of the government programs occurring several months after the crop had been planted. There was a larger decrease in harvested acreage from planted acreage in 1977 than the average in previous years.

Oregon Dryland Wheat Acreage Response Model

The estimated Oregon dryland wheat acreage response model parameters in double-logarithmic form are presented in Table 5. This model was estimated using data for 1969 through 1977. 1966, 1967 and 1968 were not included because of the lack of data with which to compute the risk variable for dryland acreage for these years. Model Oregon-DRY(1) is the initial OLS estimation of the model. All signs are as expected with the exception of the negative sign on the effective support rate shifter for the South Central region. This aberration and the estimated coefficients will be discussed below with model Oregon-DRY(2).

Model Oregon-DRY(1) was tested for serial correlation. None of the estimated coefficients are significant at the 20 percent level so serial correlation was deemed not be a problem. The equation DRY(1) was then tested for heteroskedasticity. The hypothesis that the variance of the error terms is equal among regions can be rejected. Consequently, the variables were transformed for all regions following the procedures outlined earlier and OLS was repeated on the transformed variables. The coefficients in model Oregon-DRY(2) are the GLS estimates for the Oregon dryland acreage after correction for heteroskedasticity. As anticipated, all of the standard errors are smaller in the GLS estimation. The estimated coefficients are also decreased in magnitude.

The estimated intercepts and elasticities for all independent variables are presented in Table 6 by region. These values were calculated from the base

Figure 3. Predicted versus Actual Oregon Planted Wheat Acreage

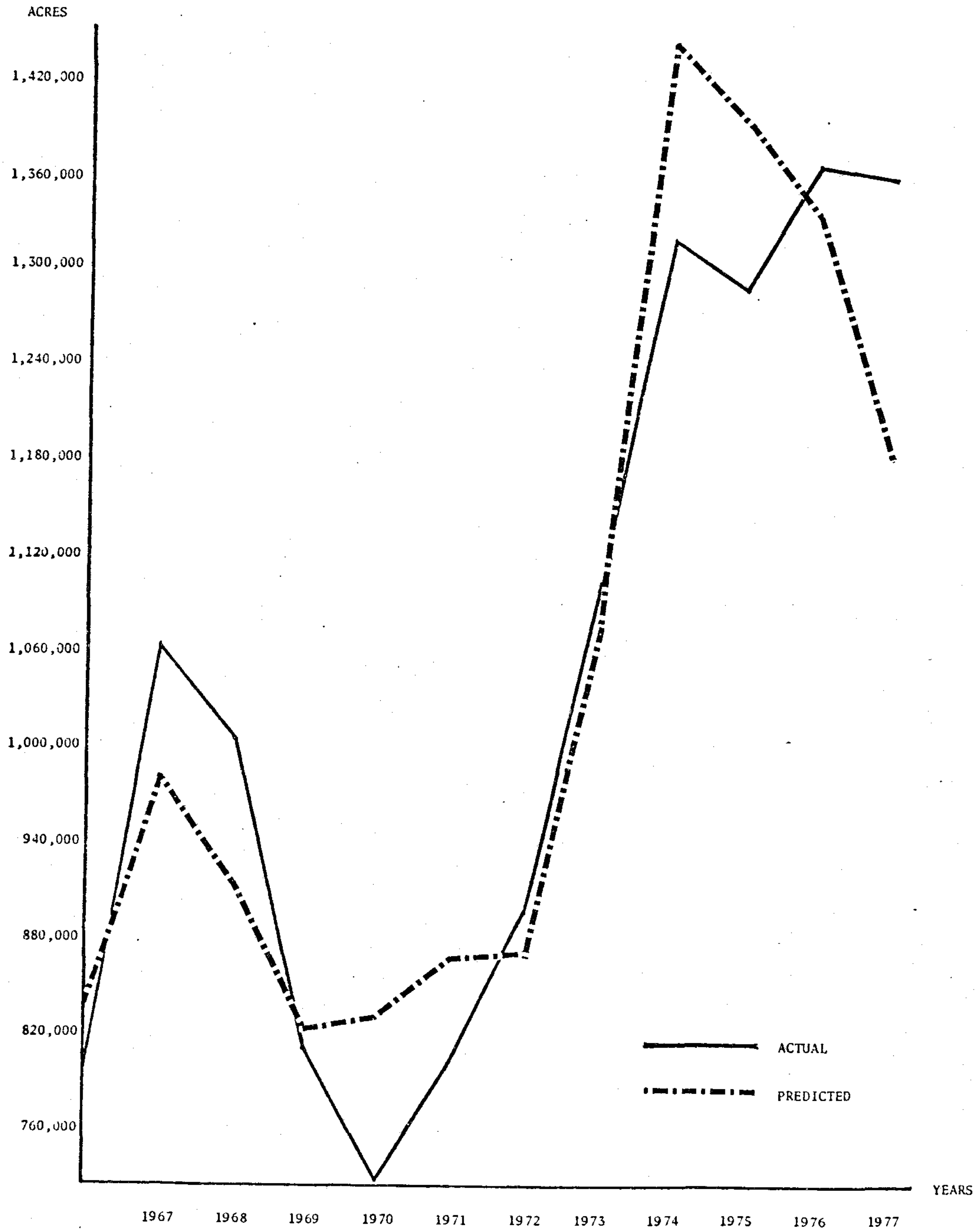

Table 5. Estimated Oregon Dryland Wheat Acreage Response Model

	Constant			Market Price		Support			Orchard Grass	Risk	
MODEL	C	$C_{EO,SC}$	C_{SW}	LNMP	$LNMP_{WV}$	LNHES	$LNHES_{CB}$	$LNHES_{SC}$	$LNGRAS_{WV}$	LNDRYRISK	R^2
Oregon-Dry(1)	13.39	-2.83	-5.90	0.56	0.66	0.92	-0.91	-1.15	-0.73	-0.16	.98
	(0.25)	(0.28)	(0.28)	(0.11)	(0.15)	(0.24)	(0.48)	(0.16)	(0.09)	(0.05)	
Oregon-Dry(2)	13.30	-2.74	-5.83	0.43	0.65	0.78	-0.76	-1.11	-0.72	-0.09	.99
	(o.15)	(0.12)	(0.15)	(0.09)	(0.13)	(0.23)	(0.32)	(0.13)	(0.06)	(0.05)	

(The standard errors are in parentheses).

Table 6. Model Oregon-DRY(2): Estimated Intercepts and Elasticities for all Independent Variables by Region

REGION	CONSTANT	Market Price LNMP	Support LNHES	Risk LNDRYRISK	Orchard Grass LNGRAS
Willamette Valley	13.30	1.08	0.78	-0.09	-0.72
Columbia Basin	13.30	0.43	0.02	-0.09	0.00
Eastern Oregon	10.56	0.43	0.78	-0.09	0.00
South Central Oregon	10.56	0.43	-0.33	-0.09	0.00
Southwestern Oregon	7.47	0.43	0.78	-0.09	0.00

coefficients and the estimated shifters as illustrated for the previous model. The negative intercept shifters resulting in smaller constants for Eastern Oregon, South Central and Southwestern Oregon were anticipated since the Willamette Valley and the Columbia Basin have the overwhelming majority of dryland wheat acreage in the state. The intercepts and elasticities estimated with the dryland model bear a marked resemblence to those for the state total acreage model presented earlier. Only the support price elasticities vary substantially.

The estimated elasticity of response with respect to expected price is 0.43 for the state with the exception of the Willamette Valley. This is exactly the estimate derived from the total acreage model for these regions. This similarity is caused by the preponderance of dryland wheat acreage in the state total wheat acreage. The inelastic estimate reflects the limited alternatives to wheat production by dryland and particularly Eastern Oregon dryland wheat producers.

The estimated elasticity of response with respect to the expected market price of wheat is 1.08 in the Willamette Valley. This is very similar to the estimate of 1.01 derived from the total wheat acreage model for this region. As discussed earlier, this estimate for the Willamette Valley is elastic, reflecting the numerous alternatives to wheat production available to Valley producers.

The estimated coefficients for the various regions of the government policy variable measuring the weighted support rate are somewhat different than those for the total wheat acreage model. The irrigated acreage included in the total planted wheat acreage model may exert a mitigating influence on the responses by dryland producers. The magnitude of the elasticity with respect to the support rate for the two coastal regions and Eastern Oregon is 0.78. This level is more elastic than Houck et al.'s national estimate of 0.58. For the western coastal regions, this elasticity is indicative of the availability of substitutes and is comparable to the 0.92 estimate for these regions derived from the total acreage model. This estimate for Eastern Oregon may be the result of the paucity of economically viable alternatives to wheat production. The support rate guarantees a certain price for wheat production on acreage participating in the government programs and may indirectly stimulate an increase in wheat production by acting as a price floor for the market price. Also, the model may be misspecified and a crop that functions as a substitute for wheat production in this region may have been ignored. However, the Eastern Oregon region contains more than five percent of the state's annual dryland planted wheat acreage.

The estimated elasticity of response with respect to the support rate is virtually zero for the Columbia Basin. This is the same estimate derived from the total acreage model for this region. Producers in this region are not responsive to changes in the government mandated effective support rate.

The estimated elasticity of the support rate in the South Central region presents a problem in that the estimated sign is not positive as expected. It may be that the decrease in acreage as a response to an increase in the effective support rate is reflective of and concurrent with changing relative prices of wheat production and an alternative to wheat production that is not included in the model. However, the estimated coefficient is not significantly different than zero at ten percent.

The estimated coefficient with respect to the price of orchard grass is -0.72, virtually the same estimate as from the total acreage model. Barley, alfalfa, potatoes and red clover were also hypothesized as substitutes to wheat production but none were statistically significant.

The estimated coefficient on risk is less than twice the size of its standard error in the version of the model corrected for heteroskedasticity, but its magnitude (-0.09) is nearly twice the magnitude of the estimated risk coefficient (-0.05) in the total acreage model.

Equation DRY(2) was used to predict dryland wheat acreage in Oregon from 1969 to 1977. The average annual estimation error for model Oregon-DRY(2) is 7.48 percent with a standard deviation of 4.91. Using this criteria, the overall wheat acreage model is a slightly better estimator. Figure 4 presents a graph of the predicted versus the dryland planted wheat acreage for Oregon. Again, the large 1977 error may be because the government program was announced so late in 1977 that planted acreage was not affected.

Oregon Irrigated Wheat Acreage Response Model

Table 4-7 presents a summary of the Oregon irrigated wheat acreage response model parameters estimated in double-log form. Model Oregon-IRR(1) is the initial OLS estimation. All coefficients are more than three times the size of their respective standard errors. All signs are as expected with the exception of the effective support price variable in the Southwestern region. A brief discussion of the estimated coefficients is included below under the Oregon-IRR(3) model which is the GLS estimation after correcting the data for auto correlation and heteroskedasticity.

Figure 4. Predicted versus Actual Oregon Dryland Planted Wheat Acreage

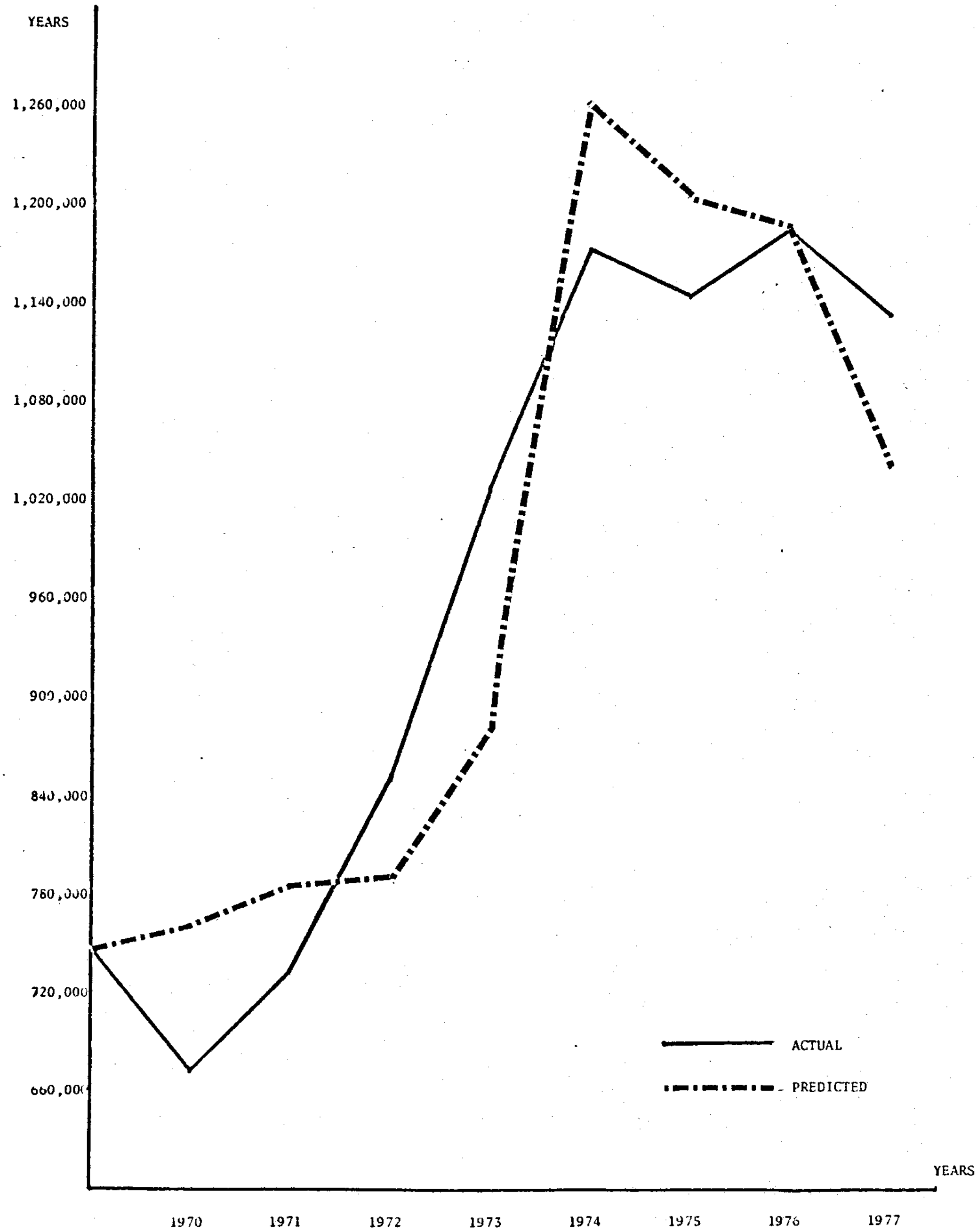

Table 7. Estimated Oregon Irrigated Wheat Acreage Response Model

	Constant				Market Price		Support	Potatoes	
MODEL	C	C_{CB}	C_{EO}	C_{SC}	LNMP	$LNMP_{CB}$	$LNHES_{SW}$	LNPOES	R^2
Oregon-IRR(1)	7.80	2.42	3.32	3.03	0.87	0.98	-2.38	-1.09	.96
	(0.12)	(0.33)	(0.31)	(0.30)	(0.12)	(0.25)	(0.63)	(0.22)	
Oregon-IRR(2)	7.82	2.87	3.19	2.88	0.82	0.52	-2.53	-0.97	.98
	(0.12)	(0.43)	(0.29)	(0.28)	(0.11)	(0.35)	(0.58)	(0.20)	
Oregon-IRR(3)	7.84	2.68	2.95	2.65	0.77	0.48	-3.02	-0.78	.99
	(0.11)	(0.39)	(0.28)	(0.27)	(0.09)	(0.29)	(0.64)	(0.20)	

(The standard errors are in parentheses.)

Model Oregon-IRR(1) was tested for serial correlation in the five regions. The estimated first order auto regressor was found to be significant in the Columbia Basin region, but serial correlation is not a problem in the other four regions. The data from the Columbia Basin were corrected following the procedure outlined earlier. The first observation, 1966, was lost because of the lagging procedure to correct for serial correlation, and OLS was then repeated on the transformed variables using data from 1967 to 1977. Model Oregon-IRR(2) is the irrigated acreage model corrected for serial correlation. The standard errors decreased from the previous model with the exception of the Columbia Basin regional shifters for the intercept and for the expected market price.

Model Oregon-IRR(2) was tested for heteroskedasticity and as in the previous models, the assumption of homoskedasticity between regions was violated. The variables were corrected and OLS was repeated on the transformed data. Model Oregon-IRR(3) presents the GLS parameter estimates of the Oregon irrigated wheat acreage model corrected for both serial correlation and heteroskedasticity. The standard errors decreased from model Oregon-IRR(2) except for potatoes which remained the same and the effective support rate in Southwestern Oregon which increased slightly. The coefficients decreased slightly in magnitude with the exception again of the effective support rate for wheat in Southwestern Oregon.

The Oregon irrigated acreage response model was estimated with the Willamette Valley designated as the base region. The positive intercept shifters for the Columbia Basin, Eastern Oregon and the South Central region were expected reflecting a greater number of irrigated acres for these three regions. These constant shifters appear to be approximately the same, but the hypothesis that these coefficients were equal was rejected in the uncorrected model. The estimated intercepts and elasticities for all the independent variables are presented in Table 8 by region.

The estimated elasticity with respect to expected price for the state excluding the Columbia Basin region is 0.77. This is a much more elastic estimate than that derived from the dryland or total acreage models (estimated elasticity of 0.43). The difference in elasticity estimates between irrigated and dryland wheat acreage illustrates the distinction between wheat production systems gained by disaggregating total wheat acreage. These estimates also differ markedly from the national estimates of Houck et al. and Nerlove, substantiating the need for regional models. The estimate of this elasticity for the Columbia Basin

Table 8. Model Oregon-IRR(3): Estimated Intercepts and Elasticities for all Independent Variables by Region

		Market Price	Support Price	Potatoes
REGION	CONSTANT	LNMP	LNHES	LNPOES
Willamette Valley	7.84	0.77	0.00	0.00
Columbia Basin	10.52	1.25	0.00	-0.78
Eastern Oregon	10.79	0.77	0.00	-0.78
South Central Oregon	10.49	0.77	0.00	-0.78
Southwestern Oregon	7.84	0.77	-3.02	-0.78

wheat producers (1.25) is even further from the national estimates. The magnitude of these elasticities reflects the existence of more substitutes to wheat production on irrigated acreage.

Potatoes were found to be an important alternative to wheat production on irrigated acreage.[8/] Potatoes were hypothesized as an alternative to wheat production in all regions of the state except the Willamette Valley where few potatoes are grown. They are extensively cultivated in two areas of the state—the Columbia Basin and Eastern Oregon. The estimated elasticity with respect to the expected price of potatoes is -0.78 for all regions in the state outside of the Willamette Valley. This is practically the same estimate but with the opposite sign as the elasticity with respect to expected market price for all regions in the state except the Columbia Basin. This estimated coefficient is indicative of producers alternating acreages between wheat and potatoes as the market signals dictate. The existence of substitute crops to wheat production provides an added discrepancy from the national wheat models which included no substitutes to wheat production.

The government policy variables were not found to have a significant impact on irrigated wheat acreage in Oregon. The diversion rate variable was not significant at the 20 percent level for any region in the state. The estimated coefficient on support was estimated to be zero for all regions except Southwestern Oregon. Hence, irrigated wheat producers in most of the state have not have been responsive to the government wheat programs. This lack of responsiveness to government programs was anticipated a priori for several reasons. Irrigated wheat acreage doubled over the data set from 1966 to 1977. Since it takes several years to obtain a government acreage allotment and to establish normal yields, much of the newly irrigated acreage was not eligible for participation in the government programs. Consequently, this acreage would not be responsive to changes in wheat policy. In addition, wheat is considered a low income crop on much of the irrigated acreage, especially in areas where potatoes are important. Potatoes are a viable economic substitute as discussed earlier, but wheat is an important rotation crop for potatoes. These factors discourage wheat pro-

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[8/] Wheat is generally used as a rotation for potatoes to control potato diseases, but the time period used to estimate this model may have made potatoes a substitute rather than a complement. Irrigated wheat acreage increased continually in the major potato producing regions of the Columbia Basin and Eastern Oregon from 1966 to 1977.

gram participation, because potatoes will yield a higher income than wheat under either support prices or market prices. In addition, at least in most years, potatoes are not an acceptable ground cover for diverted wheat acreage under the government programs. This further inhibits response to the government policy by making participation less desirable.

In contrast to the rest of the state, the estimated coefficient on the effective support rate in Southwestern Oregon is -3.02 with a standard error of .64. This large negative magnitude could be indicative of model misspecification but given the few acres of wheat planted in this region, it is probable that the response of the handful of producers to reduce wheat acreage as the effective support price increases is a spurious connection and not indicative of causality. Irrigated wheat acreage has not exceeded 750 acres in this region in any year between 1967 and 1977. This is less than one percent of irrigated wheat acreage in the state.

Risk was not found to be an important factor influencing the planting decisions on irrigated wheat acreage in the state. This reflects the increased yields and the increased investment which discourage the producer to remove irrigated land from production as well as the importance of potatoes as an economic alternative to wheat.

Equation IRR(3) was used to predict the number of irrigated acres planted to wheat in the state. For the years from 1967 to 1977, the average annual estimation error is 9.7 percent with a standard deviation of 5.2. The actual versus the predicted irrigated acreage planted to wheat in Oregon is graphed in Figure 5. The actual planted acreage in 1975, 1976 and 1977 is predicted poorly indicating that a relevant factor may have been omitted from the model. One possib cause of the poor prediction is that farmers reacted slowly to the falling price of wheat.

Washington Wheat Acreage Response Model

The estimated Washington wheat acreage response model parameters in double-logarithmic functional form are presented in Table 9. This model was estimated using data from 1969 to 1977. The information necessary to compute the risk variable for 1966, 1967 and 1968 was not available so these years were deleted from the estimation period. Model AWP(1) is the initial OLS estimation of the coefficients for the total Washington wheat acreage model. All signs are as expected with the exception of the effective diversion rate which is positive. All coefficients and the included variables will be discussed below.

Figure 5. Predicted versus Actual Oregon Irrigated Planted Wheat Acreage

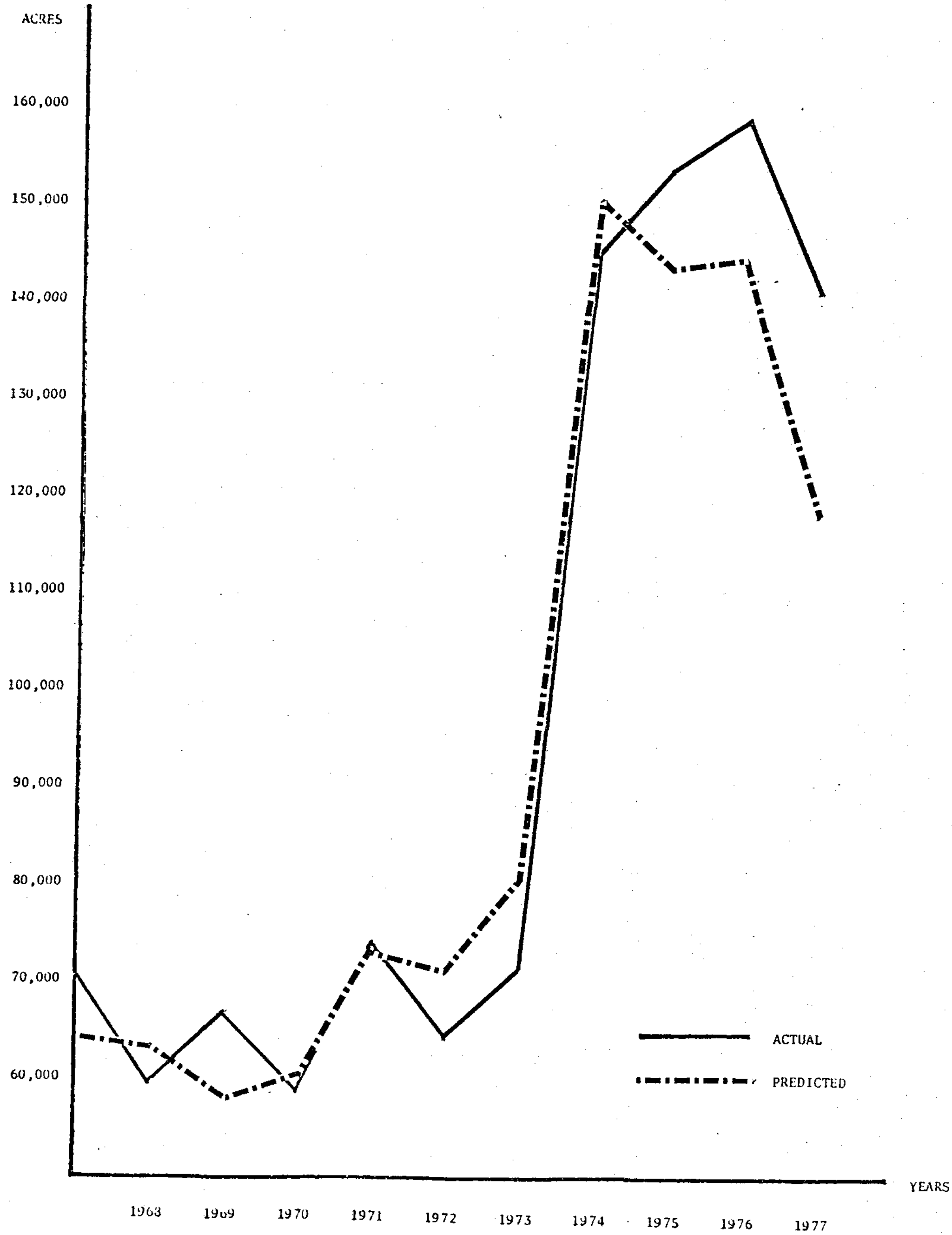


Table 9. Estimated Washington Wheat Acreage Response Model

	Constant			Market Price			Support Price		Diversion	Peas	Alfalfa	
MODEL	C	C_{NEW}	C_{WWW}	LNMP	$LNMP_{CNW}$	$LNMP_{WWW}$	LNHES	$LNHES_{WWW}$	LNHED	LNPEAS	$LNALF_{CNW}$	R^2
Washington-AWP(1)	13.73	-1.52	-6.38	0.49	0.69	1.08	0.79	0.92	1.13	-0.35	-0.64	.994
	(o.13)	(0.13)	(0.20)	(0.14)	(0.12)	(0.12)	(0.26)	(0.38)	(0.45)	(0.14)	(0.03)	
Washington-AWP(2)	13.72	-1.52	-6.34	0.39	0.67	1.07	0.64	0.87	0.68	-0.23	-0.63	.999
	(0.08)	(0.08)	(0.32)	(0.09)	(0.07)	(0.19)	(0.16)	(0.60)	(0.28)	(0.09)	(0.02)	

(The standard errors are in parentheses.)

Model Washington-AWP(1) was tested for serial correlation, and was not determined to be a problem with these data.

Equation AWP(1) was then tested and corrected for heteroskedasticity. Model Washington-AWP(2) in Table 9 is the OLS estimation of the model on the transformed variables corrected for heteroskedasticity. All standard errors decreased with the exception of the three shift variables on market price, effective support and the constant for Western Washington. Western Washington contains very little wheat acreage—less than one percent of the state total, all of which is dryland acreage.

The Washington wheat acreage response model was estimated with the major wheat-producing region of Southeastern Washington designated as the base region. The negative intercept shift variables for Northeastern Washington and Western Washington were expected, reflecting the much smaller acreages of wheat planted in these areas. The estimated intercepts and elasticities for all independent variables are presented in Table 10 by region.

The estimated elasticity of acreage response with respect to expected market price is 0.39 for most of the wheat-producing regions in the state—specifically, Southeastern Washington, the Columbia Basin and Northeastern Washington. This estimate is exactly the elasticity of acreage response estimated by Houck et al. in a national wheat supply model. It is within the range of Nerlove's estimates (0.38 to 0.45), and is comparable to the elasticity of 0.43 estimated for most of the state of Oregon.

The elasticity with respect to expected price is more elastic in Central Washington (0.67). This increased elasticity reflects the greater number of substitutes to wheat production available in this region. Alfalfa was found to be a significant substitute at the 20 percent level in Central Washington, but not in any of the other regions of the state. The elasticity with respect to market price is even more elastic in Western Washington (1.07) reflecting the existence of numerous alternatives to wheat production in the western area. Similarly in Oregon, the estimated price elasticity is 1.01 in the western region. With a wider range of alternatives, the producers in these regions are expected to be more responsive to market signals than those producers with fewer options.

The government wheat policy has a significant impact on wheat acreage in Washington. The estimated elasticity of acreage response with respect to the

Table 10. Model Washington-AWP(2): Estimated Intercepts and Elasticities for all Independent Variables by Region

		Market	Support	Diversion	Peas	Alfalfa
REGION	CONSTANT	LNMP	LNHES	LNHED	LNPEAS	LNALF
Southeastern Washington	13.73	0.39	0.64	0.68	-0.23	0.00
Washington Columbia Basin	13.73	0.39	0.64	0.68	-0.23	0.00
Central Washington	13.73	0.67	0.64	0.68	-0.23	-0.63
Northeastern Washington	12.20	0.39	0.64	0.68	-0.23	0.00
Western Washington	7.38	1.07	0.87	0.68	-0.23	0.00

support price is 0.64 for all regions except Western Washington. Since more alternatives to wheat production exist in the west, the Western Washington support price elasticity was expected to be more elastic just as the estimated market price elasticity was more elastic for this region. The estimated support price elasticity is 0.87 in this region. The Western Washington estimate is similar to the elasticity of 0.92 for western Oregon. However, no other region in Oregon displayed a response to the government support programs, differing considerably from the situation in Washington.

Wheat acreage planted in Washington was also found to be responsive to the government diversion programs. The estimated elasticity of acreage response with respect to the diversion rate is 0.68. The sign on this coefficient was expected to be negative. It was hypothesized that diversion functioned as an alternative to wheat production—the acreage could either be used for wheat production or wheat diversion just as it could be used for wheat production or alfalfa production. It appears, however, that in Washington an increase in the effective diversion rate corresponds with an increase in wheat acreage. The wheat acreage diversion programs were determined to have no impact on Oregon planted wheat acreage.

Peas were found to be a significant substitute to wheat production at the 20 percent level. The estimated coefficient is -0.23 for all regions in the state. Washington leads the country in acreage and production of peas. As discussed earlier, alfalfa was found to be an important substitute in Central Washington. Barley and sugarbeets also were hypothesized to be substitutes to wheat production, but these variables were not significant at 20 percent.

Risk was not determined to affect the planting decision in Washington. The estimated coefficient was not significant at the 20 percent level.

Equation AWP(2) was used to predict planted wheat acreage in Washington from 1969 to 1977. The average annual estimation error was 4.6 percent with a standard deviation of 2.1. Figure 6 presents a graph of the predicted versus the actual planted wheat acreage in the state over these years.

Washington Dryland Wheat Acreage Response Model

The Washington dryland wheat acreage response model parameters estimated in double-logarithmic form are presented in Table 11. As with the Washington total planted wheat acreage model, the estimation period for the dryland model

Figure 6. Predicted versus Actual Washington Planted Wheat Acreage

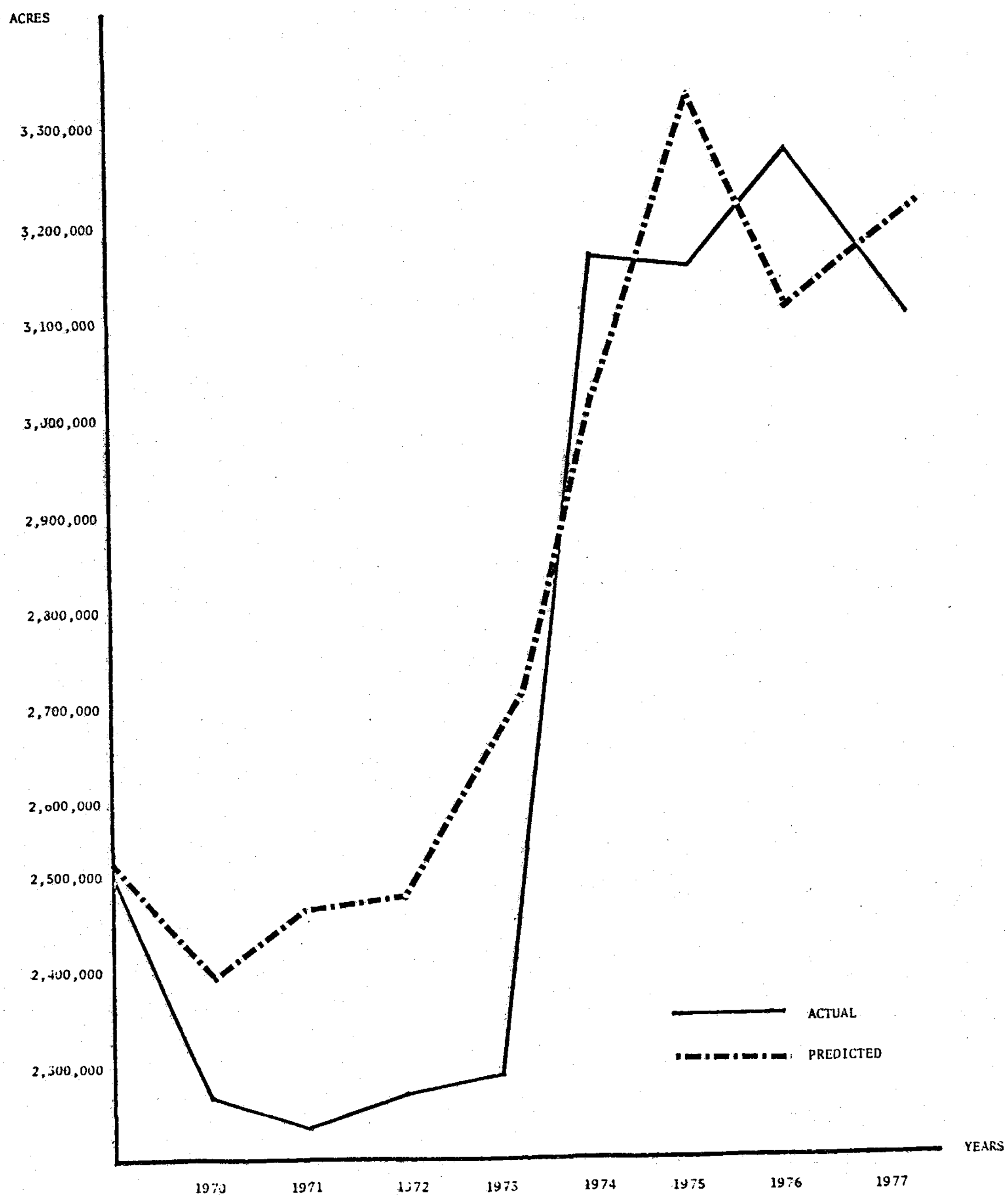


Table 11. Estimated Washington Dryland Wheat Acreage Response Model

	Constant				Market Price		Support	Alfalfa	
MODEL	C	C_{CNW}	C_{NEW}	C_{WWW}	LNMP	$LNMP_{WWW}$	$LNHES_{WWW}$	$LNALF_{WCB}$	R^2
Washington-DRY(1)	13.82	-2.26	-1.51	-6.45	0.17	1.06	1.14	-0.33	.994
	(0.06)	(0.06)	(0.06)	(0.19)	(0.05)	(0.12)	(0.36)	(0.02)	
Washington-DRY(2)	13.82	-2.26	-1.51	-6.45	0.18	1.05	1.14	-0.33	.999
	(0.03)	(0.04)	(0.04)	(0.36)	(0.02)	(0.22)	(0.69)	(0.01)	

(The standard errors are in parentheses.)

covered the years from 1969 to 1977. The omission of the observations from 1966 to 1968 was caused by the unavailability of data with which to compute the risk variable for these years. DRY(1) is the initial OLS estimation of the model. All signs are as expected and all coefficients are more than three times the size of their respective standard errors.

DRY(1) was tested for serial correlation, and the assumption of nonautoregression was not violated in any region. DRY(1) was subsequently tested for heteroskedasticity. The hypothesis of homoskedasticity was violated and the data were transformed accordingly. DRY(2) in Table 11 is the OLS estimation of the parameters using the transformed variables. The standard errors for the shift variables on the constant, the expected market price and the effective support rate for Western Washington increased in the GLS estimation, as was the case in the total acreage model. The standard errors on all other estimated coefficients decreased. The magnitudes of the estimated coefficients remained virtually the same.

The Southeastern Washington region was designated as the base for this parameter estimation because it has the most extensive planted wheat acreage. Consequently, as in the previous model, the negative shift variables for the intercept for Central Washington, Northeastern Washington and Western Washington were expected. Table 12 presents the DRY(2) estimated intercepts and elasticities for all independent variables by region.

The estimated elasticity of acreage response with respect to market price is 0.18 for all regions in the state except Western Washington where it is 1.05. The Western Washington elasticity is similar to that estimated in the total acreage model (1.07) reflecting the many alternatives to wheat in this region. The most elastic estimates in Oregon were also for the western regions. The elasticity for the rest of the state (0.18) is much more inelastic than that derived from the total acreage model. It is assumed that the inclusion of the irrigated wheat acreage in the total acreage model provided a mitigating influence. The inelastic estimate of acreage response for the Central and Eastern regions is consistent with the findings of the model that there are few economically viable substitutes for wheat on dryland wheat acreage in these areas.

Only the expected market price of alfalfa was found to be significant as a substitute for wheat and then only in the Columbia Basin. Barley, sugarbeets

Table 12. Model Washington-DRY(2): Estimated Intercepts and Elasticities for all Independent Variables by Region

REGION	CONSTANT	Market Price LNMP	Support LNHES	Alfalfa LNALF
Southeastern Washington	13.82	0.18	0.00	0.00
Washington Columbia Basin	13.82	0.18	0.00	-0.33
Central Washington	11.56	0.18	0.00	0.00
Northeastern Washington	12.31	0.18	0.00	0.00
Western Washington	7.37	1.05	1.14	0.00

and peas also were hypothesized to be economic substitutes.

There was no response to the government wheat programs for Washington dryland acreage with the exception of the support rate in Western Washington. These estimates are in sharp contrast with the estimated elasticities for support and diversion in the total wheat acreage response model. It is assumed, again, that the irrigated acreage response influenced the total acreage model. The extent of the influence is surprising, given the preponderance of dryland acreage in the total planted wheat acreage in the state. The estimated acreage elasticity with respect to the effective support rate is 1.14 in Western Washington. This estimate is similar to the elasticity of 1.05 with respect to market price estimated for this region. Because of the range of substitutes to wheat production available in this region, producers are very responsive to changes in the market price and the support price as these variables influence income expectations.

Risk, as measured by the three years standard deviation of variability in gross income per acre, was not found to affect the planting decision. The estimated coefficient on this variable is not significant at the 20 percent level of probability.

Model DRY(2) was utilized to estimate the predicted dryland planted wheat acreage in Washington over the estimation period from 1969 to 1977. The annual estimation error is 4.1 percent with a standard deviation of 2.9. Figure 7 is a graph of the predicted versus the actual dryland wheat acreage in Washington over these years.

Washington Irrigated Wheat Acreage Response Model

The Washington irrigated wheat acreage response function estimated in double-logarithmic form is summarized in Table 13. As for the other Washington models, the estimation period for this model was limited to 1969 to 1977 by the lack of data with which to compute the risk variable for the previous three years. The Western Washington region was not included in the data set since there was no irrigated planted wheat acreage in this region during any of the years considered. IRR(1) is the initial OLS estimation of the model. All signs are as anticipated with the exception of the coefficient on the effective diversion rate which is positive. All coefficients are more than twice the size of their standard errors, again with the exception of the coefficient on the effective diversion rate which is slightly less than twice the size of its standard error.

Figure 7. Predicted versus Actual Washington Dryland Planted Wheat Acreage

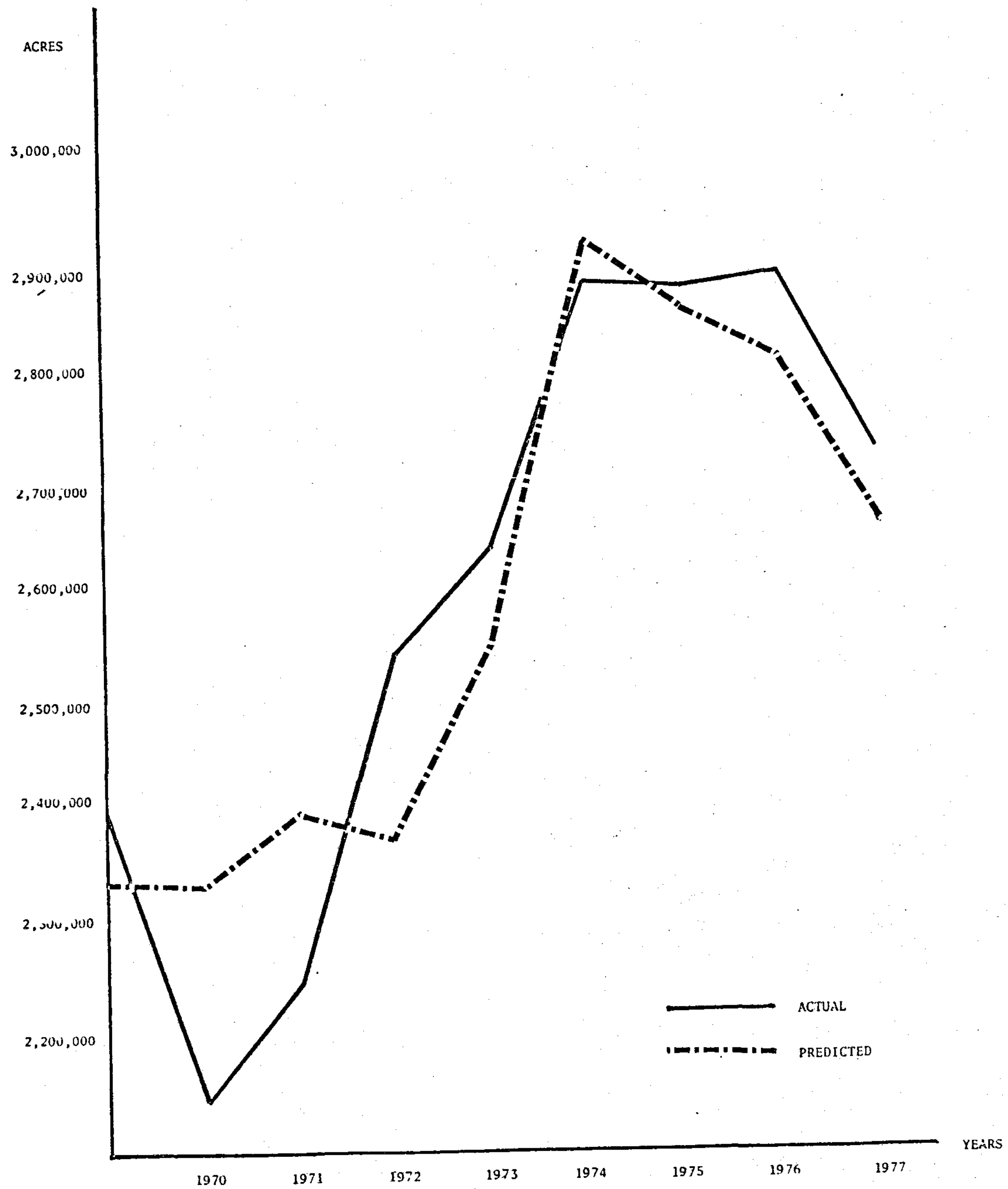


Table 13. Estimated Washington Irrigated Wheat Acreage Response Model

MODEL	Constant			Market Price		Support	Diversion	Sugarbeets	
	C	C_{WCB}	C_{NEW}	LNMP	$LNMP_{CNW}$	LNHES	LNHED	LNSBEETS	R^2
Washington-IRR(1)	10.45	-1.87	-2.54	0.85	0.45	0.72	1.07	-0.49	.98
	(0.43)	(0.43)	(0.43)	(0.13)	(0.10)	(0.28)	(0.65)	(0.15)	
Washington-IRR(2)	10.57	-1.88	-2.54	0.81	0.45	0.44	0.31	-0.45	.99
	(0.33)	(0.33)	(0.33)	(0.10)	(0.09)	(0.22)	(0.50)	(0.11)	

(The standard errors are in parentheses.)

Equation IRR(1) was tested for serial correlation, but it is not a problem with these data. IRR(1) was next tested and corrected for heteroskedasticity. Equation IRR(2) is the OLS estimation on the transformed variables corrected for heteroskedasticity. The magnitude of the estimated coefficients on the effective support rate and the effective diversion rate decreased substantially with the result that the estimated coefficient on effective support is just twice the size of its standard error and the estimated coefficient on the effective diversion rate is less than its standard error. The sign on the effective diversion rate is positive contrary to expectations but it is not significantly different from zero. All other estimated coefficients have the anticipated signs and are more than three times the size of their respective standard errors. The estimated intercepts and elasticities for all independent variables are listed in Table 14 by region.

The estimated elasticity with respect to expected market price is 0.81 for Southeastern Washington, the Columbia Basin and Northeastern Washington. This is much more elastic than the estimated elasticity of 0.18 for dryland acreage response in these regions. The more elastic estimate for irrigated wheat acreage is reflective of the greater number of substitutes to wheat production that are both technologically feasible and economically viable on irrigated acreage. The coefficient on expected market price in Central Washington (0.45) is less elastic than that estimated for the other three regions in the state.

The support rate is an important influence on the planting decision on irrigated acreage while there was no response to this variable estimated in the dryland model for the same four regions. The estimated elasticity of irrigated acreage with respect to the support rate is 0.44 for the four regions containing irrigated wheat acreage.

The estimated coefficient on the diversion rate is 0.31. The sign on this coefficient was expected to be negative. However, this coefficient is less than its standard error in the version of the model corrected for heteroskedasticity. It was significant at the 20 percent level in the uncorrected version. This may indicate multicollinearity or model misspecification.

Sugarbeets are a viable economic substitute for all regions. The estimated elasticity is -0.45 for the four regions considered in this model. Alfalfa, barley, and peas also were hypothesized to be alternatives to wheat production, but were not statistically significant. Sugarbeets may no longer be a viable

Table 14. Model Washington-IRR(2): Estimated Intercepts and Elasticities for all Independent Variables by Region

REGION	CONSTANT	Market Price LNMP	Support LNHES	Diversion LNHED	Sugarbeets LNSBEETS
Southeastern Washington	10.57	0.81	0.44	0.31	-0.45
Western Columbia Basin	12.45	0.81	0.44	0.31	-0.45
Central Washington	10.57	0.45	0.44	0.31	-0.45
Northeastern Washington	8.04	0.81	0.44	0.31	-0.45
Western Washington*	0.00	0.00	0.00	0.00	0.00

* (There was no irrigated wheat acreage in Western Washington for any of the years in the data set).

substitute because of the closing of a Washington processing plant. Risk was not found to affect the irrigated wheat acreage planting decision.

IRR(2) was used to estimate irrigated wheat acreage in the state over the estimation period. The annual estimation error was 11.5 percent with a standard deviation of 5.9. Figure 8 presents a graph of the predicted versus the actual irrigated wheat acreage in Washington from 1969 to 1977.

SUMMARY AND CONCLUSIONS

Background

Three wheat acreage response models for Oregon and three for Washington have been developed. The first predicts total acreage planted of wheat in the state and the second and third functions predict planted wheat acreage separately for irrigated and dryland acreage. The parameters of the models were estimated using pooled cross-sectional and time-series data.

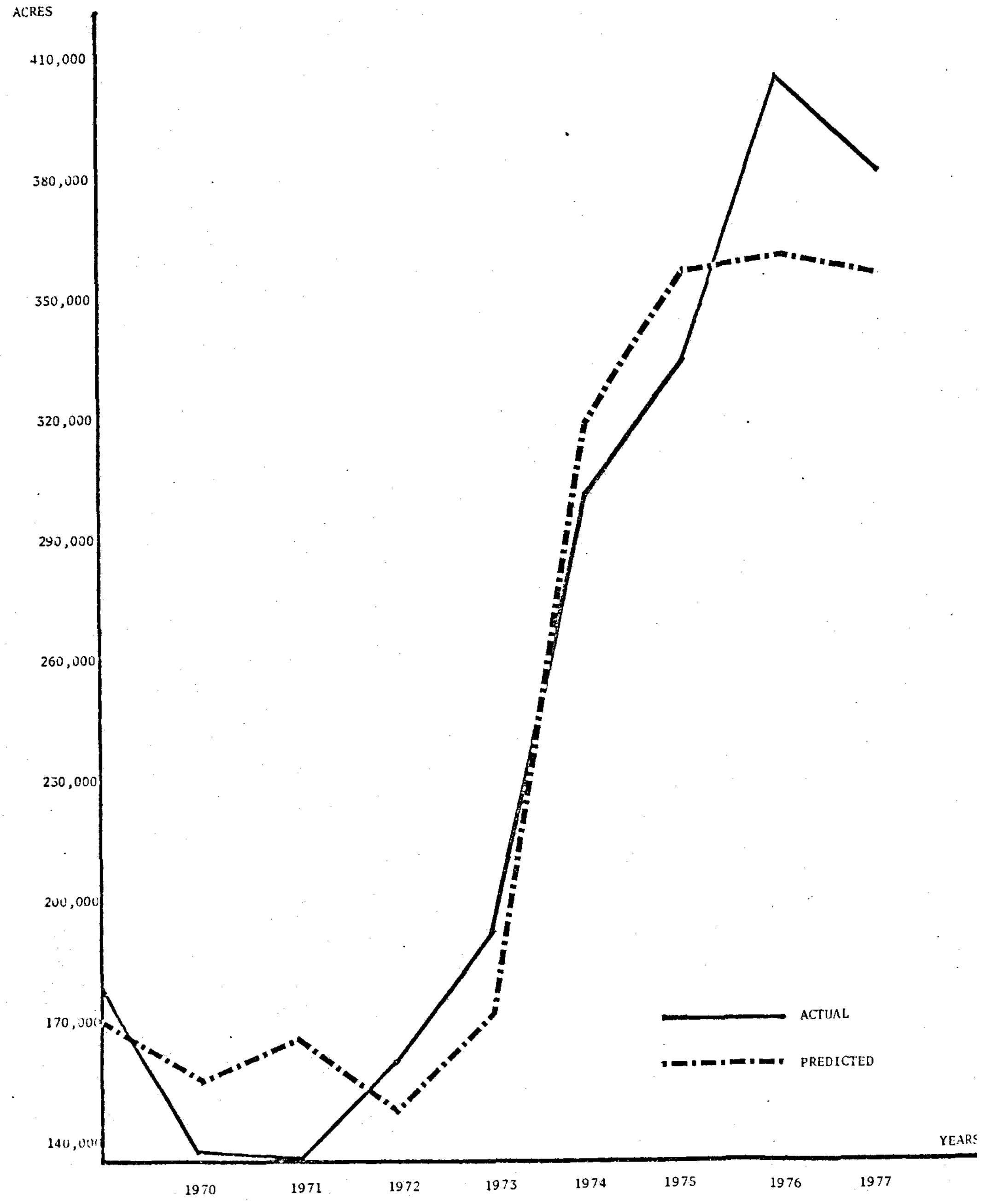
Summary

Market Price

The impacts of changes in the expected market price of wheat, the effective wheat support rate and the effective wheat diversion rate on dryland wheat acreage are similar in eastern Oregon and eastern Washington and distinct from western Oregon and western Washington. The estimated elasticities with respect to the expected market price are elastic in the western regions of these two states and quite inelastic in the eastern regions. The wheat price elasticities for western Oregon and Washington dryland wheat acreage are much more elastic than the national estimate of 0.39. The higher elasticities reflect the importance of substitutes in these areas. The estimate of price elasticity for eastern Washington is much lower, and the eastern Oregon dryland estimate is the only price elasticity that approximates the national average response as estimated by Houck *et al*.

In general, the estimated elasticity of irrigated wheat acreage in Oregon and Washington with respect to the expected market price is about the same. The central areas of both states, the Columbia Basin in Oregon and the Central Washington region, are exceptions. The Oregon and Washington irrigated acreage elasticities with respect to the market price are much higher than the national

Figure 8. Predicted versus Actual Washington Irrigated Planted Wheat Acreage



average response. The increased elasticity reflects the importance of substitutes on irrigated acreage in the Northwest.

Government programs

The dryland acreage response to the effective support rate is divided geographically between the eastern and western regions of the two states. The support rate as measured by Houck et al. has no impact on the eastern regions with the exception of the effective support rate in Eastern Oregon. In the western regions, the support price elasticity is more elastic than the national estimate of 0.58. The estimated response to the diversion rate is zero for all dryland wheat acreage in both Oregon and Washington.

The only responses with respect to the government programs on irrigated acreage were in Washington. It was found that the estimated Washington support price elasticity is slightly less than the national average while the Washington diversion price elasticity is positive, contrary to expectations, but not significantly different than zero.

Substitute Crops

Orchard grass in the Willamette Valley and alfalfa in the Washington Columbia Basin were determined to be important substitutes for wheat production on dryland acreage. Potatoes are an economic substitute on irrigated acreage in Oregon outside of the Willamette Valley. Sugarbeets were found to be an economic substitute on irrigated acreage in eastern Washington. However, because of the closing of a processing plant in Washington, sugarbeets may no longer be a substitute in this region.

Risk

Risk, measured as a three year moving average of the standard deviation of gross income per acre, was determined to be an important factor affecting dryland wheat acreage in Oregon but not in Washington. This is contradictory to the findings of Winter and Whittaker who could not reject the hypothesis that the response to risk was significant and homogeneous across the three states of Oregon, Washington, and Idaho. There was less variation in the risk variable for the major wheat producing regions of Washington than for these regions in Oregon. This was caused by more stable yields and production in Washington. The negative sign on the estimated coefficient implies a reduction of wheat acreage in response to an increase in the magnitude of the risk variable. The land transferred from wheat production in response to the risk factor is likely transferred to another use. It is doubtful that the land is left idle. However, there were no important substitutes (including diversion) that were statistically significant on dryland wheat acreage in Eastern Oregon. There are several reasons that might explain this situation. Preliminary research by Wilson et. al. suggests that both the estimated coefficient and the significance of the risk variable are highly sensitive to the measurement used. Perhaps the risk measurement formulated by Lin was not the most appropriate. There is some question as to what any hypothesized risk variable actually measures. There also may be an interaction between the risk variable and the government programs. The announced support price functions as a guaranteed price floor. By removing the lower end of the price distribution of potential market prices received by producers, the income risk would be reduced. The risk variable could be measuring this effect of the government programs.

Implications

Care should be exercised in interpreting the results of this research. The estimated acreage responses are only valid for the 12 years included in the estimation period, 1966 to 1977. The government wheat diversion/set-aside programs were not important in Oregon and were only slightly more important in Washington during these years because the payment levels were not high enough to elicit a significant acreage response in these areas. Producers found themselves better off in the open market. However, given escalating wheat price supports and target prices, and potentially low market prices, government wheat policy could have a greater impact in this region in the future.

Northwest models are distinct from the national wheat supply model in that the Northwest white wheat market is distinct from the red wheat market. Different markets could partially explain why Northwest wheat producers do not react to the effective support rate and other market facotrs consistently with the national average. Given the preponderance of U.S. wheat production in the Wheat Belt, the support rate itself reflects how the red wheat producers in the Wheat Belt are expected to react. The relevant season average price received by prodcers in Oregon (i.e., white wheat production) to the national season average price (i.e., reflecting mostly red wheat production) was not constant from 1966 to 1977. Red and white wheat have different uses, different markets, and are not perfect substitutes in food production.

In this study, acreage response varies substantially between irrigated and dryland acreage responses. The only exception is no response to diversion programs on either irrigated or dryland acreage in Oregon. It is not possible to say which type of acreage most influenced the total state acreage models. In Oregon, the dryland acreage response model was very similar to the total acreage model, while in Washington the western dryland regions and the eastern irrigated regions showed more similarity with the state total acreage model than either the overall irrigated or dryland models. It is both possible and enlightening to make the distinction between the irrigated acreage response and the dryland acreage response. The average annual estimation error statistics reported for the six acreage response models in this study suggest these models are adequate for this purpose.

Nearlly all the regional estimated elasticities differ substantially from the national estimates of Houck et al. The disparate regional acreage responses imply that the national supply model is not an appropriate basis to calculate responses of Northwest wheat producers to government wheat policy. If the government determines the national support and diversion prices in an effort to elicit some specific and known magnitude of wheat production or range of wheat production, at least regionally, these goals may not be met.

This disparity between national and regional elasticity estimates is not important if the only goal of national policy is aggregate supply management, provided that all regions in the nation balanced out to approximately the national supply goal. However, national farm policy takes many directions. Other goals such as the maintenance of the family farm make the estimation of regional acreage response models important. In addition, policy makers should be aware of the equity considerations raised by the disparate acreage responses.

In summary, this research supports the hypothesis that wheat should be disaggregated into dryland versus irrigated production and separate supply models estimated for each type of production. This study is also illustrative of the regional impacts of the government wheat programs and the regional influences on commodity supply that are masked by a national wheat supply model.

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